REPUBLIC OF TURKEY
SAKARYA UNIVERSITY
GRADUATE SCHOOL OF BUSINESS

A NEW GLOBAL FINTECH INDEX AND ITS APPLICATION TO OPTIMUM POLICY GENERATION BASED ON REINFORCEMENT LEARNING

PHD THESIS

Oylum Şehvez ERGÜZEL
0000-0001-9266-8267

Department of the Institute : Business
Subdepartment of the Institute: Accounting and Finance

Thesis Supervisor: Asst. Prof. Dr. Mustafa Kenan ERKAN
0000-0002-9975-8182

MAY - 2023

This thesis titled “A New Global Fintech Index and Its Application to Optimum Policy Generation based on Reinforcement Learning” has been prepared by Oylum Şehvez ERGÜZEL, and accepted as a successful ~~Master’s~~ / Doctorate Thesis by the following jury on 20/03/2023 as a result of the Thesis Defense Exam held in accordance with the relevant articles of the Sakarya University Graduate Education and Training Regulations.

Supervisor: Asst. Prof. Dr. Mustafa Kenan ERKAN

Sakarya University

Jury Members: Prof. Dr. Cabir VURAL

Marmara University

Assoc. Prof. Dr. Çağrı Levent USLU

Yeditepe University

Assoc. Prof. Dr. Adem AKBIYIK

Sakarya University

Assoc. Prof. Dr. Ahmet Yağmur ERSOY

Sakarya University

SAKARYA ÜNİVERSİTESİ	**T.C.** **SAKARYA ÜNİVERSİTESİ** **İŞLETME ENSTİTÜSÜ** **TEZ SAVUNULABİLİRLİK VE ORJİNALLİK BEYAN FORMU**	Sayfa : 1/1

Öğrencinin		
Adı Soyadı	**:**	OYLUM ŞEHVEZ ERGÜZEL
Öğrenci Numarası	**:**	1560D04022
Enstitü Anabilim Dalı	**:**	İŞLETME ANABİLİM DALI
Enstitü Bilim Dalı	**:**	MUHASEBE VE FİNASMAN
Programı	**:**	☐ YÜKSEK LİSANS ☑ DOKTORA
Tezin Başlığı	**:**	A New Global Fintech Index and Its Application to Optimum Policy Generation based on Reinforcement Learning
Benzerlik Oranı	**:**	**% 13**

Sakarya Üniversitesi İşletme Enstitüsü Enstitüsü Lisansüstü Tez Çalışması Benzerlik Raporu Uygulama Esaslarını inceledim. Enstitünüz tarafından Uygulalma Esasları çerçevesinde alınan Benzerlik Raporuna göre yukarıda bilgileri verilen tez çalışmasının benzerlik oranının herhangi bir intihal içermediğini; aksinin tespit edileceği muhtemel durumda doğabilecek her türlü hukuki sorumluluğu kabul ettiğimi beyan ederim.

20 / 03 / 2023
İmza
Öğrenci

Sakarya Üniversitesi İşletme Enstitüsü Lisansüstü Tez Çalışması Benzerlik Raporu Uygulama Esaslarını inceledim. Enstitünüz tarafından Uygulalma Esasları çerçevesinde alınan Benzerlik Raporuna göre yukarıda bilgileri verilen öğrenciye ait tez çalışması ile ilgili gerekli düzenleme tarafımca yapılmış olup, **yeniden değerlendirilmek üzere gsbtez@sakarya.edu.tr** adresine yüklenmiştir.

Bilgilerinize arz ederim.

20 / 03 / 2023
İmza
Danışman

Uygundur

Danışman Unvanı / Adı-Soyadı: Dr. Öğr. Üyesi Mustafa Kenan ERKAN

Tarih: 20 / 03 / 2023

İmza:

☑ KABUL EDİLMİŞTİR ☐ REDDEDİLMİŞTİR **EYK Tarih ve No: …… / …… / 20…. - …….**	**Enstitü Birim Sorumlusu Onayı**

ACKNOWLEDGEMENTS

I would like to express my gratitude to my esteemed professors Assoc. Prof. Dr. Adem AKBIYIK and Assoc. Prof. Dr. Elmas Yaldız HANEDAR, who contributed to my thesis with their suggestions and opinions in the most critical parts by accepting to take part in my thesis monitoring jury, and Prof. Dr. Cabir VURAL, who took part in my thesis presentation jury, for being with me in this long and stressful process. I would like to express my appreciation to Assoc. Prof. Dr. Ahmet Yağmur ERSOY, who read my thesis and shared his valuable opinions with me, increased my motivation with his belief in me in every step of my work, and never withheld his support during this stressful period.

I am grateful to my dear friend Asuman ÜSTÜNDAĞ for her presence and support on the day of my thesis presentation. I would like to thank my friend Samet ÖZDEMİR, we have shared the same office for ten years, who read my thesis before anyone else and shared his valuable opinions with me, who has always supported me, and my dear friend Gülçin ÖZDEMİR, who eased my burden by helping me prepare for the presentation day. I would like to thank my closest friends Seren ÖZSOY, Ecenur DEMİR, Duygu TERZİ ÇOBAN for their friendships, who boosted my morale throughout the process and gave me time whenever I needed it. I am grateful to my esteemed mentor and colleague Assoc. Prof. Dr. Erdem DOĞAN, whose opinions I frequently consulted and who carried the dissertation further in every meeting. In addition, I would like to express my appreciation to my mentor Dr. İbrahim YILDIRIM, who carried my thesis to a different dimension with his contributions, opinions and suggestions at every stage of the thesis, especially with reinforcement learning, and to my advisor Asst. Prof. Dr. Mustafa Kenan ERKAN, who always trusted me and showed his support by accepting my supervision.

I am very grateful to my mother Raziye COŞKUN, my father Nevzat COŞKUN, my sister Özlem DOĞAN, my brothers Özgür Deniz and Ali Osman COŞKUN for their supports and importance they have given to my education throughout my life. I also remember with love my grandmother Şehvaz CEYLAN, who had a great contribution to my coming to this day and who passed away during the process.

Oylum Şehvez ERGÜZEL

20.03.2023

TABLE OF CONTENTS

ABREVIATIONS

AFAI : Fintech Adoption Index for Association of Southeast Asian Nations
AHP : Analytical Hierarchy Process
AI : Artificial Intelligence
ASEAN : Association of Southeast Asian Nations
ATM : Autometed Teller Machine
BAP : Budget Allocation Process
CA : Crombach Alpha
DEA : Data Envelopment Analysis
DeFi : Decentralized Finance
DLT : Distributed Ledger Technology
E&Y : Ernest and Young
EU : European Union
EW : Equal Weight
FA : Factor Analysis
Fintech : Financial Technology
FSB : Financial Stability Board
GDP : Gross Domestic Product
GFC : Global Financial Crisis
GFI : Global Fintech Index
HKMA : Hong Kong Monetary Authority
ICT : Information and Communication Technology
IFC : International Finance Cooperation
IMF : International Monetary Fund
Insurtech : Insurance Technology
IOSCO : International Organization of Security Commission
IoT : Internet of Things
IT : Information Technology
JRC : Joint Research Center
ML : Machine Learning
mPOS : Mobile Point of Sale
OECD : Organization for Economic Cooperation and Development
P2P : Peer to Peer
PC : Principle Component

PCA	**:** Principle Component Analysis
PFM	**:** Personel Finance Management
PPP	**:** Purchasing Power Parity
R&D	**:** Research and Development
Regtech	**:** Regulation Technology
RL	**:** Reinforcement Learning
S&P	**:** Standard & Poor's
SME	**:** Small and Medium Enterprise
TAM	**:** Technology Acceptance Model
UK	**:** United Kingdom
UNDP	**:** United Nations Development Program
USA	**:** United States of America
VC	**:** Venture Capital
WB	**:** World Bank
WOS	**:** Web of Science
WWW	**:** World Wide Web

TABLES

FIGURES

ABSTRACT

Ergüzel, O., Ş. (2023). A New Global Fintech Index and Its Application to Optimum Policy Generation based on Reinforcement Learning (Unpublished doctoral thesis). Sakarya University.

The merger of technological applications with finance has taken its place in the literature as Financial Technology (Fintech) starting from the 1990s, although it has become more frequent especially after the 2008 Global Financial Crisis (GFC). Fintech, as the name suggests, is the fusion of finance and technology. It is known that technology has always affected the finance industry and changed the way it works. For example, the introduction of Autometed Teller Machine (ATM), money transfer systems and the increase in productivity emerged with these developments in the financial sector have been inevitable. The question is, what makes the current Fintech revolution different from other periods? First, the testing and introduction of new technologies into financial markets has never been so rapid before. Another important point is that the impact of today's development is not only on the financial markets, but also on the economy as a whole, as new start-ups and large technology companies create competition outside the financial sector with the financial products they develop, creating an exogenous effect on the entire economy. Today's Fintech concept has transcended the financial market and has become the focus of entrepreneurs from different sectors. For this reason, the impact of Fintech on the economies and growth of countries is a topic that needs to be researched more than ever. With all this, Fintech promotes participation in financial markets around the world, enabling millions of people and businesses to participate in the global economy. Access to financial services is critical for global development as it facilitates investment in health, education and business.

Concordantly, within the scope of this thesis, it is aimed to create a composite indicator representing Fintech development of countries by using the prominent determinants of it and to provide guidance to policy makers by revealing the policies recommended to be followed in order to come to the forefront in this field on a country-specific basis. In this direction, firstly, a composite indicator was created by detecting the determinants of Fintech and then, using the indicator scores, policy recommendations were made for each country with the help of Reinforcement Learning (RL).

Keywords: Fintech, Composite Indicator, Reinforcement Learning, Determinants of Fintech, Global Fintech Index (GFI)

ÖZET

Ergüzel, O., Ş. (2023). Yeni Bir Küresel Fintech Endeksi ve Pekiştirmeli Öğrenmeye Dayalı Optimum Politika Oluşturmaya Uygulanması (Yayımlanmamış doktora tezi). Sakarya Üniversitesi.

Teknolojik uygulamaların finansla birleşmesi, özellikle 2008 Küresel Finans Krizi sonrası daha sık olmakla birlikle, 1990'lı yıllardan başlayarak "Fintek" olarak, literatürdeki yerini almıştır. Fintek adından da anlaşılacağı üzere finans ve teknolojinin kaynaşmasıdır. Teknolojinin her zaman finans endüstrisini etkilediği ve çalışma şeklini değiştirdiği bilinmektedir. Bu durumun en belirgin örnekleri, ATM makinelerinin kullanılmaya başlanması ve banka para transfer sistemlerinin gelişimiyle birlikte finans sektöründe yaşanan verimlilik artışıdır. Buradaki asıl soru şudur; şu anda yaşanan Fintek devrimini diğer dönemlerden farklı kılan nedir? Birincisi, yeni teknolojilerin test edilmesi ve finans piyasalarına girişi daha önce bu kadar hızlı olmamıştır. Bir diğer önemli husus ise, günümüzde yaşanan bu gelişmenin etkisinin sadece finans piyasalarında değil, aynı zamanda, yeni start-up ve büyük teknoloji firmalarının geliştirdikleri finansal ürünlerle, finans sektörü dışında da rekabet ortamı yaratması ve tüm ekonomide dışsal etki oluşturmasıdır. Günümüzdeki Fintek kavramının sınırı finans sektörünü aşmış ve farklı sektörlerden girişimcilerin de odak noktası haline gelmiştir. Bu nedenledir ki, Fintek'in ülkelerin ekonomileri ve büyümeleri üzerindeki etkisi her zamankinden daha fazla araştırılması gereken bir konudur. Tüm bunlarla birlikte, Fintek dünya çapında finans piyasalarına katılımı teşvik ederek, milyonlarca insanın ve işletmenin küresel ekonomiye katılımını sağlamaktadır. Finansal hizmetlere erişim, sağlık, eğitim ve iş hayatına yatırım yapmayı kolaylaştırması nedeniyle küresel kalkınma için kritik öneme sahiptir.

Bu bağlamda, bu tez kapsamında, Fintek'in belirleyicilerini kullanarak ülkelerin bu alandaki gelişmişlik düzeylerini gösteren birleşik bir gösterge oluşturulması ve bu alanda ön plana çıkabilmeleri için izlemeleri önerilen politikaların, ülke özelinde ortaya konularak, politika yapıcılara yol gösterici olunması amaçlanmıştır. Bu doğrultuda, öncelikle Fintek'in belirleyicileri ortaya konulmuş ve birleşik bir gösterge oluşturulmuş akabinde, gösterge skorları kullanılarak pekiştirmeli öğrenme yöntemi yardımıyla ülke özelinde politika önerilerinde bulunulmuştur.

Anahtar Kelimeler: Fintek, Birleşik Gösterge, Pekiştirmeli Öğrenme, Fintek Belirleyicileri, Küresel Fintek Indeks

INTRODUCTION

The merging of technological practices with finance has become a Fintech in the literature, starting with the 1990s, especially after the 2008 Global Financial Crisis. As some researchers have summarized, it is “the marriage of finance and technology”(Zavolokina et al., 2016). Although the term's usage and origin in the literature is based on the "Financial Services Technology Consortium", a project initiated by Citigroup in the early 1990s to facilitate technological collaboration efforts (Alterkawi & Bittar, 2019; Arner et al., 2015), firstly Fintech was defined by Abraham Leon Bettinger in 1972. Bettinger (1972) defined Fintech as “an acronym for financial technology, combining banking expertise with modern management science techniques and computing”. Many different definitions of Fintech have been presented since the Bettinger(1972) and there is no single unique definition of it in the literature.

Today, most of the financial transactions are carried out through the technology based financial services such as online banking, smart phones, digital applications, e-commerce portals (Alterkawi & Bittar, 2019). Although financial technological innovations, which have increased, become widespread and adopted with globalization, they seem to have just been included in our daily lives due to their widespread use in the recent period, the coming together of finance and technology dates back to a very old history (Anyfantaki, 2016). Especially after the 2008 crisis, many areas where traditional financial intermediaries were insufficient were compensated by Fintech's innovative product solutions (Setiawan & Maulisa, 2020). In this respect, the 2008 crisis as a global shock has been an important factor in the handling of Fintech as a different paradigm and its more widespread and powerful agenda. Finally, after the devastating impact of the Covid 19 pandemic, as a different global shock on economy, trade and finance, Fintech is evolving into a new paradigm (Sugandi, 2021).

Fintech not only promotes innovations and transformations in traditional financial services and products (Luo et al., 2022; Murinde et al., 2022; Rau, 2018), but also competes with them (Philippon, 2016; Rau, 2018). Therefore, FinTech as a disruptive and sustainable innovation can have a greater impact on the financial system. KPMG (2021) reveals that global Fintech investment has reached 94.7 billion dollars, increasing by 94% compared to its value in 2008, which differentiated Fintech's position in the industry. The competitive dimension of Fintech with traditional financial products and services also

causes it to be described as a disruptive innovation (Panos & Wilson, 2020). Nevertheless, three important developments can be mentioned that enable FinTech to emerge as a disruptive innovation (Nejad, 2022). The first of these is the widespread use of innovations such as big data, Distributed Ledger Technology (DLT), robo-advisory, cloud computing, mobile banking, Artificial Intelligence (AI) and Machine Learning (ML) in finance (Gomber et al., 2017; Jagtiani & John, 2018). Thanks to these technologies, the capacity to collect, store and share information has increased and automation has been possible in financial decision-making processes (He et al., 2017).

The second important factor is the loss of confidence of financial participants in financial institutions after the 2008 financial crisis (Arner et al., 2016). The crisis had three important consequences that affected the development of Fintech. The increase in trust in technology companies has accelerated the development of the sector by increasing the adoption of Fintech applications (Jünger & Mietzner, 2020).

As a result of the 2008 global financial crisis, the increasing unemployment rate, especially in the financial sector, was among the important factors that triggered the development of Fintech. (Arner, Barberis, et al., 2017b). Particularly in the US, employees who specialized on finance and lost their jobs have used their competencies in Fintech, a new field created by the crisis. Fintech was seen as a rapidly emerging field where they could use their skills and knowledge (Arner et al., 2015).

As an another consequence, the 2008 financial crisis brought along a series of new regulations (Salerno, 2020). Strict regulations have limited banks' ability to act, particularly in the area of lending. In these conditions, where the movements of banks are restricted, Fintech has been able to attract the attention of customers who cannot meet their needs through traditional financial institutions, with solutions such as Peer to Peer (P2P) lending and crowdfunding (Saiedi et al., 2018).

The third factor is the increasing demand for technology-oriented financial products by millennials and Generation Z, who have high technology awareness, knowledge and habits, and who easily adapt to and demand technological products (Junior & Cherobim, 2019). The technological innovations that Fintech relies on as a disruptive innovation are big data, internet of things, cloud computing, AI and augmented virtual reality (Arner, Barberis, et al., 2017a).

The disruptive impact of technology on the financial sector, driven by the aforementioned factors and through the driving technologies of Fintech, first emerged in the banking sector and quickly spread to insurance and securities (L. Cao et al., 2020). Nonetheless, the global pandemic has brought Fintech to the forefront as a reasonable strategy in supply chain finance, along with banking, insurance and securities, where Fintech has been influential.

Fintech has been seen and developed as an alternative that eliminates the negativities that emerged after the global financial crisis in developed western economies (Batunanggar, 2019). However, this reason is quite different for developing countries. Fintech increases limited access to basic services such as bank account, money transfer, and funding (Ozili, 2020).

One of the main topics in the economics and finance literature is the role and impact of financial market development on economic growth (Beck et al., 1999; Levine, 1997). There is growing evidence that well-developed financial markets and environment lead to higher economic growth (Guiso et al., 2004) because they facilitate access to capital, one of the most important needs of entrepreneurs, and enable them to seize investment opportunities in the real economy (Rajan & Zingales, 2003). Despite studies pointing out that the adoption of technology in combination with finance is key to achieving productivity growth (Aghion & Howitt, 1992), financial development and product market sophistication have received much attention in the literature, while the implementation and adoption of new technologies in financial markets and the impact of them on markets and the economy have received less scrutiny. Moreover, the positive impact of technological applications and their widespread adoption on productivity growth have been shown to explain the differences in total factor productivity across large countries (Comin & Hobijn, 2010).

Technology has always been known to affect the financial industry and change the way it works. For example, the introduction of ATM machines, money transfer systems and the increase in efficiency created by these developments in the financial sector have been inevitable. The question is, what makes the current FinTech revolution different from others?

First, testing new technologies and entering the financial markets have never been this fast. Another important issue is that the impact of this development today is creating a competitive environment not only in the financial markets but also in the financial

products developed by new start-up and big technology companies outside the financial sector and effectuating an externality impact in the entire economy.

The scope of the Fintech concept today has exceeded the financial sector and has become the focus of entrepreneurs from different sectors. For this reason, the impact of FinTech on the economies and growth of countries is an issue that needs to be investigated more than ever. In addition, FinTech promotes participation in financial markets worldwide, enabling millions of people and businesses to get involved in the global economy. Access to financial services is critical for global development as it facilitates investment in health, education and business life. In this regards, Fintech offers a powerful way to increase financial access. Accessibility to financial services reveals the relationship between "Financial inclusion" and "Fintech". Financial inclusion is defined as equality of opportunity in accessing financial products and services, and aims to ensure that the worldwide unbanked population is included in the financial system, with the chance to make available various financial services, from savings, payments and transfers to credit and insurance (Beck et al., 2007). Since 2010, the G-20 and the World Bank have been leading initiatives to increase financial participation to help reduce poverty in emerging and developing economies (Alliance for Fiscal Inclusion, 2010).

Today, FinTech and "Financial Inclusion" are largely addressed in the effects of poverty reduction and economic growth, and FinTech is among the working subjects of policy makers and academics due to its positive effect on diminishing problems on individuals, businesses and governments. In addition to its positive impact on financial inclusion, Fintech is also noteworthy due to its poverty reduction in emerging economies, its positive impact on economic growth in developed and developing countries, and its externalities that encompass different sectors. For this reason, it is important that financial technologies, whose economic and social effects are revealed more sharply and clearly as a result of the technological developments entering the financial markets more rapidly than in previous periods, should be handled with different dimensions. Nonetheless, the adoption of Fintech applications by financial participants can advance financial development and provide solid foundations for the improvements of the digital economy by promoting key policy objectives such as financial stability, inclusion, efficiency, innovation and competitivenes (World Bank, 2022). Moreover, by removing geographical and physical barriers to the adoption, use and diffusion of financial services, Fintech can create new opportunities to make the global financial system more efficient

and inclusive by making information more widely available to consumers and providers (World Bank, 2022). Policymakers globally are promoting the diffusion and adoption of Fintech to drive innovation and economic growth. However, for policymakers, regulators and supervisors, balancing digital transformation, financial innovation, competition, financial stability, data security, privacy and consumer protection may require implementing different policy approaches (World Bank, 2022)

Many positive externalities that reduce poverty and imperfect market implications such as asymmetric information and high transaction costs, along with their effects on economic growth and development, increasing the living standards of households, bring the need to reveal the determinants of Fintech (Frost, 2020).

Furthermore, the need to guide policymakers to adopt practices that can balance the positive impacts of Fintech with data security, privacy and consumer protection may make it imperative to address different aspects of Fintech.

The starting point for addressing the various aspects of Fintech is to present different definitions of the term. The fact that Fintech does not have a unique definition in the literature, when it is considered with its economic, social, technological and financial dimensions, has brought along with it to be expressed with different indicators as determinants of Fintech and to be dealt with by associating it with different variables. As a matter of fact, there is no single variable that can be considered as an indicator for Fintech as a different and multidimensional concept, but different explanatory indicators have been used in the literature (Claessens et al., 2018b; Frost, 2020).

Moreover, Lee et al.(2021) argue that the difficulty in measuring the development of Fintech from two different perspectives, namely the demand-driven perspective and the supply-driven perspective, can be overcome by developing a single composite indicator.

In addition, Nardo et al.(2005) in the European Commission's handbook on Composite Indicator construction, composite indicators are expressed as a useful tool for policy making and public communications in conveying information about countries' performance in areas such as the environment, economy, society or technological development. In this sense, the main purposes of composite indicators are to provide policy recommendations on the relevant issue and to provide guidance to policy makers. In this respect, a composite indicator on Fintech could also be an effective tool to guide policymakers in adopting effective practices in this field.

Considering the development phases of Fintech, the 2008 global financial crisis, with its accompanying effects, has been the main factor in Fintech taking its current form, especially in Western countries (Arner et al., 2015). In these countries, technology-based products and solutions used in finance have played a role in eliminating the negative effects of the crisis on the economies (Batunanggar, 2019). The function of Fintech, which is seen as an alternative to traditional financial products in developed countries in the high-income group, is quite different in developing countries. While a customer in a high-income country may prefer Fintech solutions over traditional banking activities for reasons such as service quality and efficient use of time, a customer in a low-income country may use them because they cannot access basic financial capabilities such as money transfers and bank accounts with traditional finance (Arner et al., 2016). For these countries, Fintech increases limited access to basic services such as bank accounts, money transfers and funding (Ozili, 2020). In such a case, it can be said that the concerns of consumers in developing countries that encourage the use of Fintech are quite different from those in developed countries.These differences between developed and developing countries may bring about the need for differentiation in policy recommendations to be made for Fintech according to the development levels of countries.

With the 2008 GFC, the differentiated face and changing impact of Fintech on financial markets and economies, the lack of a single accepted definition of it, and the need to create a composite indicator that includes different dimensions of Fintech and thus facilitate the measurability, due to its multidimensional impact areas, especially economic, financial, social and technological, has been the driving force behind the study.

Research Questions

The main focus of this study is the construction of a composite indicator that reveals the Fintech development of countries and at the same time provides guidance to policy makers in this field.

In this regard, the main research question of the study is that “Is it possible to construct a composite indicator to help governments or policy makers to understand where they stand with regard to improving the financial technology?”. The main research question is accompanied by the following supporting research questions.

- What is the theoretical framework of Fintech and its development in terms of economic and financial theories and how they can be explained?

- What are the definitions of Fintech in the literature and what is the theoretical base of them?
- What are the determinants of Fintech in the literature?
- What are the current Fintech developments of the countries? and how does it differ according to the income groups?
- What are the recommended policies for countries to improve their Fintech developments?
- Is there a difference in the suggested policies for countries according to income levels?

Research Objective

The main aim of this study is to make Fintech, which consists of different dimensions, especially economic, social, technological and financial, measurable through a composite indicator and to support policy makers to adopt policies to guide countries' progress in this field.

In this regards, the objectives that support the main purpose of the study are given below.

- The difficulty of measuring the development of fintech from two different perspectives, demand-oriented perspective and supply-oriented perspective, by developing a single composite indicator.
- By addressing the definitions of Fintech in the literature, to define Fintech, which is the unified indicator that will make Fintech measurable.
- To reveal the conceptual and theoretical framework of Fintech and to group the existing definitions of it in this scope.
- The determinants of Fintech as a multidimensional concept expressed with different indicators in the literature and a research model to create a composite indicator
- The appropriate data set to construct the composit indicator and validating it by using different methods.
- Fintech generates many positive externalities that reduce poverty and imperfect market implications such as asymmetric information, high transaction costs, as well as increasing economic growth and development and households' living

standards. Another objective of this study is to guide policymakers to adopt practices that can balance the positive effects of Fintech with data security, privacy and consumer protection.

- Since the need for Fintech applications and the economic, social, financial and technological effects of it differ in developed and developing countries, to make policy recommendations that will increase the development of countries by taking into account the income levels of countries.

Contributions

This dissertation provides important contributions in terms of its subject, method and results.

There are indexes in the literature that address different aspects of Fintech. Among these indices, the Global Fintech Adoption Index 2019 (Ernest & Young, 2019) and the Fintech Adoption Index for Association of Southeast Asian Nations (ASEAN) Countries (AFAI) address Fintech in terms of adoption and acceptability, while the AFAI is an index constructed exclusively for the countries of the ASEAN. Nonetheless, Fintech Index 2016 (Hieminga & Lande, 2016), Index Performance Scores 2017 (Deloitte, 2017), Global Fintech Ranking (Ankenbrand & Bieri, 2018), Global Fintech Index 2020 (Findexable Limited, 2019), Islamic Fintech Competitiveness Index 2021 (Glavina et al., 2021), all consider Fintech by defining it as a start-up, and the vast majority of these indices are city-based rather than country-based. However, unlike other indices, this study is the first composite indicator that deals with Fintech as technological and digital-based innovations that cause change in the field of finance, addressing many different dimensions and revealing the Fintech development levels of countries in this scope.

Moreover, the thesis examines Fintech within the framework of economics and finance theories and reveals the theoretical background of it. Leading academic studies are discussed by making use of the bibliometric literature review, which systematically reveals different aspects of the studies conducted on Fintech. Consequently, different Fintech definitions in the literature have been classified in terms of handling and explaining Fintech. One of the distinctive features of this dissertation is the presentation of different definitions of Fintech and the categorization of these definitions based on their common aspects. There is no definition classification supported by theory and based on the common aspects of Fintech definitions and the way they are handled.

In addition to the definitions in the literature, a new Fintech definition has been introduced, which also forms the basis of the Global Fintech Index. Accordingly, as the starting point of the Global Fintech index, "Fintech" is technological, digital-based financial innovations and applications that support the sustainability of traditional financial institutions/organizations, improve their products and services, also cause a disruptive impact and radical changes with the new challenging products and services in financial markets and industry.

This dissertation is the first to define Fintech as technological and digital-based innovations and to reveal the Fintech development levels of countries within the scope of this definition.

The most important functions of composite indices are to provide guidance to policymakers and to enable them to make policy recommendations that will lead to improvements in the area measured (Organisation for Economic Co-operation and Development (OECD), 2008). Within the framework of the Global Fintech Index (GFI) results revealed in this thesis, policy recommendations are made with RL method in order to improve Fintech development of the countries

Another important and one of the most critical constribution of the thesis is that it does not only provide policy recommendations, which is the most important function of composite indicators within the scope of interpreting index scores. This dissertation differs methodologically from other index studies by using RL to present policy recommendations.

Research Methodology

In the dissertation, the development of an index as a composite indicator, which will reveal Fintech with its different dimensions, is proposed. A solid theoretical framework is the starting point in the construction of composite indicators (OECD, 2008). In order to put the study in a understadable theoretical framework and to develop the index within this scope, first, a bibliometric literature review was conducted to systematically examine the leading studies on Fintech.

The next step of the methodology has been the constructing the composite indicator. In the methodology part of the study, based on the (OECD, 2008) guideline for creating composite indicators, the steps followed were determined as follows: 1- Defining theconcept to be measured (FinTech) 2- Indicator selection and data collection 3-

Normalizing the data 4- Grouping the indicators 5- Weighting the indicators 6- Construction of Global Fintech Index 7- Interpretations of the results and visualization 8- Policy path trajectory for Fintech development based on RL.

Assumptions

The main assumption of this dissertation is that the difficulty of measuring the development of Fintech from two different perspectives, a demand-driven perspective and a supply-driven perspective, can be overcome by developing a single composite indicator (Lee et al. 2021). Nevertheless, the basic step of composite indicators is to define the concept to be measured. There are different approaches to the definition of Fintech in the literature. In this thesis, it is assumed that the Global fintech Index is constructed within the framework of the definition in Chapter 1.

Another assumption is the honesty of the participants who were interviewed and completed the expert survey in the weighting part of the study, which was conducted based on expert opinion. It is assumed that both interviewers and survey participants are honest and willingly participate in the data collection process.

Limitations

The construction of composite indicators includes the selection of indicators, compensation of missing values, choice of aggregation model, weights of indicators, etc., which require subjective judgment. Most of the disadvantages of composite indicators stem from the subjectivity of some of the stages in their construction. While it may seem idealistic to assume that this debate will be resolved (Saisana et al. 2005), combined indicators still attract the attention of policymakers and the public. The subjectivity of the construction of composite indicators is often criticized, as well as the possibility of manipulating the result if the procedures followed are not clearly and reasonably justified for all (Grupp and Mogee 2004; Grupp and Schubert, 2010). In an attempt to find a solution to this problem, the OECD (2008, p. 15) describes a ten-step process, a 'checklist', to establish common guidelines as a basis for the development of composite indicators and to increase the transparency and robustness of the process. Within the scope of this constraint, this dissertation benefited from the OECD's (2008) guidelines and adopted the OECD's methodological steps in constructing the GFI.

In the expert opinion used in the weighting of the combined indicators, it was aimed to reach experts from different countries and ensure their participation in the survey. However, while experts from Europe, the Middle East and the United States of America (USA) participated in the survey, experts from Asian countries such as India, China and Singapore could not be included. This study can be expanded by taking the opinions of experts from these countries.

Organization of the Thesis

This dissertation consists of four main chapters: Literature Review, Fintech Revolution in Finance, Application of constructing GFI, Policy Path Trajectory for Global Fintech Development based on RL.

Chapter 1: Literature Review: Constructing a composite indicator requires a detailed literature review in terms of defining the concept to be measured, laying out its theoretical foundations, and identifying the determinants of the phenomenon to be measured. In addition, due to the international characteristic of the GFI, it was foreseen that a literature review based on bibliometric analysis would contribute to the purpose of the study in terms of identifying the prominent countries in this field and enabling the presentation of findings that support the results of the study. For this reason, this section first presents the main studies on Fintech through a literature review based on bibliometric analysis, defining Fintech, revealing its determinants and determining its theoretical foundations.

Chapter 2: Fintech Revolution in Finance: In this section, the effects of Fintech, as a technology-based innovation, in the field of finance are presented in terms of development periods, while the technologies that cause change in the sector and the Fintech ecosystem in general are explained.

Chapter 3: Application of Constructing GFI: In this part of the thesis, the stages of constructing the index are explained in detail and the results of the analysis are presented, visualized and interpreted. In addition, the findings are presented within the scope of the World Bank's classification of countries according to their income levels (lower income, lower middle income, upper middle income and upper income) in order to analyze and interpret the Fintech development levels of countries in more detail.

Chapter 4: Policy Path Trajectory for Global Fintech Development based on RL: One of the most important purposes of constructing composite indicators is to provide guidance and policy recommendations to policy makers in the relevant field. For this purpose, in

this section, using GFI scores, country-specific policy recommendations are presented through RL. Similar to the third chapter, this chapter is based on the World Bank's classification of countries according to income groups. Before that, RL is explained as the methodology used and then the results of the analysis are revealed. Finally, the conclusion summarizes and interprets the findings. Subsequently, the main contributions of the thesis to the literature, limitations and suggestions for further research are presented.

CHAPTER 1. LITERATURE REVIEW

Literature reviews are important in terms of obtaining existing knowledge through studies of the related field and revealing new study topics. This study aims to present the determinants of Fintech, which expresses the combination of the terms “Finance” and “Technology” as two very comprehensive concepts, and to develop a composite indicator that will allow to present and compare the current situation of the Fintech developments of the countries. Such an objective in this study brings with it the need for a detailed literature review in an area where two broad concepts as Finance and Technology are combined. In this regard, bibliometric analysis was used as a method that provides the general view of the other studies, because it allows the analysis and interpretation of the related studies by collecting them from a certain database, and the convenience it provides in revealing the basic studies of the examined field (Öztürk, 2021).

The main stages of bibliometric research are as follows; determining the main purpose of the research, obtaining data related to the literature, analysis, and visualization, and finally interpretation of the results and findings. Within the scope of these stages, this includes a detailed literature review on Fintech.

1.1. Bibliometric Analysis

With the 2008 Global Financial Crisis, a serious financial depression emerged in the USA and the socio-economic effects of it have spread to many other countries of the world (Milian et al., 2019). As a result of the financial downturn, the performance of commercial banks has declined significantly over the last 15 years and traditional financial institutions have been unable to compensate for the recession, generate profits, increase efficiency and meet customers' changing demands over time (Breidbach et al., 2020). In such an environment, new Fintech solutions have emerged to meet the needs of the customers and industry (Gomber et al., 2017; Haddad & Hornuf, 2019). There is no single agreed definition of FinTech in the literature (Milian et al., 2019; OECD, 2018). FinTech is expressed with different variables due to the lack of a single accepted definition, the emergence of new technology-based products against traditional financial solutions in different areas of finance, and it has multidimensional spheres of influence. The study is aimed to reveal the different dimensions of FinTech, create a composite indicator containing them, thus facilitating the measurability of FinTech. The purpose and method of the study, within the scope of economic theories on which Fintech is based, require a

wide literature review, starting from its definition, revealing its determinants and areas of influence. In this regard, a detailed bibliometric study on Fintech is included within the scope of the following research questions.

- What are the key references on Fintech?
- What are the main scholarly periodicals on this subject and how has the number of publications changed over time?
- Which countries have shown the most interest in the field?
- Which Fintech studies have been conducted in different countries?
- Which countries cooperate and collaborate in the field?
- How did the thematic evolution of the field take place between 1982 and 2022? Also, how does this thematic shift provide a theoretical base for Fintech?
- How do the topics of interest on Fintech differ across countries?
- What are the most common topics on Fintech?

Bibliometric analysis enables the discovery of the distribution patterns of the literature by objectively and systematically determining the number of studies on a particular topic in the literature with various characteristics (Öztürk, 2021). It also describes the current state of scientific research and developments in the field, making it possible to identify the most prolific authors, the periodicals and periods in which publications are produced, the evolution of publications over time, the most influential papers in a study group, and the topics most closely related to the research question (Feng et al., 2015).

Therefore, bibliometric analysis (Ikpaahindi, 1985) was applied to identify the diversity of scientific literature on Fintech and to answer the above research questions.

1.1.1. Data Collection

Due to its scope, the Web of Science (WOS) database is frequently used for data collection in bibliometric and content analysis-oriented studies (Zhang et al., 2021). Therefore, during the publication identification phase, searches were conducted in databases indexed in WOS using preliminary definitions for search strings. The terms that were finally used were identified through different pilot searches in which multiple possible combinations of search strings and keywords were tested. Initially, the search process started with the term "Fintech" only, and then moved on to "factor" or

"determinant" or "antecedent" AND "fintech" or "FinTech" or "financial technology" or "financial innovation". However, as many of these keywords could be applied to different themes, the search was repeated with a different set of keywords consisting of finance-related terms. Finally, the expanded keywords that included finance-related terms are as follows:

"FinTech" or "Financial Technology" or "Financial innovation"

AND

"blockchain" or "bitcoin" or "P2P lending" or "robo advisory" or "Regulation Technology (Regtech)" or "startup" or "banking" or "crowdfunding" or "cryptocurrency" or "financial inclusion".

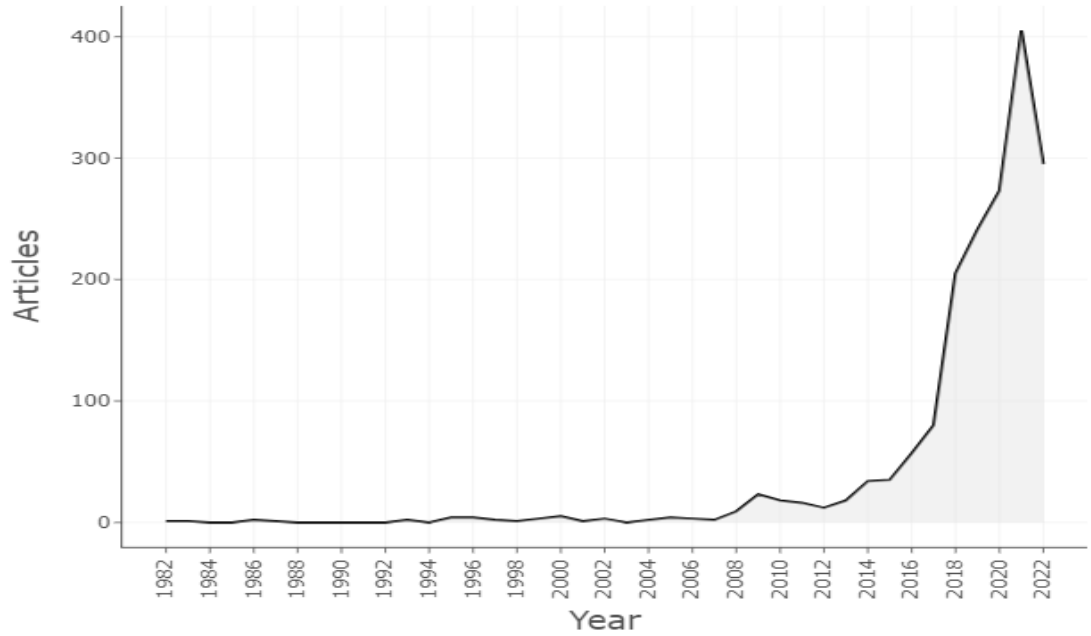
As a result of the specified search words, 1870 studies were found between 1982 and 2022. When the scope of the study was narrowed down to articles, book chapters and books, 1456 academic publications were obtained to be used in quantitative analysis. While 1319 of these studies consisted of articles, 137 of them consisted of book chapters and books.

Main Statistics about the 1982-2022 Fintech collection

Figure 1 shows the number of the studies on Fintech between 1982 and 2022. As can be seen, the number of publications on Fintech has increased since 2008.

Figure 1

The Number of the Studies on Fintech between 1982 and 2022



Source: Results obtained by author with a dataset from WOS via R Studio

The emergence of Fintech has been attributed to three main reasons: the widespread and effective use of technologies such as big data, cloud computing, ML, AI in finance (Gomber et al., 2017; Jagtiani & John, 2018), the existence of a new generation that is interested in technology and eager to adopt and use new technologies and finally, after the 2008 global financial crisis, the decline in customers' trust in traditional financial institutions and their inability to meet consumer demands as a result of the strict regulations imposed on them after the downturn (Jagtiani & John, 2018).

Concordantly, in parallel with Fintech applications, which have become widespread with the effective solutions they offer to the insecure environment created by the global financial crisis in the markets, there has been an increase in the number of publications after 2008. While the number of publications on Fintech was 20 between 2000 and 2007, this number increased to 31 in just two years, 2008 and 2009. These results reveal that an increasing number of researchers are interested in this particular research area and more and more relevant research results are being published.

1.1.2. Analysis

Scientific literature review and analysis within the scope of bibliometric analysis can help interested parties to more clearly understand the general research pattern and direction of a research field. In this way, research trends can be better tracked. Today, a variety of

software is available for bibliometric analysis, such as Bibexcel, Citespace, Histcite, Vosviewer, and Gephi. R Studio is software for the scientific analysis of big data and represents an easy-to-use bibliometric toolkit. Vosviewer was used to create scientific knowledge maps to clarify the relationship between information units. In this regard, among the bibliometric tools used in this study are R Studio and Vosviewer.

1.1.2.1. Author Analysis

Table 1

Top 10 Most Local Cited Authors on Fintech

Authors	Local Citations	Country	Organization
Kauffman, RJ.	108	Denmark	Copenhagen Business School
Gomber, P.	88	Germany	Goethe University
Parker, C.	88	United States of America	American University
Weber, BW.	88	United States of America	University of Delaware
Jagtiani, J.	77	United States of America	Federal Reserve Bank Of Philadelphia
Lee, I.	77	Switzerland	Western Illinois University
Shin, YJ.	77	South Korea	Hankyong National University
Hornuf, L.	71	Germany	University of Bremen
Thalor, AV.	61	United States of America	Washington University
Lemieux, C.	57	United states of America	Federal Reserve Bank of Chicago

Source: Results obtained by author with a dataset from WOS via R Studio

According to *Table 1*, Kauffma is the most cited researcher on Fintech, with 108 citations.

Kauffman's work focuses on the Fintech revolution and its disruptive impact on financial products and services. Gomber, Parker, and Weber are the other most cited researchers. The general feature of these studies, including different studies by Kauffman, Gomber, Weber, and Parker, is that they deal with the evolution, development, and ecosystem of Fintech in the field of finance. The joint work of Lee and Shin is one of the main and highly cited studies that present the Fintech ecosystem with all its actors and impact areas.

1.1.2.2. Affiliation Statistics

In addition to the most cited and most influential authors on Fintech, the journals of the articles are also listed. *Table 2* shows the top ten journals in the field of Fintech and the number of publications in these sources.

Table 2

Top 10 Most Relevant Sources on Fintech

Sources	Type	Articles
Financial Innovation	Journal	121
Sustainability	Journal	39
Journal of Banking & Finance	Journal	29
Journal of Risk and Financial Management	Journal	29
Rise and Development of Fintech: Accounts of Disruption from Sweden and Beyond	Book	26
Finance Research Letters	Journal	23
Handbook Of Blockchain, Digital Finance, and Inclusion, Vol 1: Cryptocurrency, Fintech, Insurtech, and Regulation	Book	22
Technological Forecasting and Social Change	Journal	19
Financial Innovation and Resilience: A Comparative Perspectıve on The Public Banks of Naples (1462-1808)	Book	16
Journal of Banking Regulation	Journal	16

Source: Results obtained by author with a dataset from WOS via R Studio

According to *Table 2*, Financial Innovation, which ranks first among the journals, is a leading journal on Fintech, ranking 8th in the Business, Finance category and 1st in the Social Sciences, Mathematical Methods category. Sustainability is a representative academic journal on sustainable development, which is related to environmental science and ecology (Zhang et al., 2021). Studies published in this journal generally focus on the relationship between fintech and sustainability (Vergara & Agudo, 2021).

In *Table 3*, the top 10 most locally cited articles on Fintech are included.

Table 3

Top 10 Most Local Cited Documents

Document	Journal	Local Citations	Global Citations	LC/GC Ratio (%)
Gomber et al. (2018)	Journal of Management Information Systems	88	248	35.48
Lee and Shin (2018)	Business Horizons	77	226	34.07
Gabor and Sally (2017)	New Political Economy	51	180	28.33
Thakor (2020)	Journal of Financial Intermediation	49	104	47.12
Haddad and Hornuf (2019)	Small Business Economics	43	124	34.68
Tang (2019)	Review of Financial Studies	41	103	39.81
Chen et al.(2019)	Review of Financial Studies	41	99	41.41
Milian et al. (2019)	Electronic Commerce Research and Applications	39	91	42.86
Jagtiani and Lemieux (2018)	Journal of Economics and Business	37	72	51.39
Leong and Sung (2017)	International Journal of Innovation, Management and Tech.	35	87	40.23

Source: Results obtained by author with a dataset from WOS via R Studio

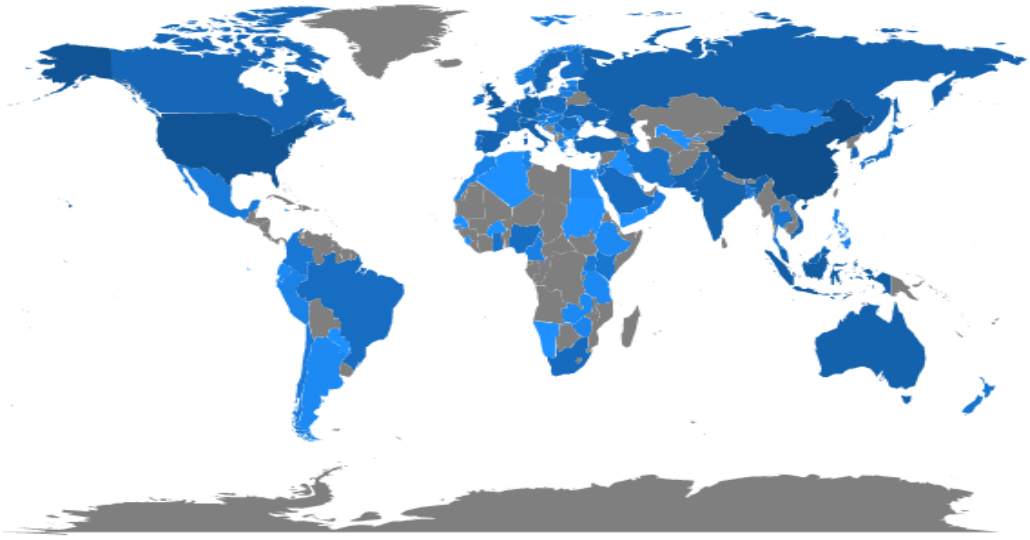
According to *Table 3*, Gomber et al. (2018) and Leong and Sung (2018), Chen et al. (2019) are among the ten most influential studies on Fintech and focused on the impact

of innovations such as cryptocurrency and blockchain on financial products and services, while Lee and Shin (2018) discussed the main factors that affect Fintech within the financial system, together with its ecosystem. However, Gabor and Sally's (2017) study on the impact of Fintech on financial inclusion stands out from the other papers in terms of the subject matter. In addition, Tang (2019), Jagtiani and Lemieux (2018) discussed the impact of P2P lending platforms on banking as a Fintech business model. Thakor (2020) and Milian et al. (2019) are among the influential studies that provide a detailed literature review on Fintech, starting from different definitions of it. Differently, Haddad and Hornuf's (2019) reveals the determinants of Fintech specifically for start-ups.

Figure 2 shows the geographical location of all countries that have contributed on Fintech. *Figure 2*, the number of publications decreases from dark blue to light blue, while the gray color indicates no contribution. The darker the blue on the map, the more articles the country or region has published.

Figure 2

Geographical Locations Contributing Countries



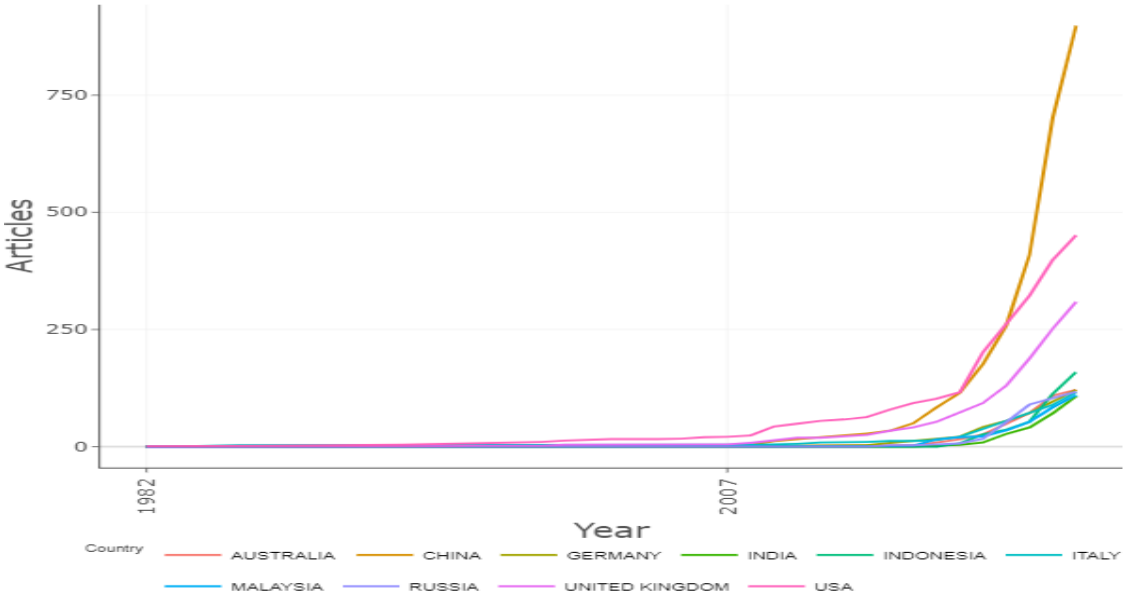
Source: Results obtained by author with a dataset from WOS via R Studio

According to *Figure 2*, China, is the country that has published the most articles with 960. China is followed by the USA with 473 articles and the United Kingdom (UK) with 335 articles. In addition, the fact that some countries in Europe (Germany and Italy, Spain) are at the top of the list shows that European countries are actively trying to participate in this research area. Other countries in Asia, such as India, Malaysia, Vietnam, South Korea, also have a remarkable position in this field. However, very little work has been done in Central Asia (e.g. Kazakhstan, Tajikistan) and Africa.

Figure 3 which is complementary to *Figure 2* shows the detailed number of academic studies of the top 10 countries on Fintech.

Figure 3

Countries Production Over Time



Source: Results obtained by author with a dataset from WOS via R Studio

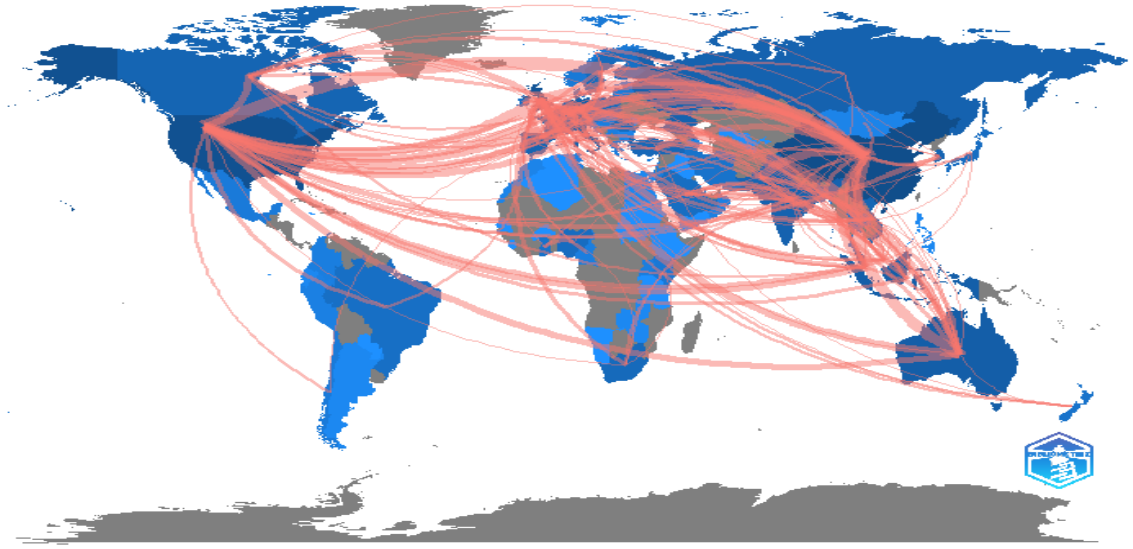
According to *Figure 3*, half of the top 10 countries are developing Asian countries, while the rest are developed European countries and the USA.

Nevertheless, the two most prominent countries that have long and continuously published on Fintech are the USA and the UK. After the 2008 crisis, Asian countries joined them.

In addition, *Figure 4* shows the country cooperation map.

Figure 4

Country Collaboration Map



Source: Results obtained by author with a dataset from WOS via R Studio

As can be seen from *Figure 4*, studies on Fintech are carried out through academic collaborations of researchers in different countries. In this respect, authors from China have 295 joint publications with authors from other countries; 50 of them are collaborations with authors from USA, 34 with authors from UK, 31 with authors from Australian and the remaining 180 are collaborations with authors in the remaining 47 different countries. China is followed by the USA with 186 collaborations and the UK with 167 collaborations.

1.1.2.3. Keyword Analysis

Figure 5 shows the word cloud obtained after analyzing 2578 keywords of 1456 articles with R Studio.

Figure 5

WordCloud of Fintech

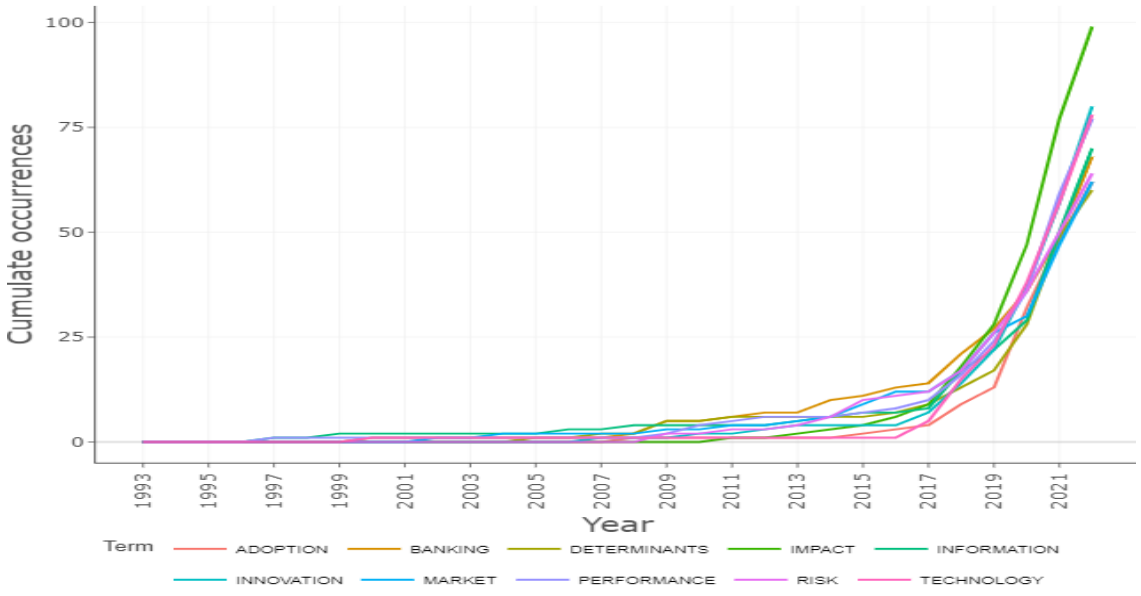
Source: Results obtained by author with a dataset from WOS via R Studio

Figure 5 reveals that "Fintech", "blockchain", "financial innovation", "financial inclusion" and "financial technology" are the five words with the highest frequency and also constitute the main scope of research in the field. "Bitcoin" is another area of research with high frequency. The emerging research areas such as bitcoin, crowdfunding, cryptocurrency may also indicate that developments in decentralized finance are prominent topics on financial technology and may be among the topics to be explored on Fintech in future studies.

In addition to the keyword analysis, *Figure 6* represents the timing analysis of keywords plus

Figure 6

Timing Analysis of Keywords Plus



Source: Results obtained by author with a dataset from WOS via R Studio

Unlike title and author keywords, keywords plus is another type of keywords analysis that further describe the content of the article by utilizing its references and help to obtain more comprehensive search results (Zhang et al., 2021). Keywords plus refers to words or phrases extracted from the title of references with the help of computer algorithms (Liao et al., 2019).

As can be seen in *Figure 6*, as a complementary keyword, "impact" emerged as the plus keyword with the highest frequency. However, the prominence of keywords plus such as "impact", "determinants", "performance", "adoption" may indicate that the adoption, impacts and determinants of technological innovations on finance are increasingly the subject of research.

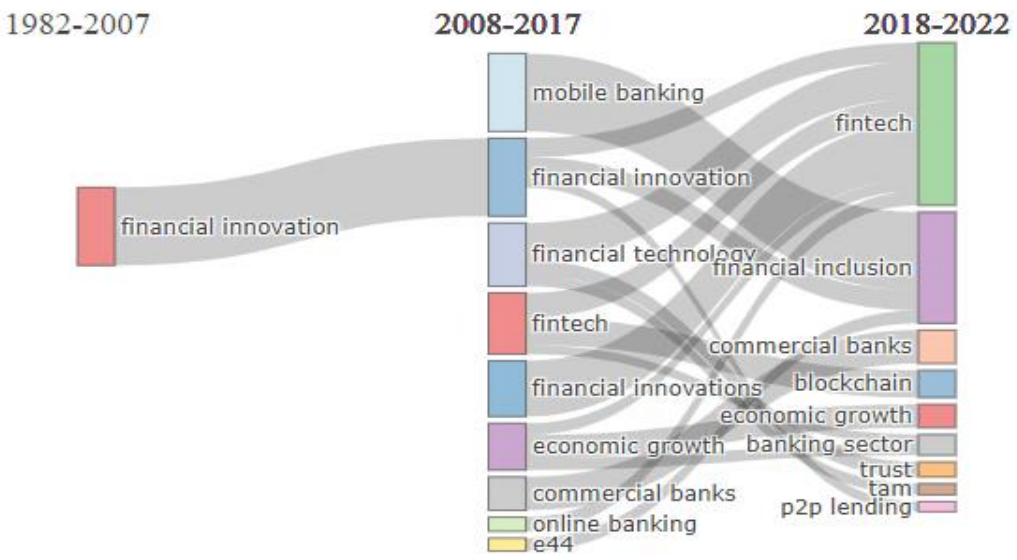
When keyword and keyword plus analyses are considered together, it can be stated that studies on the impact and determinants of financial technologies and innovations on financial inclusion in general and the impact of decentralized financial intermediaries in the financial sector will be among the research topics to be focused on.

1.1.2.4. Thematic Evolution

Thematic Evolution shows the time-wise evolution of research themes (Aria et al., 2020). In *Figure 7*, sankey diagram is used to show how different themes on Fintech have been combined and developed over the years 1982-2008, 2008-2018 and 2018-2022. The reason for choosing the years 2008 and 2018 is that these periods are the ones in which the GFC and the global pandemic and the development of Fintech experienced breaks.

Figure 7

Thematic Evolution on Fintech Through The Different Periods

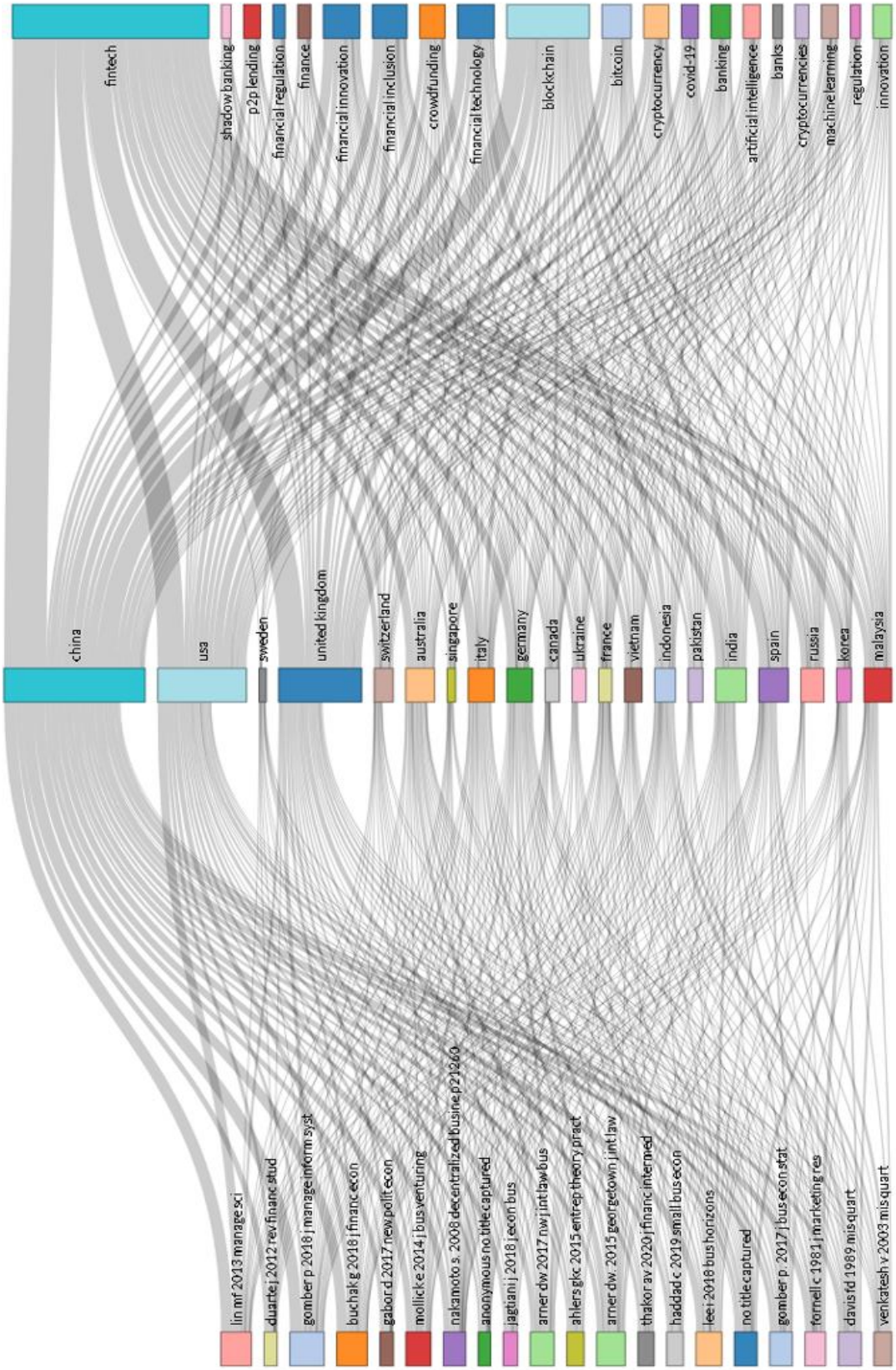


Source: Results obtained by author with a dataset from WOS via R Studio

The focus on Fintech in academic publications may also indicate the areas where countries need it, given the role of Fintech in filling the gaps of traditional financial products and markets. Therefore, a Three-Field-Plot analysis consisting of references, country and author's keywords is presented in *Figure 8*. As a result of the analysis, blockchain is seen as a common topic in China, USA, UK, India, Spain, Australia, Malaysia, Italy, Germany, Russia, Indenosia, Vietnam, Korea, Pakistan, Singapore, Sweeden, Canada, Ukrain.

Figure 8

Three-Field Plot (Reference- Country- Author's Keywords) of Fintech



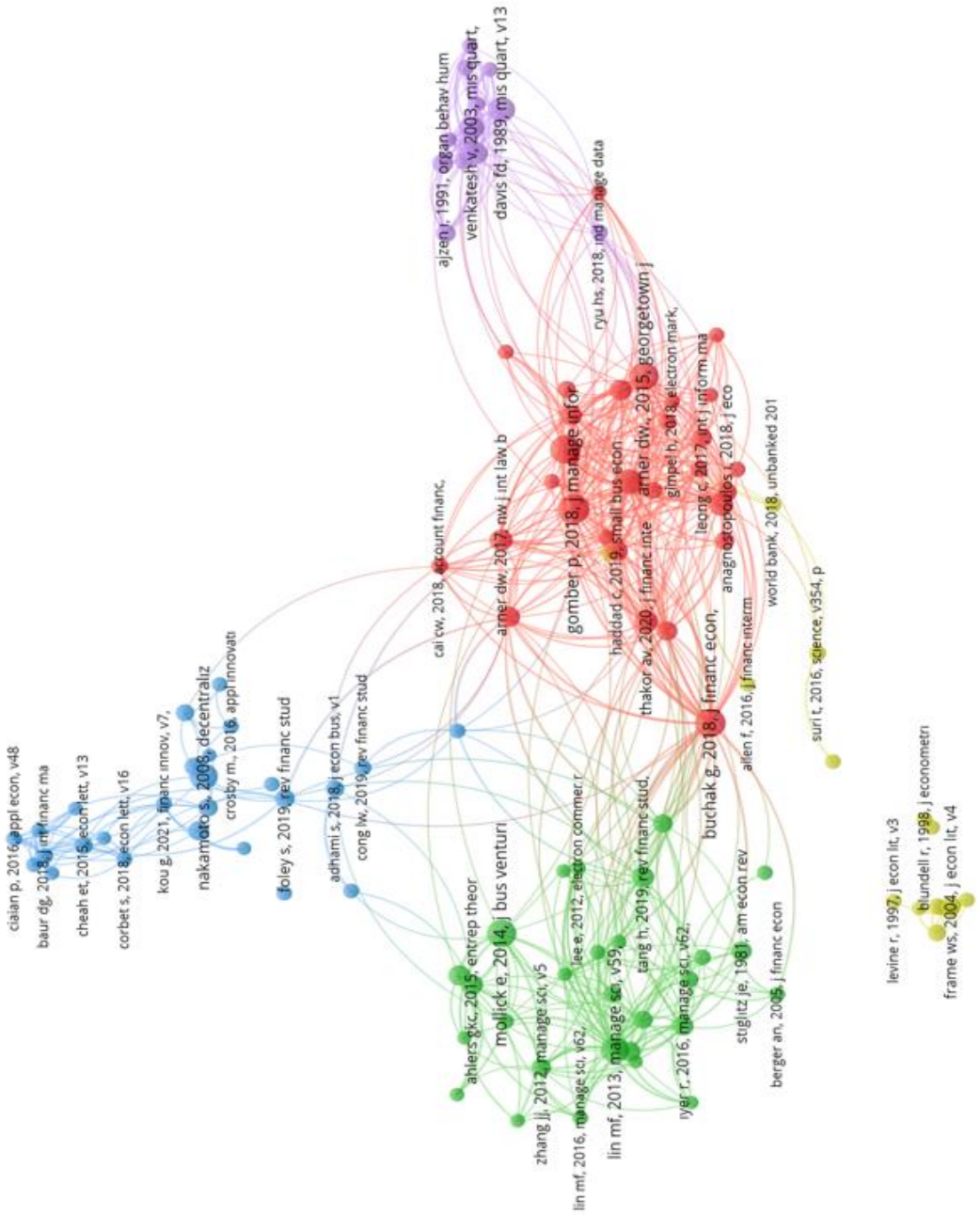
Source: Results obtained by author with a dataset from WOS via R Studio

1.1.2.5. Co-citation analysis

In 1973, American intelligence scientist Henry Small proposed co-citation analysis in his article titled "Co-citation in the scientific literature: a new measure of the relationship between publications" (Small, 1973). Co-citation refers to two studies included together in the reference list of a third cited article. Together, these two studies form a co-citation relationship. Therefore, co-citation analysis is accepted as the comparison of a set of spatial data obtained from studies to reveal the co-citation relationship in the literature of a particular field (González-Alcaide et al., 2016). Co-citation analysis can also reveal the focus areas of the literature in terms of content and the core, classical literature on a given topic. However, it is an effective analysis in terms of revealing the academic impact of the references. Co-citation analysis at Vosviewer includes correlation analysis of cited authors, cited references, and cited sources. *Figure 9* shows the co-citation analysis diagram of cited authors.

Figure 9

Co-Citation Network of Cited Authors



Source: Results obtained by author with a dataset from WOS via R Studio

While the Co-citation network in *Figure 9* reveals the driven publications and authors in the literature, it also reveals the prominent topic clustering. The network indicated in red refers to studies that show the concept of Fintech, its evolution, ecosystem, impacts and determinants. Among the studies in this category; Gomber et al. (2018), Arner et al. (2015), Thakor (2020), Haddad and Hornuf (2019)and (2018) stand out as the most cited studies. Secondly, the network, which is expressed in green, also indicates the studies on crowdfunding. In this field, Mollick (2014), Iyer(2016), Lin and Viswanathan (2013) and

Tang (2019) are among the studies with high academic impact. The area outlined in blue shows the studies on blockchain technology and cryptocurrency, bitcoin, which are among the most popular topics on Fintech, and the studies with high academic impact in the field. In addition, Nakamoto (2008), Foley et al. (2019), Baur et al. (2018), which are considered as the main articles in the field of blockchain technology and cryptocurrency, are the prominent studies. In the network shown in purple, there are articles on the adoption and acceptance of Fintech, which Fintech studies have recently started to address frequently and Davis et al.(2017) and Venkatesh et al. (2003) are among the main articles. Finally, the studies in the network identified in yellow are studies on financial innovation and Frame &d White (2005) being the most cited publication in the group

As a result of the findings obtained from the bibliometric analysis, based on *Figure 2* and *Figure 3*, it is seen that in addition to the developed European countries and the USA, developing Asian countries such as China, India, Vietnam, Malaysia, Indonesia come to the forefront considering the ranking of countries conducting research on Fintech.

Especially *Figure 3* shows that financial technologies, which were the subject of studies in a few countries such as the USA and the UK until the 2008 global financial crisis, turned into a field of study in which many countries from Europe and Asia were involved after 2008. Arner et al.(2015) reveals that the development phases of Fintech from past to present, the phase we are experiencing today, which is described as Fintech 3.5, took place under the leadership of developing Asian countries. According to Arner et al. (2015), the characteristics that have emerged in Asian countries since 2008, such as a strengthening middle class, a large young population, increasing demand for financial technology based products and competition, make these countries increasingly prominent in the development of Fintech. As a result of the bibliometric analysis on Fintech, the fact that Asian countries, together with European Union (EU) countries and the USA, are becoming more prominent and can be considered as supporting the Fintech 3.5 phase that Fintech is currently in.

In the meantime, the free movement of capital, labor and goods brought about by globalization has enabled finance to the forefront as one of the areas most affected by globalization. Fintech has become an area of interest for an increasing number of researchers globally with the solutions it provides. In this regard, as a research area in which EU countries, the USA and Asian countries cooperate intensively, it is a field of study in which researchers from different countries and continents show common interest.

Fintech is influential on different fields of study, from credit, money transfer, supply chain financing to financial inclusion. A "timing analysis of keywordplus" *Figure 6* was conducted to analyze the keywords of existing studies *Figure 5* and the change in study subjects over the years *Figure 6.* As a result of these analyzes, blockchain, bitcoin, cryptocurrency, crowdfunding, P2P lending are the keywords with high frequency. These topics also show that the studies on Fintech focus on decentralized financial instruments. In this respect, it can be said that today's Fintech studies focus on the development of financial products and services where intermediaries are eliminated, along with the areas that improve the performance of traditional intermediary institutions. These results can also be supported by emphasizing the distruptive and sustainable features of Fintech innovations.

In addition, based on *Figure 6* as a complementary keyword, "impact" emerged as the keywords plus with the highest frequency. Nevertheless, according to *Figure 6***,** while keywords such as "banking", "innovation", "risk" were prominent until 2019, the emergence of keywords plus such as "impact", "determinants", "performance", "adoption" as of the 2019 global pandemic can be stated that studies on the adoption, impact and determinants of technological innovations in finance have become increasingly important research topics under the influence of the measures limiting daily life introduced by the global pandemic.

Besides, *Figure 8* represents the study areas and studies in which countries are concentrated on Fintech in a triple figure. As a result of the analysis in question, blockchain stands out as the common topic on which countries with different levels of development from different continents such as China, USA, UK, India, Spain, Australia, Malaysia, Italy, Germany, Russia, Indenosia, Vietnam, Korea, Pakistan, Singapore, Sweeden, Canada, Ukrain have put forward the most studies of Fintech.

The “Thematic Evolution Analysis” in *Figure 7***.** shows the evolution of Fintech research themes between 1982 and 2022. The Thematic Evolution Analysis has also been helpful in determining the theoretical framework of the study. Between 1982-2007, "financial innovation" emerged as the only theme. In line with this result, in the thesis, the theoretical framework on which Fintech is based is first discussed within the scope of innovation theories and then financial innovation theories are emphasized.

As mentioned before, the 2008 GFC was a breaking point in the development of Fintech. After the 2008 global financial crisis, themes such as mobile banking, online banking,

economic growth, financial technology were added to the theme of Fintech studies. Financial intermediaries, which stand out on the axis of banking in Fintech studies, paved the way for Fintech to be considered within the scope of financial intermediation theories.

Between 2019 and 2022, when the global pandemic, which is considered as another global crisis affecting the development of fintech, was effective, themes on the adoption and effects of fintech came to the fore. In this period, the themes of studies on mobile banking evolved into financial inclusion, and the themes of studies on financial technology evolved into trust and Technology Acceptance Model (TAM) in relation to blockchain, P2P lending and adoption of financial technologies.

In addition, financial inclusion, which is the most important impact of Fintech, stands out as another important issue that countries emphasize. Crowdfunding and P2P lending, on the other hand, are important in terms of meeting the demands of users of financial products with low credibility but in need of financing, which cannot be met by traditional financial institutions. The fact that P2P lending and crowdfunding became prominent issues especially in the UK and the USA after the 2008 global financial crisis emphasizes the compensatory nature of these products in the markets

Therefore, as part of the thematic evolution analysis, the theoretical underpinnings of Fintech are discussed with respect to innovation theories, financial intermediation theories, TAM model and financial inclusion.

1.2. Theoretical Framework of Fintech

1.2.1. Innovation Theory

Fintech has emerged with the use of technological innovations in finance in order to make existing financial products and services less costly and more efficient (Breidbach et al., 2020). Concordantly, Fintech is considered as a technology-based financial innovation that increases the efficiency of existing financial products and services and is the main driver of industrial evolution (Gomber et al., 2017).

Until the 2008 crisis, financial innovations were highlighted by their positive effects on economic growth and financial markets (Finnerty, 2001; Levine, 1997; Merton, 1992; Shiller, 2013). However, in and after the GFC, innovations on financial technology, together with their triggering effects, have begun to be reconsidered in two different

dimensions, namely their functions, uses, and regulations that reduce the negative effects of the crisis (Boz & Mendoza, 2014).

Today, financial innovation, which comes to the fore again with the concept of Fintech, makes it necessary to define the concept of financial innovation. In general, financial innovation can be defined as the innovation that is put forward depending on the technological progress in finance (Frame & White, 2005). The widespread use of financial technologies today brings along the necessity of theoretically presenting innovation in general and the emergence of innovation in finance.

One of the most important problems in innovation studies has been the definition of innovation (Kahn, 2018; OECD, 2008). Definitions of innovation from different aspects have been discussed in much different theory and practice-oriented studies (Garcia & Roger, 2002; Hauser et al., 2006; Kahn, 2018; OECD, 2008). Blach (2011) defines innovation as the introduction of a new product and service combination with a high-added value that will contribute to the overall growth of the economy by using technology-intensive methods. In this regard, it can be stated that financial innovation is based on technology. Technology, on the other hand, is defined by Sironi (2016) as the process of transforming information, data, human resources, and economic capital into high-value added products or services with high added value by an enterprise.

Based on these definitions, when innovation is considered as a process, it refers the stages of developing, producing, and presenting a new product with high added value to the market, and if it is considered as a result, it is defined as the introduction of a new product, service or business model (Garcia & Roger, 2002; Hauser et al., 2006; Kahn, 2018). However, the broadest definition of innovation with its different dimensions was first introduced by Schumpeter, who emphasized that innovations are the main driving force and engine of economic development.

Schumpeter (1983) defines innovation as a continuous mutation in which the old is constantly replaced by the new. In general, Schumpeter exhibited his innovation theory on the combination of technology and economy and used the concept of mutation from biology terminology to refer to the reformist power of technology that triggered a change in the economy and destroyed the old (Blach, 2011).

According to Schumpeter's definition, there are five dimensions of innovation that form the basis of development; new products, new production methods, new markets, new

sources of raw materials, inputs or semi-finished goods, and new industry structure (Dabic et al., 2013; Śledzik, 2013). Schumpeter argued that innovation is the driving force behind economic development and promotes industrial and economic structural changes. In later studies, Schumpeter's theory of innovation was discussed with an emphasis on the relationship between technological innovation and industrial evolution (Dabic et al., 2013).

The most comprehensive studies on innovation have been conducted within the OECD, and the results of the study have been compiled in the handbook known as the Oslo Manual. Based on Schumpeter's explanation, OECD reintroduced the concept of innovation focusing on four categories: product, process, marketing, and business organization (OECD, 2008). The Oslo Manual defines innovation at the firm/enterprise level. In other words, when a firm introduces a new practice for itself (even if that application is already being implemented by firms in the same or other sectors), this is considered an innovation. Innovation in the OECD/Eurostat (2018) Oslo Manual, a global guide to obtaining knowledge and data on innovation defines innovation as "a new or improved product or process (or a combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)". According to this definition, innovation include all activities that result in developmental, financial, and commercial innovation by the firm. The part of innovation that focuses on the production process and deals with the dimension of new products or business processes developed based on innovation that differs significantly from the previous products and business processes of the firm referred to as business innovation (OECD/Eurostat, 2018).

Nonetheless, Baumol (2002) defines innovation as a complex process with multiple actors and takes Schumpeter's definition further by stating that it can be incremental or distruptive in nature. Bessant (2015) uses the term "knowledge spaghetti" for innovation, stating that commercialization, diffusion, adoption and widespread use are necessary for innovation to gain value. These general innovation concepts are important in that they influence the definitions of financial innovation in the literature and the classification of it (Khraisha & Arthur, 2018).

The most distinctive feature of the modern financial system is that while technology-oriented products and processes improve current operations, disruptive innovations rapidly change the system and technological innovations are the basis of this development

(M. Yao et al., 2018) Technological innovation is defined by Dosi (1988) as solving problems with formal knowledge gained from previous experiences. Laeven et al. (2015), on the other hand, state that technological innovations and financial innovations develop over time depending on each other. While this means that financial innovations provide the necessary resources to finance technological innovations, it also indicates that the advancement in technology provides new products and services that financial institutions need (Junior & Cherobim, 2019). Thus, technological innovations and financial innovations seem to be interconnected.

The definition of financial innovation is closely related to the classification of financial innovation (Oke, 2006). The starting point of the classifications in the literature is the proposition that financial innovations are categorized under two main groups as product and process innovations (Barras, 1990; Bátiz-lazo & Woldesenbet, 2006; Oke, 2006). Product innovation is defined as new products and services developed to meet the needs and demands of financial markets and participants, and is market and consumer oriented (Ettlie et al., 2014). Process innovation, on the other hand, entails new ways or changes in the way financial activities are carried out (Oke, 2006). Unlike product innovation, organization is at its center (Bátiz-lazo & Woldesenbet, 2006).

Another important approach in defining financial innovation is the functional approach (Nejad, 2022). According to this approach, in order to define financial innovation, the basic functions of the financial system should be emphasized (Merton, 1992; Nejad, 2022). Nejad(2022) underlines 4 main functions of the financial system: transfer of resources across time and space, obtaining resources, risk management and collection of information in the market to eliminate information asymmetry. The main objectives of the financial system within the markets are to reduce transfer costs, pricing and distribution of risk, liquidity management, providing credit and fund formation, insurance, asset management, funding of financial institutions and equity generation (Khraisha & Arthur, 2018; Nejad, 2022).

Based on the objectives of the financial system, a broader set of six basic functions are emphasized to define financial innovation (Finnerty, 2001; Merton, 1992). These are;

- moving funds across time and space
- collection of funds
- risk management

- bringing together decision-making information beyond time and space
- reduction of moral hazard and asymmetric information problem
- facilitating the purchase and sale of goods and services with payment systems.

In order for an innovation to be defined as a financial innovation, the emerging technologically-based innovation must have an efficiency-enhancing and/or radically changing or cost-reducing effect in at least one of the six core functions (Khraisha & Arthur, 2018). In this regard, Nejad (2022) defines financial innovation as the development, promotion, and management of a product, process, business model or technology to improve and/or change one or more of the six core functions of the financial system mentioned above.

As another approach, Llewellyn (2009) divides financial innovation into four main categories as defensive (in terms of regulation and policy), aggressive (introduction of new creative products into the market), responsive (creation of new instrument or service to meet customers' demand) and protective (adoption of new technological instruments due to the constraints of institutes).

The definition of financial innovation within the framework of the functional approach focuses more on securities innovations (Nejad, 2022). In addition, financial innovations can be introduced by traditional financial institutions in the financial system, or they can be developed by technology firms and startups that are not in the sector (Guidotti, 2017; Khraisha & Arthur, 2018; Laeven et al., 2015). However, all the approaches assume that financial innovations come only from financial institutions and ignore the fact that the majority of innovations come from non-financial institutions as is the case today (Arthur, 2017).

With based on theoretical framework, financial innovation is defined as the creation and dissemination of new financial products, regulations, processes, markets, and institutions based on technology in line with the demands and needs of financial participants (Arthur, 2017; Frame et al., 2019; Lerner & Tufano, 2011).

However, this definition considers financial innovation only as products and services offered by financial institutions, and in this respect, it is insufficient to present financial innovation with its current broad perspective (Mention & Torkkeli, 2014). In this regard, Karisha and Arthur (2018) define financial innovation as a process that can be carried out by any institution and involves the creation, introduction, and adoption of new products,

platforms, processes, or enabling technologies that bring new ways or changes to the way a financial activity is run. While the this definition refers to both sustainable and disruptive aspects of financial innovation, it also includes the argument that financial innovation does not necessarily come from financial institutions, and that innovations such as Blockchain, PayPal, etc. are all financial innovations from non-financial institutions. Karisha and Arthur (2018) not only limit financial innovation to innovations in the securities or financial instruments segment but also povide a definition that includes all financial innovation types, including Fintech applications, which are increasingly effective today.

The theoretical aspect of financial innovation is discussed concerning both demand and supply (Dharmadasa, 2021). When considered from the supply side, the basic foundation of financial technology is the spillover and development of technical knowledge (Kauffman et al., 2015). Innovations introduced by enterprises in finance can be aimed at improving existing processes or new applications based on the production of new technologies (Tornatzky and Fleischer, 1990). The new financial applications that emerge with the production of new technologies are also important because they drive the technological transformation and have a distruptive effect in the sector (Currie & Seltsikas, 2001). Considering this aspect, the basis of the supply-side theory of financial innovations is to give businesses a competitive advantage (Dharmadasa, 2021). Technological innovation benefits innovators and adopters as well as the general market (Frame & White, 2005).

It supports financial innovation in terms of demand by fueling the need for new financial instruments and institutions with the effect of convenience, new job opportunities, and economic growth brought by technological innovation (Laeven et al., 2015; Lerner & Tufano, 2011; Nejad, 2022; M. Yao et al., 2018). The demand-side theory of financial innovations, imperfect financial markets, is based on the view that the existence of asymmetric information and transaction costs is the main reason for the development of new financial products and services (Fabozzi & Modigliani, 1995). The aforementioned deficits of the markets constantly lead the market participants to seek solutions, however, changing customer demands push businesses to develop innovative tools with new solutions (M. Yao et al., 2018). Today, many Fintech instruments such as widely used internet and mobile banking, online payment systems, and digital lending platforms have emerged as demand-sensitive innovations that reduce transaction costs (Dharmadasa,

2021). In addition, financial innovations aim to provide products and services to consumers and are adopted by financial institutions with innovations such as customer relationship management systems, leading to significant developments in the basic functions of the financial system (M. Yao et al., 2018). Financial innovations support customers who receive financial products and services, as well as consumers who cannot receive service or receive inadequate service (Nejad, 2016). While low-cost solutions such as crowdfunding and peer-to-peer lending provided by financial innovations increase financial inclusion, they also enable the population that cannot reach financial services effectively to benefit from financial products and services (E. Berger & Nakata, 2013; Martin & Parigi, 2013; Nejad, 2016).

Another important study on the classification of innovations was conducted by Henderson and Clark (1990). In this study, after emphasizing that the change in a system (product, process or organization) can be made at the level of components/core concepts or system/linkages, it was determined that there can be four types of innovation as incremental innovation, architectural innovation, modular innovation and radical innovation according to the change at these two levels.

An incremental innovation is defined as one in which a component changes, its quality improves, but there is no change in the system or in the relationship between components. Radical innovations are the result of both the development of new components and a change in the system architecture. In modular innovations, there is no change in the system, but a component that performs a specific function is replaced. Architectural innovation is defined as minor innovations and stylistic changes without any change in the basic skeleton of a product. These small innovations are reshaping the sector by causing big changes.

Christensen and Bower (1996) indicate the concept defined as architectural innovation as sustainable innovation and distinguish it from disruptive innovation as a new concept. Sustainable innovation enhances the performance of the product by improving the existing dimensions without changing the basic dimensions of the products (Weeks, 2015). Sustainable Innovation refers to small technology-based changes in existing products and services to support the continued dominance of established businesses in the sector (Christensen & Bower, 1996; Weeks, 2015).

In this theoretical framework, while financial innovations can be categorized as disruptive innovations, new developments that preserve the market position and improve the

financial situation as a new risk management tool can also emerge as sustainable innovations (Błach, 2011).

Disruptive innovation was first introduced by Christensen (1996). Although the disruptive innovation approach is a product and technology-oriented approach, it initially focused on emerging technologies (Sironi, 2016). Subsequently, the approach was expanded to include services and business models (Junior & Cherobim, 2019). Herein, disruptive innovation is an approach that refers to innovations that take advantage of technological advances, causing disruptions and radical changes in the existing technological paradigm and business routines, increasing competition and causing changes and shifts in consumer behavior towards products and services (Christensen & Bower, 1996; Elia et al., 2022; Tajudeen et al., 2022).

Disruptive innovation is a technology that destroys the status quo by initiating radical economic changes and transformations in the current system and markets, displacing established market founders and leaders, services and products (Schueffel, 2017). When disruptive innovations are introduced, businesses that are already leaders in the market find themselves in serious competition. With these aspects, destructive innovations have the effects of increasing competition in the sector (Danneels, 2004). Concordantly, disruptive innovations become effective and dominant and change the processes and consumer preferences in the sector, while forcing the existing traditional financial institutions to change, ensuring the permanence and continuity of the change they create (Arief et al., 2020).

Three important developments enable financial innovations to be evaluated as disruptive (Junior & Cherobim, 2019). The first of these is that the majority of financial innovations are developed by technology-oriented companies and Fintech start-ups outside of the traditional financial industry (Brown & Piroska, 2022). Secondly, the increasing demand for technology-based financial products of millennials and generation Z, who are highly interested in technology, adopt and demand technological products (Cojoianu et al., 2021; PwC, 2019). The last critical development is the expansion of the financial sector out of certain cities and centers where it is concentrated, spreading to America, Europe and Asia (Nejad, 2022).

Fintech as a financial innovation has emerged through the use of technological innovations in financial transactions in order to make existing financial products and services less costly and more efficient (Breidbach et al., 2020). In this regard, Fintech is

considered as sustainable innovation as an innovation that increases the efficiency of existing financial products and services (Breidbach et al., 2020; Sironi, 2016). However, with the global financial crisis, the significant loss of trust in traditional financial services and service providers has led to a significant change in the function of Fintech in the financial system (Junior & Cherobim, 2019).

Based on the impact of Fintech in today's financial system, Philippion (2016) argues that Fintech should be conceptualized within Christensen's (2006) view of distruptive innovation (Breidbach et al., 2020; Muzellec et al., 2015). Furthermore, Arner et al.(2015), refer to Fintech applications as a disruptive innovation in their definition of Fintech. According to this definition, Fintech is defined as the development process in the financial sector of innovations with different disruptive effects such as internet banking, mobile payments, robo-advisory, peer to peer lending, which emerged as a result of the combination of finance and technology.

Similarly, Fintech is considered a disruptive innovation as digital technologies such as big data technology, cloud computing, AI, robo-advisory, DLT, ML, which have emerged based on technological progress, have radically changed the traditional financial system with products and services such as payments, asset management, insurance, legal regulations, consumer preferences and all competitive business dynamics (Elia et al., 2022; Financial Stability Board, 2017; Shaydullina, 2018). These financial innovations have played an important role in the business world and in the daily lives of consumers by differentiating traditional financial products and services. In this conceptual dimension, Fintech is a new sector that is described as “innovative” and “disruptive” with start-ups that are the pioneers of technological innovation in the finance industry and technology companies such as Apple and Microsoft that have not been in the industry before, and new business models and services offered by them (Basole & Patel, 2018; Micu & Micu, 2016).

1.2.2. Financial Intermediation Theory

Financial intermediaries, as traditional definition, are specialized financial institutions that bring together lenders and borrowers with different preferences according to the amount of funds invested and borrowed, financial commitment and maturity characteristics (Hasman et al., 2014; Huebner et al., 2019). According to Arrow-Debreu's resource allocation model, the absence of a complete and perfect market conditions

necessitate the financial intermediaries (Allen & Santomero, 1998). Financial intermediation is based on the critical functions of financial intermediaries in the allocation of capital in the presence of financial information, transaction costs and market imperfection (Demir et al., 2022).

Imperfect market conditions imply asymmetric information sharing among market participants and high transaction costs (Haas et al., 2015; Huebner et al., 2019). Information asymmetry refers to the situation where one party in a commercial transactions has more information than the other. Therefore, the information between the parties is not symmetrical. Asymmetric information can lead to undesirable consequences such as adverse selection and moral hazard. (Brealey & Stephen, 1977; Diamond, 1984; Holmstrom & Tirole, 1997).

Traditional financial intermediation theory is based on the presence of asymmetric information and transaction costs in the market (Fama, 2012; Stiglitz & Weiss, 1982) . Financial intermediaries help reduce information asymmetry by reducing the costs of financial transactions (Huebner et al., 2019). The fact that financial intermediaries undertake the function of bringing together funders that enables them to play a critical role in economic growth and development through the conversion of funds into investment (Hasman et al., 2014). Moreover, financial intermediaries enable risk-averse actors to be included in the market by sharing the risks of individual lenders and borrowers through different measures such as intertemporal smoothing and hedging against the non-diversifiable risk (Allen & Santomero, 1998). Financial intermediaries bring flexibility to the market by causing asset transformations in their features such as maturity, liquidity, risk, and divisibility (Hasman et al., 2014).

In a word, financial intermediaries play an important role in reducing the problem of asymmetric information in an imperfect market conditions, increasing the accessibility of financial services by reducing transaction costs, and thus increasing access to financial markets by ensuring that participants who do not have sufficient financial information and opportunities are included in the market (Haas et al., 2015)

There are three main critical functions that financial intermediaries undertake in the financial system. These are reducing information asymmetry, asset transformation according to maturity, liquidity and risk, and reducing transaction costs (Huebner et al., 2019). Within the scope of financial intermediation, the fact that Fintech can be considered as an innovation that reinforces traditional intermediation functions and/or

eliminates traditional intermediaries with its distruptive effect is closely related to the innovations in the 3 basic functions undertaken by financial intermediaries (Dharmadasa, 2021; Huebner et al., 2019). *Table 4* shows the impact of Fintech on the three main critical functions of financial intermediaries in the financial system.

Table 4

Three Functions of Financial Intermediaries and Fintech

Category	Examples for Implementation by FinTechs
Transaction Costs	• Assessment of crowdfunding projects' likelihood for success through manual vetting • Continuous, automated checks of a customers' asset portfolio, with alerts for critical events and rebalancing suggestions. • Investment advice by a robo-advisor, based on the user's risk profile • Crowdfunding or peer-to-peer lending platforms that legally pursue participants who fail to honour their part of agreements • Aggregation of multiple bank accounts and stock portfolios in a unified dashboard • Automated provision of personalized investment advice through computerized recommendation systems to customer segments previously excluded from such services
Information Asymmetry	• Investment advice provided by market experts whose interests are fully aligned with those of their customers, e.g. by advice-neutral and / or directly performance-dependent compensation of advisors • Lending marketplaces that allow borrowers and lenders to independently specify the timeframe of their loans / investments
Asset Transformation	• Crowdfunding platforms that split up project goals into smaller chunks, thus allowing investors to participate to a much larger project with a small investment • Crowd-investing platforms that enable third parties to invest in early-stage startups, which is otherwise a hardly accessible and tradeable type of asset •Real-estate investment companies that allow for a multitude of small investments into properties with a variety of different risk-reward profiles

Source: Huebner et al.(2019)

In the scope of financial intermediation, Fintech can be evaluated in two different ways. First, Fintech are innovations that play an important role in supporting the functioning of the existing financial system and addressing its shortcomings, often benefiting traditional financial intermediaries and even encouraging its development as a factor that increases efficiency (Huebner et al., 2019). In this case, Fintech is considered as an element that supports and makes existing traditional financial intermediaries and their functions more efficient without destructively eliminating them (Dharmadasa, 2021). Second, Fintech applications often act as a new type of intermediary while eliminating existing financial intermediaries with their more competitive pricing and efficient user experience (Domowitz, 2002; Huebner et al., 2019) Fintech instruments such as P2P lending applications and crowdfunding are emerging as a new type of financial intermediary in

the sense that they fulfill the fund-seekers and fund-demanders in a way that eliminates traditional banks as a third party and an important function undertaken by them (Riasanow et al., 2018).

This can also be referred to as financial disintermediation (Zhang et al., 2022). In general, financial disintermediation refers to a situation in which direct financing replaces indirect financing, allowing those who demand and those who supply funds to come together without a third party, eliminating financial intermediaries (Hester, 1969; Zhang et al., 2022).

In general, financial disintermediation that eliminates financial intermediaries takes two forms: capital driven disintermediation and technology driven disintermediation (Zhang et al., 2022). Capital driven disintermediation refers to the direct financing of enterprises by issuing securities (Zhang et al., 2022). Technology-driven disintermediation, on the other hand, refers to situations where direct financing is provided by eliminating the intermediation provided by third parties through technological innovations (Wang et al., 2018). Fintech applications encourage technology driven disintermediation by creating more flexible, efficient, low-cost financing models for financial participants (Zhang et al., 2022).

It has been demonstrated by many different studies that fintech come to the forefront as they eliminate different fucntions of traditional financial intermediaries (Boot et al., 2021; Ding et al., 2022). These studies show that Fintech applications have taken on many functions of intermediary institutions, have become new competitors of traditional financial institutions and eliminating information asymmetry among businesses, especially Small and Medium Size Enterprises (SMEs), and have demonstrated that they support economic growth by providing financial support to SMEs, investors with low credibility, and R&D expenditures.(Ding et al., 2022; Zhang et al., 2022) .

1.2.3. The Technology Acceptance Model

According to *Figure 4*, "adoption", "impact" and "effect" are the prominent keywords in the studies on Fintech between 2018-2022. Between 2019 and 2022, when the global pandemic, which is considered as another global crisis affecting the development of fintech, was effective, themes on the adoption and effects of fintech came to the fore. In this period, the themes of studies on mobile banking evolved into financial inclusion, and

the themes of studies on financial technology evolved into trust and TAM in relation to blockchain, P2P lending and adoption of financial technologies.

In parallel with this, according to the Thematic Evolution on Fintech through the different periods in *Figure 5*, Fintech is theoretically structured around the Technology TAM during these periods.

TAM was first proposed by Davis(1989) and has become one of the most widely cited models in the field of adoption of information technologies, products, services and processes.

The basic idea behind TAM is that the acceptance and use of technology is determined by two key factors: perceived usefulness and perceived ease of use (Meyliana et al., 2019). Perceived usefulness refers to an individual's belief that using a particular technology will improve job performance or overall quality of life (S. Singh et al., 2020). Perceived ease of use refers to the individual's perception of the technology's ease of use and confidence in being able to use the technology effectively (Meyliana et al., 2019).

Based on TAM, these two factors play an important role in shaping the user's attitude towards technology and intention to use it. The model suggests that perceived usefulness and perceived ease of use will directly influence an individual's attitude towards technology, which in turn will influence actual usage behavior (Hu et al., 2019).

1.2.4. Fintech and Financial Inclusion

Although financial innovations increase efficiency and effectiveness in the financial system, their impact on economic development, growth and living standards is driven by their widespread use and adoption (Kanga et al., 2022; Scott et al., 2017).

The effect of the adoption and widespread use of Fintech applications not only remains within the financial sector but also offers important opportunities that can raise the living standards of households (Demir et al., 2022). In this regard, Comin (2010) revealed that 25 percent of Gross Domestic Product (GDP) differences between countries are due to differences in the widespread use and adoption of financial innovations across countries. Financial systems play a critical role in transforming savings into investments to promote technological diffusion as well as financing entrepreneurship and Research and Development (R&D) (Kanga et al., 2022)). When this relationship is considered in terms of improving living standards, financial inclusion comes to the fore (Demir et al., 2022).

In standard models of financial inclusion, approximately 1.7 billion people over the age of 15 are excluded from the financial system, assuming that everyone is registered with a bank (WB, 2018). According to the World Bank's Findex Report (2021), 76 percent of adults globally will have an account with a bank, credit union, microfinance institution or mobile financial services institution. This rate has increased by 50 percent in the last decade, from 51 percent to 76 percent, since the Global Findex database was launched in 2011. However, from a different perspective, institutions, organizations and governments within the financial system are unable to include the savings of 30 percent of the world's adult population in the system to be converted into investments due to reasons such as high transaction costs, access to financial services, distance, and difficulties in obtaining identity information (Demirguc-Kunt et al., 2018; Senyo et al., 2022). Today, there is still a large population in developing countries that lack access to financial services and products (WB, 2018).

In the theoretical framework, imperfect market implications such as asymmetric information and transaction costs limit financial participants' access to financial products and services (Banerjee & Newman, 1993; Galor & Zeira, 1993). Limited access to instruments and intermediary institutions necessary for saving, investing and raising funds has a poverty-increasing effect by lowering the standard of living (Allen, 2021; Demirguc-Kunt et al., 2018). Galor and Zeira (1993) show that high transaction costs and asymmetric information constrain low-income households' access to funds to cover education expenses. In many studies where financial inclusion is defined as accessibility, availability and utilization of financial services, the mitigating effect of financial inclusion on income inequality has been demonstrated (Hermes, 2014; Turegano & Herrero, 2018).

Although financial inclusion has different definitions, it is generally defined as ensuring that all segments, especially the poor and those with limited access to financial products and services, have access to solutions that meet their financial needs (Allen et al., 2015; Ozili, 2020). Dev (2006) defines financial inclusion as the provision of financial services at affordable costs accessible to low-income and disadvantaged segments of the population.

The United Nations Development Program (UNDP) (2019) defines financial inclusion as the ability of a large segment of society to access and use different financial products and services in a well-regulated environment. Sahay et al. (2015) define it as ensuring the

access and use of financial solutions provided by financial institutions and organizations by all segments of society. International Monetary Fund (IMF) & World Bank (WB) (2019), on the other hand, define financial inclusion as the sustainable access of individuals and businesses to transactions such as payments, savings, credit, and insurance to meet their needs.

In another of its broadest definitions, Demir et al. (2022) defined financial inclusion as the opportunity for all financial participants to engage in the financial system and benefit from the opportunities created by it. Financial participants in this definition are as follows; individuals, companies, public institutions, non-governmental organizations, institutions and organizations that provide financial services such as banks and insurance companies, and governments.

The common point of the definitions in the literature is the emphasis that financial services and solutions are accessible to all segments of society (Demir et al., 2022). Financial inclusion and financial access are considered two different concepts. While financial inclusion is expressed as the ratio of actors benefiting from these services by providing access to financial products and services they are complementary with financial exclusion (Carbo, Gardener, and Molyneux, 2005). Lack of use is not necessarily due to lack of access (Gabor and Brooks, 2016). In the financial system, there may be cases where certain services are not preferred by some participants, although they can access financial services with affordable costs and opportunities (Sahay et al., 2015). However, contrary to non-preference for some participants, they may be deprived of access to financial products and services due to reasons such as high transaction costs and reliability (International Monetary Fund & World Bank, 2019). The main distinction is whether the access to financial products and services is driven by the choice of the individual or by external factors that prevent the access of financial participants (Demir et al., 2022).

While financial inclusion practices are listed as the ability to complete banking transactions based on few documents, free access to services such as debit cards and insurance policies, and the adoption of direct-to-person payment systems (Ozili, 2020), the number of bank branches (Mookerjee & Kalipioni, 2010), having a bank account (Honohan, 2017), the number of ATMs (Park & Mercado, 2018), and the number of commercial bank branches (Park & Mercado, 2018) have been expressed in the literature. However, today's innovations in finance, which are defined by means of the Fintech, have led to an increase in the use of mobile applications through the widespread use of the

internet and its technical infrastructure, which has brought with it a variety of products and services, and the indicators of financial inclusion in the literature include the level of mobile phone penetration (Andrianaivo & Kpodar, 2014; Ghosh & Vinod, 2016) and the use of mobile money (Gosavi, 2018; Jack & Suri, 2011; Morawczynski & Pickens, 2009; Ouma et al., 2017).

Herein, the impact of the extensive use of Fintech applications such as mobile payment services, robo-advisory, crowdfunding is not only limited to the financial sector, but also has a significant potential to increase the living standards of individuals and contribute to the growth and development of economies (Demirguc-Kunt et al., 2018).

Contrary to this conclusion, studies generally draw attention to the possibility of achieving better results by emphasizing country-specific needs (Omar & Inaba, 2020). Moreover, the mitigating effect of Fintech on asymmetric information and transaction costs makes it an important tool for increasing financial inclusion (Makina, 2019). In the report titled Financial Inclusion in the Digital Age (2018) ,jointly prepared by Credit Ease, International Finance Cooperation (IFC), a member of the World Bank Group, and Stanford Graduate School of Business, it is stated that FinTech significantly promotes financial inclusion through the increasing use of emerging technologies such as digital identity, Internet of Things (IoT), AI and innovative business models.

The widespread use and adoption of Fintech increases financial inclusion by enabling the embracement of financially excluded populations who do not have access to financial services. In this way, it increases savings (Jamison et al., 2014) and positively affects investments, entrepreneurship, wages, economic growth and income distribution thanks to more easily accessible funds (Beck et al., 2007; Chen & Jin, 2017).

Moreover, based on the expected positive externalities on growth and welfare from the availability of financial products and services to all, including the marginalized segments of society, many governments consider financial inclusion as a policy objective (Allen et al., 2015). Studies have shown that the widespread use of Fintech and policies that increase financial inclusion are effective in reducing income inequality and increasing economic growth and development, especially in less developed and developing countries such as Ghana (Senyo et al., 2022), India(Ghosh & Vinod, 2016), Rwanda (Otioma et al., 2019), Kenya (Van Hove & Dubus, 2019) and Peru (Cámara & David, 2015).

Similarly, Asongu and Nwachukwu (2018) examined the link between mobile banking and inclusive development (inequality, growth quality and poverty). They find that Fintech, measured by the use of mobile phones to pay bills or send/receive money, has a significant negative impact on income inequality in upper-middle-income countries. Incidentally, Asongu and Odhiambo (2021) found an inverse relationship between mobile banking and income inequality in middle-income countries, depending on the country's level of economic development as measured by the human development index.

In developing countries, studies on the use of mobile money, which allows money transfers without the need for a bank account, are coming to the fore. (Iman, 2018; Oborn et al., 2019; Ozili, 2020; Senyo et al., 2022). Among these studies, Oborn et al. (2019) found that M-Pesa, a mobile money, reduces household poverty by increasing financial inclusion in Kenya. With the spread and adoption of M-Pesa in Kenya, financial inclusion increased from 26.4% in 2006 to 40.5% in 2009 (Ozili, 2020). Similarly, the impact of mobile money examples such as the use of TCASH in Indonesia (Iman, 2018) and Modelo Peru in Peru (Ozili, 2020) on financial inclusion has also been discussed.

In addition to these studies examining the effect of Fintech on financial inclusion, Sahay et al. (2020) from a different point of view, revealed that the positive or negative effects of Fintech on financial inclusion are related to many different factors. In their study, they found that Fintech-based financial practices have a positive impact on economic growth by increasing financial inclusion, even when traditional financial inclusion decreases. However, they also found that the positive effects of Fintech on economies through financial inclusion depend on several factors such as financial literacy, legal and political regulations, and the digital gap between households, regions, and countries.

Furthermore, Burns (2018) uses the mobile currency revolution in Sub-Saharan Africa to ensure the most effective models of financial inclusion and development, market conditions free from oppressive regulation and giving the industry complete freedom to use innovative ways to access the unbanked population, and argues that it depends on the implementation of facilitating rather than restrictive regulations for FinTech entrepreneurs.

Chuang et al. (2016), Hu et al. (2019) and Jünger and Mietzner (2020) indicate that trust has an impact on the acceptance and use of FinTech. Reliability, transparency, user innovation, and financial literacy (Hu et al., 2019; Jünger & Mietzner, 2020) as well as

perceived usefulness and perceived ease of use (Chuang et al., 2016) also have a significant impact on FinTech.

In addition, the financial divide has also been considered among the factors affecting the benefits of widespread use and adoption of Fintech to financial inclusion (Wójcik, 2021). The unequal access and use of Information and Communication Technologies (ICT) across geographies and demographics are called the digital gap (Otioma et al., 2019). According to (2003), there are gaps in individuals with different socio-economic levels in terms of both accessing ICTs and using the internet for different activities. Different studies show that the adoption and use of Fintech are hampered by the lack of insufficient electricity or communication infrastructure and other resources in most parts of Sub-Saharan African countries (Odei-Appiah et al., 2022).

1.3. Definitions of Fintech

Although the origin of the word "Fintech" seems to express the merging of “Finance” and “Technology”, there is no unanimous definition of this term (Milian et al., 2019). The fact that there was no formal definition of Fintech that was accepted by everyone. However, despite the belief that it is premature to define in a rapidly evolving field, some institutions and organizations, and academics have developed definitions for Fintech. In general, Fintech definitions consist of definitions that express an innovative service, indicate it as a business model, and point to innovative businesses that combine finance and technology to create new financial products and services. In some definitions, a clear distinction is made between innovation as a sustainable process and distruction (Sironi, 2016). In these definitions, innovation refers to the advancement of the already existing system, while distruction refers to the introduction of new rules within the system (Christensen, 2006). Distruption-based definitions do not include innovations based on existing technologies like mobile payments (Bank of International Settlements, 2018; Christensen, 2006; Gomber et al., 2017).

In some studies, the term Fintech refers to companies mostly start-ups that present technologies used in finance (Ernest & Young, 2019; Gomber et al., 2017, 2018; Haddad & Hornuf, 2019; Laidroo & Avarmaa, 2020). The majority of these definitions ignore large financial service providers that use these new digital technologies or offer similar services, based on the assumption that Fintech businesses are start-ups (Haddad & Hornuf, 2019). Laidroo and Avarmaa (2020) define FinTech as start-ups that ensure at

least one financial service like payment, insurance, risk management, or combinations of them by using technological innovations such as AI, big data, and blockchain technologies. Gomber et al. (2017) define FinTech as innovators and disruptors in the financial sector, especially those companies that take advantage of the widespread communication networks provided by the internet and information and communication technologies. By this definition, they are also referring to the disruptive innovation aspect of Fintech. Gomber et al. (2017) also attribute the disruptive emergence of start-ups in the financial sector to three main reasons. The first is that traditional financial institutions are insufficient to meet the changing demands of customers. The second is that Fintech companies offer new opportunities for product and service sales through the application of new technologies and new concepts. The last is that technology-intensive Fintech start-ups are agile enough to put traditional financial institutions under competitive pressure. According to E&Y's (2019) Fintech Adoption Index, Fintech is defined as organizations that bring together innovative business models and technology to increase, improve and disrupt the effectiveness of financial services. In addition, fintech refers to innovators and disruptors in the financial sector, who widely use digital technologies, information, and communication in all sphere of the finance (Gomber et al., 2017). According to EU Parliament (2018), Fintech refers to businesses that use technology-oriented systems to provide financial services or to make the existing system more effective. In a different study, Haddad and Hornuf (2019) considered Fintech as startups and they classified it into nine different types according to the financial field in which they operate. These are "financing", "payment", "asset management", "insurance (insurtechs)", "loyalty programs", "risk management", "exchanges", "egulatory technology (regtech)", and "other business activities".

Milian et al. (2019), based on Christensen's (2006) disruptive innovation theory, stated that Fintech can be handled under two groups "Disruptive Fintech" and "Sustainable Fintech". "Sustainable Fintech" refers to businesses that currently operate as financial services providers and use technology-driven innovations to maintain their position in the market (Lacasse et al., 2016; Milian et al., 2019). "Disruptive Fintechs", on the other hand, refers to young start-up companies that challenge the financial service providers currently operating in the market by offering new technology-based financial products and services (Chiu & Iris, 2016; Milian et al., 2019).

The common point of all these definitions is that they express Fintech through businesses that combine finance, digital technologies, and innovation and make progress in this field.

In addition to the definition that sees Fintech as technology-oriented businesses, especially start-ups that reveal financial innovation and technologies, some studies identify Fintech as a combination of different business models that use financial innovation and technology (I. Lee & Shin, 2018; Liu et al., 2020; Narayan & Sahminan, 2018; Schindler, 2017). International Organization of Securities Commissions (IOSCO) (2017) defines Fintech as a combination of different innovation-oriented business models and technological innovations with the potential to change the financial sector. These business models reduce the cost of financial transactions, facilitate access to financial services and increase the quality (Narayan & Sahminan, 2018; Schindler, 2017). According to the term Fintech put forward by Akkizidis and Stagars (2015), Fintech is the whole of business models such as online lending, crowdfunding, crowd investing, transaction and payment terminals, Personal Finance Management (PFM), digital currency and cryptocurrency, mobile Point of Sale (mPOS), Robo-advisors, e-banking. Lee and Shin (2018) identified Fintech through 6 different business models. These are the "payment business model", "wealth management business model", "crowdfunding business model", "lending business model", "capital market business model", and "insurance services business model". Liu et al. (2020) define Fintech as the use of business models such as "online lending", "crowdfunding", "transaction" and "payment terminals", "PFM", "digital currency" and "cryptocurrency", "mPOS", robo-advisors, ebanking created with a focus on digitalization, technology, and innovation.

If the aim is to define a Fintech that captures all the financial innovations provided by the use of digital technology, all these definitions will be insufficient and the definitions emerging for this purpose also differ. In this regard, the FSB's definition and classification of "digitally enabled financial innovation" reveals a wide-ranging pattern between finance and technology by relating various technological innovations to their economic objectives (Buckley et al., 2020). According to the FSB (2017), FinTech can be defined as "technologically-enabled financial innovation that could result in new business models, applications, processes or products with an associated material effect on financial markets and institutions and the provision of financial services". It also addressed Fintech from the perspective of financial stability and financial risk. According to Hong Kong Monetary Authority (HKMA) (2016), Fintech is the leading force focused on innovation

in financial services and changing the nature of economic activities and consumers' expectations and demand for financial services. The definition of HKMA (2016) draws attention to the impact of Fintech on global financial systems. It also clearly stated the financial applications meant by Fintech, such as AI, blockchain, cloud computing, and big data. In addition to this, Thakor (2020) claims that Fintech is a technological innovation that is used to provide more efficient and improved financial products and services. The United State National Economic Council (2017) is seen Fintech as a technological innovation that affects financial activities such as “payment”, “insurance”, “capital raising”, “investment”, “lending”, and “inancial regulations”. Also, these innovations can be considered as innovations such as algorithmic savings and investment tools, digital currency, biometric digital customer identification and authentication, and automated mid- and back-office enterprise functions based on algorithms, big data, AI, and IoT. Also, Chen et al. (2019) and Carney (2017) define Fintech as technological innovations that make financial transactions cheaper, more convenient, and more secure, disruptively transforming financial services and enabling the creation of new products and services. In another definition, Gai et al. (2018) consider Fintech as information and communication technology applications that increase the performance and quality of financial services and products.

Although there is no general definition, putting forward different definitions of Fintech is the starting point in determining which aspect of it to consider. In this respect, it is understood that the definitions in the literature are gathered under three main themes. The first of these are the definitions that describe Fintech as businesses, mostly start-ups that create innovations that combine finance and technology (Ernest & Young, 2019; Gomber et al., 2017, 2018; Haddad & Hornuf, 2019; Laidroo & Avarmaa, 2020). The second is that Fintech is defined through different, technology and innovation-oriented business models (I. Lee & Shin, 2018; Liu et al., 2020; Narayan & Sahminan, 2018; Schindler, 2017). None of these definitions refers to financial applications that emerge with technological and digital innovations. To increase the efficiency of financial processes, regulations, and products, the use of technology and digitalization and the solutions created are ignored. Technological and digital innovations and applications affect financial services in every aspect with the increased efficiency and decreased costs they provide (Ernest & Young, 2019). At the same time, they are inducing significant changes in the way financial service providers operate. For this reason, the inclusion of these

applications in the definition of Fintech emerges as a necessity. Therefore, third, fintech is defined in terms of broad financial technology, innovation, and digital technologies that lead to the creation of new financial products, business models, and processes (Buckley et al., 2020; Financial Stability Board, 2017). It is the most comprehensive definition of Fintech and can refer to two other definitions as well (Milian et al., 2019). Different Fintech definitions and groups are also given in *Table 5* below.

Table 5

Existing Different Fintech Definitions

Authors	Definition	Classification
Bettinger (1972)	Fintech are financial technologies that represent a combination of bank expertise with modern technology based on management, IT and computer systems.	Fintech as a financial innovation&technology/Sustainable innovation perspective
Akkizidis and Stagars (2015	Fintech is the whole of business models such as online lending, crowdfunding and crowdinvesting, transaction and payment terminals, personal finance management (PFM), digital currency and cryptocurrency, mobile point of sale (mPOS), robo-advisors, e-banking.	Fintech as business models / Distruptive innovation perspective
Micu and Micu (2016)	Fintech is a new sector that includes technology-oriented new products and services to increase efficiency in the financial sector.	Fintech as a financial innovation&technology/Sustainable innovation perspective
Maier (2016)	They are businesses that aim to challenge traditional financial institutions and organizations by using technology to offer new and alternative financial solutions to customers.	Fintech as businesses / Distruptive innovation perspective
Jun and Yeo (2016)	They are innovations that ensure the spread of new and innovative products and services in the field of finance based on information and communication technologies.	Fintech as financial innovation and technology/Distruptive innovation perspective
Kim et al.(2015)	Fintech is financial innovation based on information technologies to improve the efficiency of the financial system.	Fintech as a financial innovation&technology/Sustainable innovation perspective
Schueffel (2016)	New technology-driven financial sector to improve existing financial services.	Fintech as a financial innovation&technology/Sustainable innovation perspective
Ernst & Young (2017)	Fintech is defined as organizations that bring together innovative business models and technology to increase, improve and disrupt the effectiveness of financial services.	Fintech as businesses / Distruptive innovation perspective
Gomber et al. (2017)	Fintech refers to innovators and disruptors in the financial sector, who widely use digital technologies, information and communication in all areas of finance	Fintech as businesses / Distruptive innovation perspective
EU Parliament (2017)	Fintech refers to businesses that use technology-oriented systems to provide financial services or to make the existing system more effective	Fintech as businesses / Sustainable innovation perspective
International Organization of Securities	FinTech as a combination of different innovation-oriented business models and technological innovations with the potential to change the financial sector	Fintech as business models / Distruptive innovation perspective

Commissions (IOSCO) (2017)		
Financial Stability Board (FSB) (2017)	FinTech can be defined as "technologically-enabled financial innovation that could result in new business models, applications, processes or products with an associated material effect on financial markets and institutions and the provision of financial services	Fintech as financial innovation / Distruptive innovation perspective
National Economic Council (2017)	Fintech as technological innovations that affect financial activities such as payment, insurance, capital raising, investment, lending and financial regulations.	Fintech as financial innovation / Distruptive innovation perspective
Gimpel et al. (2018)	They are characterized as start-ups that offer new products and services through the use of digital technologies such as the internet, mobile computing and data analytics to improve the efficiency of financial services.	Fintech as businesses / Distruptive innovation perspective
Basole and Patel (2018)	Offering traditional financial services by transforming them into new business models through technology-oriented start-ups.	Fintech as a financial innovation&technology/Sustainable innovation perspective
Gomber et al. (2018)	Fintech refers to innovators and disruptors in the financial sector that capitalize on the availability of ubiquitous communication, especially through the internet and automated information processing. Such companies have new business models that promise greater flexibility, security, efficiency and opportunity than established financial services.	Fintech as businesses / Distruptive innovation perspective
Haddad and Hornuf (2019)(2019)	Fintech as startups and they classfied it into nine different types according to the financial field in which they operate. These are "financing, payment, asset management, insurance (insurtechs), loyalty programs, risk management, exchanges, regulatory technology (regtech), and other business activities	Fintech as businesses / Distruptive innovation perspective
Lee and Shin (2018)	Fintech defined through 6 different business models. These are the payment business model, wealth management business model, crowdfunding business model, lending business model, capital market business model and insurance services business model	Fintech as business models / Distruptive innovation perspective
Laidroo and Avarmaa (2019)	FinTech as start-ups that ensure at least one financial services like payment, insurance, risk management or combinations of them by using the technologial innovations such as AI, big data and block chain technologies.	Fintech as businesses / Distruptive innovation perspective
Liu et al. (2020)	Fintech as the use of business models such as online lending, crowdfunding, transaction and payment terminals, personal finance management, digital currency and cryptocurrency, mobile point of sale, robo-advisors, ebanking created with a focus on digitalization, technology and innovation	Fintech as business models / Distruptive innovation perspective

This dissertation focuses on the definition of Fintech in the third group, which defines Fintech as broad financial technology, innovation and digital technologies that lead to the creation of new financial products, business models and processes. Accordingly, as the starting point of the Global Fintech Index, "Fintech" is technological, digital-based financial innovations and applications that support the sustainability of traditional financial institutions/organizations, improve their products and services, also cause a

disruptive impact and radical changes with the new challenging products and services in financial markets and industry.

1.4. Determinants of Fintech

The fact that Fintech does not have a unique definition in the literature when it is considered with its economic, social, technological, and financial dimensions, has brought along with it to be expressed by means of different indicators as determinants of Fintech and to be dealt with by associating different variables. As a matter of fact, there is no single variable that can be considered as an indicator for Fintech as a different and multidimensional concept, but different explanatory indicators have been used in the literature (Claessens et al., 2018; Frost, 2020).

Nevertheless, Lee et al.(2021) argue that the difficulty in measuring the development of Fintech from two different perspectives, a demand-driven perspective and a supply-driven perspective, can be eliminated by constructing a single composite indicator. In addition, the many positive externalities that reduce poverty and imperfect market implications such as asymmetric information, high transaction costs, as well as their effects on economic growth and development, increasing the living standards of households, bring along the need to reveal the determinants of Fintech (Frost, 2020).

Schidler (2017) categorizes the emergence and determinants of Fintech in terms of supply and demand. While the supply side deals with factors such as technology, macroeconomic circumstances, financial market conditions that encourage and affect the providers of products and services to the financial markets to offer innovative financial products and services to the markets, the demand side deals with demographics that ensure the widespread use and adoption of the products and services offered by financial service providers.

Technological advancement, one of the two main dimensions of Fintech as finance and technology, is revealed as one of the main factors of Fintech (Ettlie et al., 2014; Haddad & Hornuf, 2019; Pollari, 2016; Schindler, 2017). Technological innovations in Fintech refer to a wide variety of products and services, starting with the use of ATMs in the 1980s, to today's mobile payment systems, crowdfunding tools, and blockchain technology (Puschmann, 2017). Another supply-side factor that drives Fintech innovations is macroeconomic conditions such as low-interest rates (Narayan & Sahminan, 2018; Schindler, 2017) and inflation (Narayan & Sahminan, 2018). Narayan

and Sahminan (2018) indicated the positive effect of low-interest rates and inflation on the development of Fintech, with the effect of reducing the costs of doing business. Also, Ernest & Young (2014) shows that talent and entrepreneurial availability are key factors for an efficient Fintech ecosystem. Therefore, Haddad and Hornuf (2019) found that increased labor supply has a positive effect on Fintech startups.

Within the Fintech ecosystem, traditional financial institutions and organizations are seen as important participants, even though they perceive Fintechs as a threat due to their disruptive impact on the sector (Lee & Shin, 2018). While the relationship between traditional financial institutions and Fintech was initially a competition, it has turned into cooperation as Fintech focuses on the development of services and products rather than being a financial institution (Anagnostopoulos, 2018). The vast majority of fintechs' advancements depend on ICT services and technical knowledge and know-how (Haddad & Hornuf, 2019). Therefore, Laidroo and Avarma (2020) found that a high tertiary education rate, university-industry cooperation, ICT infrastructure, and an advanced financial system are necessary to support the development of Fintech.

The adoption and widespread use of Fintech products and services differ across countries (Frost, 2020). Especially in some emerging economies, they are increasing due to unmet demand for financial services. In general, the high costs of traditional financial products and services, market regulations, macroeconomic indicators such as growth rate, inflation, real interest rates, and demographic characteristics may cause differentiation of adoption across countries (Pollari, 2016; Puschmann, 2017).

Consumers' unmet needs and demands can be the driving force in Fintech adoption, and this adoption supports expanding the access of financial services. In studies conducted in China (Hau et al., 2019), the USA (Tang, 2019), Germany (de Roure et al., 2016), and Argentina (Frost, 2020), traditional financial institutions and organizations fund financial participants with high credibility, the results showed that the unmet demands of financial participants out of the system with low credibility or in need of small-scale loans accelerated their adoption by providing widespread use of Fintech loans. On the other hand, Frost (2020) indicated that 35% of small-scale customers who obtain financing from Mercada Libre, an e-commerce platform, do not have a credit score that can obtain loans from traditional institutions and organizations. In addition, in the same study, in the evaluation made across countries, it has been revealed that technology loans make up for the shortcomings of traditional loans and are widely used in cases where bank branches

are low compared to the population. When the results of these studies are summarized, in general, Fintech's traditional financial institutions and organizations show rapid growth when they cannot meet the existing domestic demand, and this growth is based on increasing demand and widespread use.

It has been showed that Fintech develops faster in markets where financial transaction costs are relatively high. It determines that Fintech applications increase efficiency in financial markets by facilitating access to financial products and services for both retail and commercial customers (Leong & Sung, 2018), and they are preferred over traditional financial products and services, where transaction costs are high, as well as providing better quality services at lower costs (Lee & Shin, 2018).

Nonetheless, Claessens et al (2018) also find that Fintech is more prevalent in countries with higher average income as an indicator of development.

In addition to these, legal rights and regulations are factors that allocate trust in the economic cycle in terms of protecting the rights of investors, entrepreneurs, parties in commercial relations, borrower and lenders (Groh & Wallmeroth, 2016; Herck Giaquinto & Bortoluzzo, 2020). In terms of Fintech effects, Rau(2018) argues that Fintech develops and diffuses faster in countries that have adopted the rule of law, where markets are based on rules and regulations, where corruption can be prevented, where entry to the market is relatively easy, and where the profitability of traditional financial institutions and organizations is high. For good measure, Dushnitsky et al.(2016) in their study on European crowdfunding markets found that these markets are influenced by cultural and legal practices. Furthermore, Navaratti et al. (2018) argue that Fintech is more prevalent in countries where regulations on financial markets are relatively flexible. However, Braggion et al. (2017); Buchak et al. (2018), Cizel et al. (2019) show that the demand for non-bank loans such as P2P loans as a Fintech product increases in countries where regulations on traditional banks' lending policies are strict. In terms of legal rights and regulations, start-up investments and entrepreneurship, which are important parts of the Fintech ecosystem, are negatively affected due to increased uncertainty, risk and costs of doing business in countries with high levels of corruption (Cherif & Gazdar, 2011). In addition, the removal of barriers to entry and regulations to be made in this direction increase competition in the sector and facilitate the adoption of Fintech products and services (Rau, 2018).

As with all other startups, Fintech startups also need financing to develop new business models, products, and services. Haddad and Hornuf (2019), in their study on the economic and technological factors that accelerate the development of Fintech by directing entrepreneurs and start-ups to the Fintech sector, found that the development of Fintech and the demand for its products and services are higher in countries with a developed economy and developed traditional capital markets. Similarly, Fintech is more likely to to develop through regulations, economic freedom (including property rights, financial freedom and commercial freedom), efficient financial institutions, and deep and financially developed capital markets, as entrepreneurs and investors have more opportunities to raise funds (Herck Giaquinto & Bortoluzzo, 2020). This conclusion is also supported by the results of studies by Nofsinger and Wang (2011), Precup (2015) and Felix, Pires and Gulamhussen (2013) on entrepreneurship and Venture Capital (VC) investments.

In a different context, Blaseg and Koetter (2015), and He et al., (2017) attribute the sudden development of Fintech to the 2008 financial crisis. Studies show that the widespread use of Fintech start-ups in the sector is largely due to the decrease in trust in traditional financial institutions and organizations and the decrease in financial soundness. With the financial crisis, banks followed a stricter and more stringent policy in the credit evaluation process and in some cases increased borrowing costs for entrepreneurs and small businesses or stopped lending, leading these retail and commercial customers to seek alternative ways to find financing (Blaseg, 2015; Schindele & Szczesny, 2016).

The emergence and spread of Fintech solutions such as equity crowdfunding, crowdlending, and crowdfunding as an alternative financing source are expected from countries affected by financial crises and where the banking sector is less sound (Haddad & Hornuf, 2019; He et al., 2017). In addition, Fintech is expected to develop more easily in countries with tighter regulations with a more fragile banking sector, since strict economic and financial regulations represent a systemic risk in the financial system (Brunnermeier et al., 2012). Cumming and Schwienbacher (2018) revealed that Fintech VC investments are relatively more common in countries that have weaker regulatory practices and do not have a large financial center after the financial crisis. In addition, Pollari (2016) has made VC investments stand out as a driver that supports the spread of Fintech, based on the increase in VC investments made in the Fintech sector globally (indicating an increase of 106% in 2015 compared to the previous year).

In addition to all these, as policymakers realize the positive externalities of Fintech, they increase their spending on the sector by increasing awareness, education and technological and financial literacy (Pollari, 2016).

Ernest and Young (2019) found that the use and adoption of Fintech is higher among the young population. In support of this, the demand for Fintech applications is also high in countries with high youth populations such as India, Colombia and South Africa (Frost, 2020). According to Fintech Report of KPMG (2016) on the main drivers of the development of Fintech, considered the young population, especially millennials, as a driving factor in the development of Fintech due to the increasing proportion of millennials in the population, Alt et al. (2018) evaluated the issue from a different perspective and revealed that the traditional use of cash is higher in countries with a dense elderly population.

Table 6 summarizes the determinants of Fintech in the literature.

Table 6

Summary of Fintech Determinants

Factors	References for Factors	Proxy Indicators	References for Proxy Indicators
Well developed economies and capital market	Haddad & Hornuf (2019)	GDP per Capita	Haddad & Hornuf (2019), Yartey (2007), Lee & Shin (2018)
		Number of commercial bank branches	Haddad & Hornuf (2019), Chinoda and Mashamba (2021)
		Freedom to trade internationally	Haddad & Hornuf (2019)
		Sound money	
		MSCI returns	
ICT Infrastructure-Quality-Usage and Affordability	Haddad & Hornuf (2019), Laidroo & Avarma(2020), Glavina et al. (2021); Schidler, 2017; Ernst & Young (2016), Pollari (2016), Guo et al. (2019)	Mobile telephone subscriptions	
		Internet penetration	Haddad & Hornuf (2019)
		Secured internet servers	
		Fixed broadband subscriptions	
		Latest technology	Haddad & Hornuf (2019)
		ICT service export as % of service expprt	Laidroo & Avarma(2020)
		Internet user	Glavina et al. (2021)
		Mobile phone cost	
		Average fixed broadband upload speed	
		Average fixed broadband download speed	The Inclusive Internet Index (2021)
		Average mobile upload speed	
		Average mobile download speed	
		Network coverage—min. 3G	
		Government initiatives to make WIFI available	Glavina et al. (2021)
		Private sector initiatives to make Wi-Fi available	The Inclusive Internet Index (2021)
		Urban electricity access	
		Rural electricity access	
		Network coverage—min. 3G	Glavina et al. (2021)

Soundness of financial system	He et al. (2017), Blaseg & Koetter (2015); Guiso et al. (2013); Schindele & Szczesny(2016), Bollaert et al.(2021), Haddad & Hornuf (2019), Laidroo & Avarma(2020)	Mobile telephone subscribers	
		Soundness of banks	
		Investment profile	Haddad & Hornuf (2019)
		MSCI crisis period	
		Crisis-Dummy variable equal to 1 if the country experienced a banking crisis over 2007–2017	Laidroo & Avarma(2020)
Policy and Regulation	Rau (2018), Navaretti et al.(2018), Dorfleitner & Hornuf (2017), Glavina et al. (2021)Groh & Wallmeroth (2016); Giaquinto & Bortoluzzo (2020), Gautam et al. (2022),Haddad & Hornuf (2019)	Regulations	Haddad & Hornuf (2019)
		Privacy Regulations	Dorfleitner & Hornuf (2017)
		Number of initiated regulatory sandboxes	Glavina et al. (2021)
		Legal rights index capturing the legal protection of borrowers and lenders	Rau (2018), Navaretti et al.(2018),
		Corruption perception index	
		Government e-Inclusion Strategy	Feyen et al. (2021)
		National Boadband Strategy	
		Support for Digital Literacy	The Inclusive Internet Index (2021)
		Privacy Regulations	Dorfleitner & Hornuf (2017), The Inclusive Internet Index (2021)
Domestic demand and Fintech Adoption	Frost et al.(2019), Laidroo & Avarma(2020),Lee & Shin (2018), Solarz & Swacha-Lech (2021)	Government's responsiveness to change	Glavina et al. (2021)
		Percentage of citizens at the age of 15 years or older, who accessed their bank account via mobile phone or the internet	Laidroo & Avarma(2020)
		Domestic market size index	
		Younger population-millennials	Lee & Shin (2018),Frost (2020)
		Urban population	Holland FinTech (2015)
		Number of crypto owners	Fujiki (2020)
		Education attainment	Solarz & Swacha-Lech (2021)
		Trust in technology	Frost (2020)
		Tertiary education enrolment rates	Laidroo & Avarma(2020)
Developed factor conditions	Laidroo & Avarma(2020), Glavina et al. (2021),Groh & Wallmeroth (2016	University-industry cooperation	Laidroo & Avarma(2020), Glavina et al. (2021)
		Fixed-line availability, and overal	Laidroo & Avarma(2020)
		ICT readiness	
		Value of e-commerce	Glavina et al. (2021)
		Level of financial literacy	Panos & Wilson (2020)
Financial development	Laidroo & Avarma(2020)	Financial freedom index	
		Financial development index	
		Financial institution index	
		Financial market index	
		Stringency of capital requirements	Laidroo & Avarma(2020)
		Supervisory power of regulatory authorities	
		Banking activity restrictions	
		Legal rights index	
Financial inclusion	Guo et al. (2021)	Number of commercial bank branches per 100,000 adults in the population	Chinoda & Mashamba(2021), Haddad & Hornuf (2019)
		Unit cost of financial intermediation	Philippon (2016)
		Digital financial inclusion which is composed of digital financial indicators	Guo et al. (2021)
		Affordability of financial services, 1-7 (best)	Global Financial Inclusion Database(2021)

Entrepreneurial activity	Haddad & Hornuf (2019)	Availability of financial services, 1-7 (best) Financial services meeting business needs, 1-7 (best) The extent of VC investment Financing of SMEs R&D expenses Labor force	Haddad & Hornuf (2019), Cumming (2018),Glavina et al. (2021) Glavina et al. (2021) Groh & Wallmeroth (2016), Glavina et al. (2021)
Financial innovation	Milian et al. (2019)	Corporate tax rate Ease of access to loans Number of startup ATMs per 100,000 adults Made digital payments in the past year (% age 15+) E-Finance content E-Commerce content Number of Crypto owners	Haddad &Hornuf (2019) Haddad & Hornuf (2019) Gershenson et al. (2021) The Inclusive Internet Index (2021) Milian et al. (2019)
Risk&Security	Gai et al. (2018)	Trust in government websites and apps E-Commerce safety Trust in non-government web sites and apps Trust in online privacy Secured internet servers	The Inclusive Internet Index (2021)

CHAPTER 2. FINTECH REVOLUTION IN FINANCE

2.1. Introduction

The merging of technological practices with finance has become a fintech in the literature, starting with the 1990s, especially after the 2008 GFC. As some researchers have summarized, it is “the marriage of finance and technology” (Zavolokina et al., 2016). The use and origin of the term in the literature are traced to the “Financial Services Technology Consortium”, a project initiated by Citigroup in the early 1990s to facilitate technological collaboration efforts (Alterkawi & Bittar, 2019; Arner et al., 2016). Today, most financial transactions are carried out through technology-based financial services such as online banking, smartphones, digital applications, and e-commerce portals (Alterkawi & Bittar, 2019). Although financial technological innovations, which have increased, become widespread, and adopted with globalization, seem to have just been included in our daily lives due to their widespread use in the recent period, the coming together of finance and technology dates back to a very old history (Anyfantaki, 2016). Especially after the 2008 crisis, many areas where traditional financial intermediaries have been insufficient to be compensated by Fintech's innovative product solutions (Setiawan & Maulisa, 2020). In this respect, the 2008 GFC as a global shock, has been an important factor in the handling of Fintech as a different paradigm and its more widespread and powerful agenda. Finally, after the devastating impact of the Covid-19 pandemic, as a different global shock, on the economy, trade, and finance, Fintech is evolving into a new paradigm (Sugandi, 2021). For this reason, it is important to analyze Fintech's evolution so that policy makers, Fintech innovators, and users can analyze Fintech's effects and future development stages. At the same time, they can benefit from this inevitable change by revealing the pros and cons of the system, whose advancement is irreversible, over time.

Since Fintech is a combination of technology and finance in general, it shows parallel progress with the emergence and acceleration of technological developments (Milian et al., 2019). Fintech in this respect is not a new concept for finance. It has made progress over the years by shaping people's relationships with money. By this framework, the development of Fintech is discussed in 4 main periods. These periods are expressed as Fintech 1.0 (1866-1967), Fintech 2.0 (1967-2008), Fintech 3.0 (2008- Present), and

Fintech 3.5 (Present Emerging Countries) according to their distinctive features (Arner et al., 2016; Setiawan & Maulisa, 2020).

In this part of the study, the interaction and evolution processes between finance and technology, dating back many years, will be revealed.

2.1.1. FinTech 1.0 (1866-1967)

"The inhabitant of London could order by telephone, sipping his morning tea in bed, the various products of the whole earth, in such quantity as he might see fit, and reasonably expect their early delivery upon his door-step; he could at the same moment and by the same means adventure his wealth in the natural resources and new enterprises of any quarter of the world, and share, without exertion or even trouble."

John Maynard Keynes

Technological developments in this period enabled financial information to be shared globally (Arner et al., 2017). Therefore, this period is referred to as financial globalization. Although the invention of the printing press was an important innovation that allowed the mass production and widespread use of paper currency, the most important technological innovations that enabled rapid transmission and sharing of information in this period were the commercial use of the telegraph in 1838 and the laying of the first successful transatlantic cable by the Atlantic Telegraph Company in 1866 (Arner et al., 2017b; Hill et al., 2021). All these developments laid the groundwork for Fintech with an invention known as the pantelegraph, which is mostly used in banking transactions to verify signatures by sending and receiving transmissions through telegraph cables (Alt et al., 2018). In 1918, the United States Federal Reserve Banks developed a system known as the Federal Reserve Wire Network, or more recently Fedwire, created to facilitate the electronic movement of funds (Thomas & Morse, 2017). The system, which connects 12 reserve banks across the country with Morse codes, was used as a real-time gross payment fund transfer system until the 1970s and formed the basis for computerized financial transactions in the following years (Lerner & Tufano, 2011). In the 1950s, Diners Club Inc started the use of the first credit card, as a basis for today's credit cards and Fintech trends (Arner et al.,2015). The first credit card gave credit an exchangeable feature. The American Express Company then introduced the travel and entertainment card in a similar fashion (Arner et al., 2017b). The rapid adoption and

widespread use of credit cards led to the establishment of the Interbank Card Association, today's Mastercard, in 1966 (Thomas & Morse, 2017).

2.1.2. FinTech 2.0 (1967 – 2008)

At the end of the 1960s, the Quoton electronic system was put into practice for the first time in order to facilitate the transactions of the brokers, announce the prices on the stock market, and facilitate the follow-up of the investors (Arner et al., 2017a). This development was followed by the introduction of the global Telex network in 1966 (Giglio, 2021; Kalra, 2019). This technology has also been a source of inspiration for different technology-based financial innovations used today (Mortimer et al., 2015). Technological developments, the foundations of which were laid and accelerated during World War II, became the pioneers of many innovations in information and communication technologies after the war (Arner et al., 2016). Code-breaking tools and information technology advanced by wartime technology also inspired the first computer commercially developed by International Business Machine (IBM) and the first financial calculator produced by Texas Instruments (Giglio, 2021). In addition to these, the most important innovation of this period in the field of financial technology is the use of Automatic Teller Machines (ATMs) by Barclays Bank in 1967 (Giglio, 2021). The use of ATMs is the first financial technological innovation that significantly reduces, if not completely eliminates, the need to physically come to banks to carry out financial and commercial transactions (Anyfantaki, 2016). The most important feature of this period is that traditional financial institutions, with their financial services and products, are the main engine that enables Fintech to move forward (Arner et al., 2016; Giglio, 2021). One of the most important milestones in the development of fintech was the creation of the National Association of Securities Dealers Automated Quotations or NASDAQ in 1971 (Gomber et al., 2018). The world's first digital stock exchange was followed by the introduction of the Society For WorldwideInterbank Financial Telecommunications (SWIFT) as a digital payment system for cross-border financial institution transactions (Alt et al., 2018). These two major developments were also the starting point of the analog-to-digital transformation in finance during this period (Arner et al., 2017).

By the 1980s, the effective use of computers began in many financial institutions for data security, storage, and sharing, which is critical for financial transactions (Giglio, 2021). Until the 1980s, the application of technology in finance was seen only as tools that technically support financial institutions such as banks, stock exchanges, and trade

centers within the sector (Bons et al., 2012). However, E-Trade as a business model introduced in 1982 succeeded in reversing this perception and practice (Arner et al., 2016). This model has also been an indication that the global financial system cannot be considered independent of technology. However, the most important factor enabling the evolution of Fintech in today's sense is the transformation of internet technology in the 1990s (I. Lee & Shin, 2018).

This digital move of banks has subsequently encouraged the development in the global financial markets, with the 1990s, the use of the internet has become widespread as a cost-reducing solution (Arner et al., 2016). The use of the Internet in financial transactions has also started the e-finance era (Gomber et al., 2017). E-finance refers to the widespread use of the internet and the world wide web (www) in payment, investment, insurance, and trade transactions (Riggs, 2015; Gomber et al. 2017). During this period, many different business models such as online banking and brokerage were developed within the scope of e-finance (Bons et al., 2012). These business models have reduced the physical contact between financial institutions and customers, leading to a reduction and shrinkage of the branches of these institutions (Giglio, 2021). In this period, traditional financial institutions, especially banks, are still at the center as the executive and developer mechanisms of Fintech (Arner et al., 2016). The use and effects of internet technology are particularly evident in the banking sector (Alt et al., 2018). Internet banking has reduced the operational costs of banks, enabling transactions to be carried out in a shorter time, reducing turnaround times, and allowing real-time tracking of transactions (Demirguc-Kunt et al., 2018; Giglio, 2021). Widespread use of the internet provided the infrastructure to accelerate Fintech's development by facilitating the connection of countries in the 2000s (Kauffman & Ma, 2015). In this way, Fintech has evolved into a field that produces advanced solutions and differentiated applications in financial fields such as payment systems, trading, risk management, data storage, and analysis, which consist of more sophisticated products (Gomber et al., 2018). The widespread use of smartphones and applications such as mobile banking and mobile payment systems have enabled e-finance to evolve into mobile finance (I. Lee & Shin, 2018). In addition, the infrastructure provided by the internet enabled Fintech start-ups to emerge years later, as well as traditional financial institutions Arner et al., 2016). In this period, Fintech enabled the emergence of new global financial applications and sectors that offer different solutions for the problems and difficulties faced by customers with the benefits of

technological progress and innovations (Alt et al., 2018).. In addition, most of the innovations mentioned in this period took place in parallel with the advances in international trade and play an important role in meeting the needs of companies and consumers in this process (Murinde et al., 2022). PayPal is one of the best examples of applications in this period. PayPal offers money management services to its customers as an alternative to banks, with online payment baneer (Banerjee, 2020). The customer can securely carry out a commercial transaction on a global scale without physically visiting the bank (Alt et al., 2018). The payment system offered by PayPal is one of the best practices of the speed, transparency, and reliability features that Fintech brings to international payments (Banerjee, 2020). E-Bay, on the other hand, complemented an e-commerce-oriented business model with a secure payment and auction environment (Gomber et al., 2018). The acceleration of international trade with globalization, the differentiation provided by technological innovations in trade, and new business models have enabled Fintech to progress by offering solutions to the changing demands and problems with the changing business models (Blakstad & Allen, 2018). As of 2001, 8 of US banks had at least 1 million online customers, while in 2005 the first direct banking without physical branches started in England. In the 21st century, banks have digitized all customer transactions and relationships, including their internal processes such as risk management, auditing, and operational transactions. This period lasted until the global financial crisis in 2008 (Lu, 2018).

2.1.3. FinTech 3.0 (2008-Present)

The 2008 GFC started in the USA and spread to developed and developing countries and affected the real economies of the countries. According to Arnet et al (2015), the 2008 global financial crisis and its accompanying developments were the main factors that carried the Fintech 2.0 era to Fintech 3.0 in Western countries. The crisis had 3 important consequences that affected the development of Fintech. These are rising unemployment, new regulations, and decreased trust in banks (Arner et al., 2016).

With the 2008 crisis, the decrease in consumers' trust in traditional financial institutions such as banks facilitated the adoption of Fintech as an alternative to these institutions. According to the results of the survey conducted by Instantly Brand Monitor in cooperation with Statista (2015), Americans have more confidence in technology companies than banks. When the detailed results of the same study are examined, it is seen that while the confidence in Bank of America and Citibank is 36% and 37%,

respectively, this ratio is 73% and 71% for Paypal and Amazon. A similar survey conducted by Bain & Company in 29 countries in 2019 shows that 54% of respondents trust at least one technology firm more than banks. The increase in trust in technology companies has accelerated the development of the sector by increasing the adoption of Fintech applications (Jünger & Mietzner, 2020). According to the E&Y (2019), which reveals the consumer adoption rates of Fintech services, the adoption rate of Fintech applications, which was 16% in 205, steadily increased to 33% in 2017 and 64% in 2019. Even among non-fintech adopters, awareness of technology-based financial applications is quite high. The rate of those who have knowledge of at least one Fintech solution to be used for money transfers or payments is 96% worldwide. In the post-crisis period, technology-based financial products and applications filled the gap caused by the declining trust in traditional financial institutions and the disruptions of the system with the 2008 financial crisis (Arner et al., 2016).

The rising unemployment rate is one of the most crucial consequences of the 2008 global financial crisis (Arner et al., 2020). In the United States, the country where the crisis began, approximately 8.7 million employees lost their jobs. For many educated financial professionals who lost their jobs, Fintech was seen as a rapidly in-demand and emerging field where they could use their skills and knowledge (Arner et al., 2016).

The 2008 GFC brought along a series of new regulations such as the Dodd-Frank Act regarding the financial system, especially the banks (Salerno, 2020). These regulations, which focused on protecting the customer, the financial system, and the economy, narrowed the banks' range of action compared to the pre-crisis period (Magnuson, 2018). Regulations regarding the regulatory capital requirement, credit, and liquidity risk of banks have also affected their lending behavior (Gambacorta & Mistrulli, 2004). With these regulations, banks were prompted to act more risk-averse in lending (Salerno, 2020). In these conditions, where the movements of banks are restricted, Fintech has been able to attract the attention of customers who cannot meet their needs through traditional financial institutions, with solutions such as P2P lending and crowdfunding (Saiedi et al., 2018).

The Asian Economic crisis experienced in 1997 initiated a change in the understanding that puts banks at the center of finance and sees them as the only financial service provider (Batunanggar, 2019). The most important reason for this change is the entry of financial start-ups and big-tech companies into the sector (Cornelli et al., 2020). These innovative

companies, which started to appear in the sector after the 1997 financial crisis, became dominant in the sector with the solutions they produced and technology-oriented applications, as the trust in banks decreased after the 2008 financial crisis (Arner et al., 2020). The first digital wallet that emerged in 1999 was followed by Google Wallet (2011) and Apple Pay (2014), which were developed by big technology companies and innovative start-ups after the 2008 financial crisis (Kang, 2018). In addition, in 2009 Bitcoin entered the Fintech market (Chen, 2016). Subsequently, different cryptocurrencies following bitcoin became an important turning point in the financial world (Chen, 2016).

One of the most important determinants of the Fintech 3.0 era has been the changing social habits of people with technology (Arner et al., 2020). In this period, the increase in the use of social media platforms and the fact that people spend more time online have made technology the first option for accessing financial services (Alt et al., 2018).

2.1.4. FinTech 3.5 (2008-Present)-Emerging Markets

Fintech has been seen and developed as an alternative that eliminates the negativities that emerged after the global financial crisis in developed western economies (Batunanggar, 2019). However, this reason is quite different for developing countries. For these countries, Fintech increases limited access to basic services such as bank accounts, money transfers, and funding (Ozili, 2020). While a customer in the UK may prefer mobile banking instead of traditional banking activities for reasons such as service quality and efficient use of time, the reason for a customer to use P2P Lending or E-Wallet in Ethiopia is that it is not possible to reach these opportunities with traditional financial services (Baiju & Radhakumari, 2017). According to World Bank Global Findex (2018) , developing countries are at the bottom of the list of populations that can access financial services. The development of Fintech in these countries increases access to financial services.

(Arner et al., 2016) stated that with the demand for access to financial services, some features of developing countries support Fintech 3.5. These features are listed as follows.

- Presence of young population who have knowledge about mobile technology and have access to this technology
- A growing middle class

- Existence of traditional financial institutions that do not fully perform their functions and create opportunities for alternatives
- Inadequate physical infrastructure in the banking sector
- Consumers prefer trust over convenience
- Market opportunity created by consumers without access to financial services (1.2 billion people without bank accounts)
- Insensitivity in data protection and increased competition

In addition, the educated young population in India and China, trained in information technologies, is also qualified to provide human capital, which is one of the most important factors for the development of the sector (Gupta & Xia, 2018).

When all these come together, it can be seen that the main dynamic of the Fintech 3.5 period in developing countries, especially in Asia, is the increasing demand and entrepreneurial movements designed to meet this (Arner et al., 2016).

2.2. Changing Financial Services and Operations

2.2.1. Key Technologies in Fintech

Based on different Fintech definitions, it covers not only technological innovations in the development of new products and services but also the applications of these technologies to the development of business models and products based on digital platforms and processes (Huebner et al., 2019). In this respect, the main driving force (or factor) in the development of Fintech is technological innovation (Gomber et al., 2017). Technological innovations that Fintech relies on as disruptive innovation are big data, the internet of things (IoT), distributed ledger technology, cloud computing, AI, biometric technologies and augmented/virtual reality (OECD, 2018).

Table 7 shows the application areas of these technologies in financial products and services.

Table 7

Application of Digital Technologies to Financial Products and Services

DIGITAL TECHNOLOGY	FINANCIAL ACTIVITIES AND SERVICES							
	Payment services	Advisory& agency services Planning	Investment & trading	Lending & funding	Insurance	Security	Operations	Communications
Distributed ledger technology	X	X	X	X	X	X	X	X
Big Data		X	X	X	X	X	X	X
IoT					X			X
Cloud computing				X			X	
AI		X	X		X			X
Biometric technology					X	X		
Augmented/ Virtual reality		X	X					X

Source: OECD (2018)

Big data are complex data sets where technological progress, digitalization and the widespread use of the internet have significantly increased the amount of data available (OECD, 2018). Big data are complex datasets that are larger, more diverse, and rapidly increasing, especially from new data sources (Charoenwong et al., 2021). Although these datasets cannot be managed with traditional data processing software due to their volume, they offer effective and efficient solutions and new inferences in the areas where they are used (Brandl & Hornuf, 2020).

Technologies such as the IoT, cloud computing, AI, etc. have paved the way for the development of big data analytics, which allows for the storage and recording of large amounts of data while leaving a digital footprint (Awotunde et al., 2021). Big data includes not only text and numeric form, but also images, audio, video and data generated on smartphones and computers (Gepp et al., 2018). In of finance, big data is used as a technology that increases effectiveness and efficiency in the sector in many different areas such as ensuring customer satisfaction through call center calls and analysis of the data obtained from these calls, customer satisfaction and marketing through social media, fraud detection, detection and management of credit risks and operational risks, and strategy development (OECD, 2018).

The IoT is a global network of billions of uniquely addressable communicating objects to exchange information and make understandable decisions (Maiti & Ghosh, 2021). IoT refers to a large number of connected devices that capture information about the motion and other sensing data of objects in the physical world, but it is a serious source of big data (Khanboubi et al., 2019). There may be devices such as PCs, laptops, smartphones,

and PDAs used in the internet of things and sensors that can collect information from the environment (Maiti & Ghosh, 2021).

As in many different sectors, IoT is widely used in finance and causes a technological transformation in the sector (OECD, 2018). The demand for IoT has increased, especially after the Covid-19 pandemic, as customers turn to digital payments, and today IoTs is the technology behind mobile and digital payments (Maiti & Ghosh, 2021). Examples of mobile payment systems such as IoT-based Amazon Go and Go make it possible to pay from anywhere at any time (Suseendran et al., 2020).

Besides, Fintech's IoT-based solutions such as M-Pesa, M-KOPA, and BanQu are also shown as Fintech-supported green finance initiatives (Khanboubi et al., 2019). In the field of sustainable finance, it is predicted that Fintech will contribute to creating a sustainable environment by minimizing the balance between energy demand and energy efficiency with its IoT and technology-based solutions ranging from mass funding tools to cryptocurrencies (Suseendran et al., 2020).

DLT refers to a database shared between multiple parties (nodes) to execute mutually agreed transactions based on some consensus mechanism (Nakamoto, 2008). In other words, it is a technological innovation that allows data to be stored and shared across multiple data stores (or ledgers), but also allows transactions and data to be stored, shared and synchronized across a distributed network of different network participants (Bonneau et al., 2015). Its main characteristic is that all nodes have the same versions of the data and there is no central trusted authority (e.g. a clearing house), and this feature of DLT ensures data security by preventing cyber-attacks (Suseendran et al., 2020).

DLT is the innovation on which blockchain and bitcoin technologies, which are widely known today, are based (Brennan et al., 2019). The terms "blockchain" and DLT are often used interchangeably, but blockchain is a type of DLT popularized by Bitcoin from 2009 (Burniske and Tatar, 2018). For example, when a new digital currency transaction is recorded in a data block, it is transmitted to the network. This block, on the other hand, is first validated by the network members and then connected to an existing blockchain as an attachment only, forming a blockchain (Brennan et al., 2019). Since the linear chain grows when new blocks are added, previous blocks cannot be modified retroactively by any network member, thus guaranteeing data security (Brennan et al., 2019).

In Bitcoin, the transaction ledger is in the form of a series of data blocks interconnected via cryptography (blockchain) based on the work of "miners" (nodes that constantly solve cryptographic puzzles to verify transactions that will form the blockchain) (Schindele & Szczesny, 2016). DLT has many potential applications in finance, such as cryptocurrencies, central bank fiat currencies, public records (e.g., property, birth, and identity records), and smart contracts (Bonneau et al., 2015). DLT can have profound effects on the financial sector with its decentralized structure by increasing efficiency, and changing financial and non-financial infrastructures (Gandal et al., 2021).

In addition, smart contracts are digital contracts based on DLT that can be executed automatically when conditions are met (Dyson & Hodgson, 2016). The DLT reliance on smart contracts also brings potential benefits such as tremendous process and cost efficiency and interoperability (Duran & Griffin, 2021; Hellwig & Huchzermeier, 2019). Ethereum and Corda are among the DLT examples used as the most well-known smart contract platform (Higginson et al., 2019) .

As user demands, the amount of information processed and the complexity of this data increase in finance, data integration becomes necessary (Raskin & Yermack, 2016). According to Statista, global data report (2021), more than 79 zettabytes of data are created in 2021, of which only 10% is unique (original) data, while the other 90% is replicated data (data copied to backups and backup storage). Given that Statista estimates we will produce more than twice that (181 zettabytes) by 2025, Fintech operations seem to need technology-driven solutions to handle the massive data volume required to be in this industry. Cloud computing is shown and used as a solution to the huge data piles that the financial sector will face now and, in the future, (Meng et al., 2021). Cloud computing is the technology that provides cost-effective on-demand processing and storage services for data (Marston et al., 2011). While cloud technology significantly increases the capacity to collect and analyze data in finance, it also reduces costs by increasing the agility, flexibility, and speed of the system (Rossi, 2014).

AI, on the other hand, is a technological innovation that enables computer programs to perform tasks such as problem-solving, speech recognition, visual perception, decision-making, and language translation (Chakraborty & Joseph, 2017). AI has a large number of applications used in different fields, and it has a place in the sector with applications and advantages such as robo-consulting in the financial sector, transaction authentication, as well as providing cost-effective solutions that enable 24/7 communication with the

customer, reducing the errors caused by manual transactions (Buchanan, 2019). Along with increases in data processing and storage power, advances in some of its subsets, particularly ML, have strengthened AI in recent years (Helbing, 2019).

ML, on the other hand, is a technological innovation that focuses on parsing and learning from large amounts of data to make detection or prediction (OECD, 2018). It uses a variety of techniques, including ML, neural networks, and deep learning. In the past, while AL tried to imitate human behavior through rule-based methods and logic-based algorithms, today ML provides data-based analysis of large volumes and different types of data (Helbing, 2019). One of the most important applications of ML in the finance sector is credit scoring (Aziz & Dowling, 2018; Dastile et al., 2020).

Instead of scoring systems based on traditional financial methods, ML provides a faster and more accurate assessment of a potential borrower by using advanced classification algorithms, various explanatory variables (e.g., demographics, income, savings, historical credit history, transaction history at the same institution, and much more) to reach the final score that determines whether a person will take the loan, and more complex methods (Chakraborty & Joseph, 2017).

Another area where ML is causing effective transformations in finance is fraud prevention. Any illegal transaction can be easily detected by examining thousands of features such as customers' past behavior, location, spending patterns, etc., related to transactions made with many ML algorithms that are specialized in anomaly detection and highly advanced in detecting fraudulent transactions (OECD, 2018).

Augmented/virtual reality is another technological innovation that is frequently used in Fintech applications. The main difference between the two technological approaches is that augmented reality provides an enhanced view of the physical world in which the individual lives, while virtual reality creates an environment based on simulation (OECD, 2018). These technologies offer a virtual way of simulating the physical world for consumers to interact with and perceive their environment (Pant, 2020). In finance, especially with the visualization of big data used in many segments, which is complicated to analyze and organize, investors can make different asset management decisions, such as virtual reality payments, financial education, customer service, and security, in virtual trading stations, such as Citi's use of the Microsoft HoloLens application to offer investors Holographic Workstations (Dolega-Dolegowski et al., 2022).

2.2.2. Fintech Ecosystem

In management sciences, businesses and their ways of working are tried to be explained according to their position and relations in the environment and ecosystem they are in, by considering them as living organisms (Yazıcı, 2022). In this regard, it is important to analyze the Fintech ecosystem with all its participants and understand the relationships between them, in terms of developing strategies that will ensure the continuity of the system, its development, and continuity in a competition-oriented climate (I. Lee & Shin, 2018).

Muthukannan et al (2021) define the Fintech ecosystem as a heterogeneous, non-linear, dynamic, and complex network of intermediaries that interact with end users to provide financial products and services. With increasing technological innovations, the emergence of new players and the establishment of new connections increase the complexity of Fintech ecosystems exponentially (Bethlendi & Szocs, 2022; Muthukannan et al., 2021).

What determines the existence and continuity of an ecosystem is the communication with each other and the power they create when they come together, rather than the abilities and equipment of the participants who make up the ecosystem one by one (Yazıcı, 2022). Making sense of the Fintech ecosystem is also important in terms of revealing the sources of differences between countries.

Although the components that make up the Fintech ecosystem are the same in every country, the ecosystem's power and ability to create strategies that will provide a competitive advantage and factors such as legal, economic regulations, financial, technological infrastructure, and the development of labor markets differ across countries (Diemers et al., 2015). These differences indirectly express the relationship between the participants that make up the ecosystem.

Fintech has a wide range of influences from financial institutions and organizations to customers and start-ups in the sector, with the advantages such as reduced transaction costs, increased quality and accessibility, and a stable financial environment (Leong & Sung, 2018). The changing needs of customers and businesses and the technological innovations introduced have accelerated the development of Fintech from time to time and created an ecosystem in which different participants are involved in the process

(Puschmann, 2017). This ecosystem is also the leading force of innovative processes and solutions in the sector, efficiency, and competition (Diemers et al., 2015).

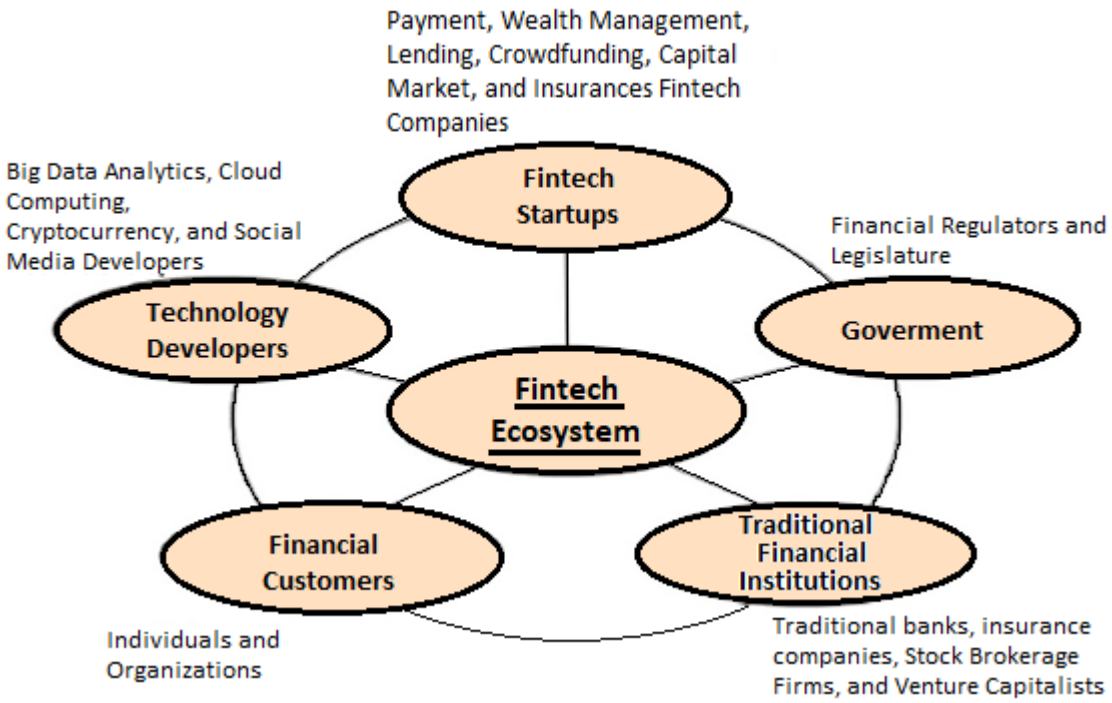
In the literature, there are different studies that deal with the functions of the participants of the Fintech ecosystem in a country and their relationship with each other (Bethlendi & Szocs, 2022; Blakstad & Allen, 2018; Gupta & Xia, 2018; Shim & Shin, 2016). In general, Fintech consists of 5 basic elements (Lee and Shin, 2018; Muthukannan et al.,2020; Bethlendi and Szocs, 2022) These factors are;

- Fintech startups
- Government
- Technology developers
- Fintech customers
- Designated as Traditional Financial Institutions.

Figure 10 illustrates the key factors within the Fintech ecosystem.

Figure 10

Fintech Ecosystem



Source: Lee & Shin (2018)

2.2.2.1. Fintech startups

Lee & Shin (2018) positioned start-ups at the center among the 5 elements of the Fintech ecosystem. Fintech start-ups provide financial services based on innovation and technology in areas such as cash management, insurance, and wealth management (Chuen & Teo, 2015; Kim et al., 2015).

Gimpel et al (2018) define fintech start-ups as newly established businesses that provide services to meet the changing demands of customers with innovative products and services in Fintech. The remarkable point here is that start-ups, as non-financial technology-driven enterprises, are the centers of Fintech-based innovations (Dapp, 2014; Kim et al., 2015). Although they are technology-oriented enterprises, they have had a devastating effect on banks as traditional financial institutions with the innovations they brought to the sector after the 2008 financial crisis.

The cost-effective solutions offered by Fintech start-ups and the variety of products that customers can choose in line with their needs were the main factors in this devastating effect (Gimpel et al., 2018) . Due to the distrutive effect in question, Fintech start-ups are described as the main driver in the middle of the Fintech ecosystem (Lee & Shin, 2018).

As stated before, Fintech innovations can be disruptive or sustainable in the sector. Herein, two different types of Fintech start-ups, competitive and collaborative, can be mentioned in the ecosystem, considering both the innovation introduced and the relationship with other participants in the Fintech ecosystem (Accenture, 2016)

Competitive companies are companies that aim directly at customers to gain a better user experience in relatively less profitable segments, which have a devastating effect on traditional financial institutions and organizations and the industry with the products and services they offer. They also come to the fore as the makers of disruptive innovations.

Collaborative companies, on the other hand, are businesses that introduce innovations to increase performance in the products and services of traditional financial institutions and organizations (Accenture, 2016).

2.2.2.2. Governments

Governments are one of the most critical participants in the Fintech ecosystem, affecting its sustainability (I. Lee & Shin, 2018). Fintech has caused disruptive changes in traditional financial institutions, products and services, operations and processes (Leong

& Sung, 2018). This change, which accelerated after the GFC, has also required regulations by international organizations and local governments (I. Lee & Shin, 2018). Governments act as the main regulator of the ecosystem as a supervisory body by ensuring that the necessary trust is allocated for investments through regulations and the rule of law (Yazıcı, 2022). These regulations address factors that may directly affect competition in the sector, such as ensuring the financial and personal information security of consumers, transparency, secure financial transactions in the digital environment, and determining commission and tax conditions (I. Lee & Shin, 2018). In addition, in some countries, governments also implement regulations for incentives to accelerate the establishment and development of start-ups, which play an important role in the development of Fintech. This legal framework drawn by governments and international organizations has brought a bureaucratic dimension to Fintech, which is an innovation based on less bureaucracy compared to traditional financial institutions and organizations (Puschmann, 2017). These regulations, which are enacted by countries within the framework of their own governance styles and economic policies, also differ between countries (Yazıcı, 2022). These regulations, which countries put into effect within the framework of their management styles and economic policies, also differ among them (Yazıcı, 2022). This is one of the primary factors affecting competition

2.2.2.3. Technology Developers

New technologies and new financial approaches come to the fore in the emergence of the fintech ecosystem. Concordantly, technology developers are supporting elements that provide AI, the internet of things, social media, digital platforms, and big data analytics technological lat structures for innovations that change the processes in the sector, introduced by Fintech start-ups, together with the progress in information and communication technologies (Bethlendi & Szocs, 2022). These companies can be IT companies, telecom service providers, as well as some technology start-ups and large companies as technology developers (I. Lee & Shin, 2018). Innovations introduced by technology-developing actors have caused radical changes in the sector. Especially the development of mobile and wearable technologies and their adaptation to the sector with changing economic and financial approaches have an important place in the development of the ecosystem (Yazıcı, 2022). In addition, social media platforms, crowdfunding, especially P2P lending as the most common crowdfunding product, distributed ledger technologies, transfer and trading technologies that allow customers to make instant

transactions, and cloud computing have been innovations introduced by technology makers as technologies that pave the way for more efficient operational transactions (I. Lee & Shin, 2018).

2.2.2.4. Fintech Customers

Fintech customers, which are the source of income for fintech companies, generally consist of two basic groups, individuals and organizations (Bethlendi & Szocs, 2022; I. Lee & Shin, 2018). Although organizations are an important source of income within the ecosystem, these groups are also the main source of income, as usage and adoption are more common in individual customers and SMEs (I. Lee & Shin, 2018). However, while the adoption rates of Fintech increase every year, it has been revealed that its widespread use as a demographic feature is most common among the young, technology-informed, urban population aged between 18 and 38 (Holland Fintech, 2015).

2.2.2.5. Traditional Financial Institutions

Traditional financial institutions are also one of the important drivers of Fintech. These institutions are banks, insurance companies, and other intermediary institutions and organizations. Although they have a competitive advantage over Fintechs in terms of being dominant in the sector due to their widespread use and adoption among financial participants, due to the distruptive effect of Fintechs, these organizations also needed to develop new strategies by updating their existing positions (I. Lee & Shin, 2018). Especially after the 2008 GFC, the decline in trust against traditional financial institutions and countries' stricter regulation and supervision of these institutions in the aftermath of the downturn, customer demands that could not be met within the ecosystem have been compensated by Fintech product and service provider technology companies and start-ups and the services they offer such as P2P lending and robo-advising (Bethlendi & Szocs, 2022). Initially in competition with start-ups, these institutions and organizations have evolved to collaborate and partner with them in the process of updating existing business plans and transitioning to technology-based systems and performance-enhancing applications (Alt et al., 2018). In the Fintech ecosystem, strong traditional financial institutions' collaborations with start-ups pioneer innovations that will ensure the sustainability of the ecosystem (I. Lee & Shin, 2018).

2.2.3. Banking

The impact of financial innovations and emerging technology on factors such as banks' service, operational activities, efficiency, assets, etc. are still research gaps in the literature. The impact of technology on banks has been discussed within the framework of an innovation-growth or an innovation-fragility perspectives (Lee et al., 2021). Within the scope of the innovation growth approach, it has been revealed that banks have increased their product and service diversity (Berger, 2002) risk management capability (Allen & Gale, 1994) and ability to develop asset management strategies (Houston et al., 2010) through technology-based innovations.

In contrast to the positive effects of technological innovations on banks and indirectly on the financial system via the innovation growth approach, the innovation fragility perspective has indicated that the excessive risk assumed with overconfidence brought about by banks' increased risk management capabilities with the widespread use of financial technologies has triggered financial crises by causing credit expansion (Brunnermeier et al., 2012).

After the 2008 GFC, the decline in trust in banks, the decrease in loan approval rates as a reflection of strict banking regulations, the high transaction costs charged by traditional banks to customers, the decline in service quality, the increasing demand of millennials and Generation Z for technology-driven solutions, and the inability of traditional banking and financial approaches to improve financial inclusion in geographies with low financial participation have led to the adoption of Fintechs in banking (Murinde et al., 2022).

FSB (2017) states that with Information and Communication Technology (ICT), Fintech increases efficiency in all processes from operational transactions to product and services in the sector, not only reducing the information asymmetry between the parties but also eliminating the intermediary in financial transactions. In addition, technologies used in data analytics such as big data, cloud computing, ML, and IoT are used in banks' credit monitoring systems (Dachyar et al., 2019) and in ensuring effective communication between departments by increasing operational efficiency (International Monetary Fund & World Bank, 2019).

In addition, it has also been revealed that banks that use Fintech technology effectively have also increased their risk management capabilities (Norden et al., 2014). In addition to all these, the 2008 GFC and its causes have led to a more frequent focus on the negative

effects of financial innovations as well as their positive aspects (Lee et al., 2021). The fact that technology has increased the effectiveness and efficiency of businesses in different fields has also led them to generate profits with high leverage ratios. This has brought with it vulnerability and high risk (Norden et al., 2014).

Fintech has also led to significant declines in traditional banks' credit volumes. Buchak et al (2018) found that Crowdfunding as a fintech instrument increased their market share from 30% in 2007 to 50% in 2015, while banks' paperwork and bureaucratic burdens and banking regulations were among the major reasons for their declining share in the sector.

Along with the rise of Fintech in the banking sector, new generation banks such as "neobanking" and "challenger banking", which emerged in the UK, have also played an important role in the transformation of traditional financial intermediation (Yıldız, 2022). The differences between neo banking and challenger banking emerge in three areas: banking license ownership, target customer base and branch banking (Yıldız, 2022).

While neo banks do not have a banking license, challenger banks have a banking license (FT Partners, 2020). In this respect, Navaratti et al (2018) compared Fintechs that do not have a banking license to “full reserve” or “narrow banks”, and stated that by pooling the funds, customers can access them whenever they need, but they cannot use these funds to provide illiquid loans or acquire fewer liquid assets. In this case, neobanks are required to cooperate with financial intermediaries that have a banking license to offer banking products. Having a banking license for challenger banks eliminates the obligation to cooperate with any intermediary institution to carry out banking activities. With these aspects, neo banks show the characteristics of technology start-ups in the field of Fintech, while challenger banks have features closer to banks as traditional intermediary institutions. However, while the target customer mass of neo banks is SMEs and entrepreneurs, challenger banks deal with customers from every segment. In addition, as challenger banks have a small number of branches, neo banks only serve on online and digital platforms.

The rise of next-generation mobile and digital bank networks, such as neobanks and challenger banks, has emerged and spread in developed countries with high smartphone ownership and financial literacy. In Europe, the first country to stand out in this regard was the UK with Monzo and Atom. The UK was followed by Germany with N26, Fidor and Penta, while the US lagged behind European countries in next generation banking. In Latin America, Nubank is seen as an important opportunity to increase financial inclusion

in a region where unemployment and interest rates are high and financial exclusion has reached 40% (Yıldız, 2022).

The area where Fintech compete destructively with banks is the "liquidity provision" function. After the 2008 GFC, banks' inclusiveness was severely restricted with increased controls and tightened regulations on banking (Murinde et al., 2022). This pressure on traditional banks has enabled new generation banks to increase their influence in the market. The limited access to financial products and services due to the geographical characteristics of some developing countries, the strict regulations imposed on them, and the low transaction costs that Fintech firms charged to customers compared to traditional intermediaries increase the ability of new generation banks to compete with traditional solutions (Murinde et al., 2022).

Tang (2019) argues that in the crowdfunding, where banks and Fintech compete the most, Fintechs are not competitors or substitutes for banks, but rather complements them. However, Thakor (2020) argues that whether crowdfunding platforms have the potential to be substitutes for banks depends on their funding costs, collateral requirements, and widespread use and adoption by financial participants. Similarly, Navaratti et al (2018) argues that the fact that Fintech do not have access to Central Bank liquidity like traditional banks leads to limited liquidity access for Fintech, and therefore Fintech cannot be seen as substitutes for banks.

Thakor (2020) also stated that the impact of Fintech on traditional banks will vary depending on the economic characteristics of the countries. In payments, Fintech solutions are increasing their widespread use due to their critical role in increasing financial inclusion in developing countries. At the same time, cryptocurrencies, blockchain and smart contracts are examples of financial disintermediated transactions where banks are eliminated in terms of monitoring transfer transactions (Murinde et al., 2022).

2.2.4. Insurance (InsurTech)

The impact of technology on the financial sector first emerged in the banking and rapidly spread to the insurance and securities. Insurtech refers to the use of next-generation technological innovations such as big data, blockchain, and ML in the insurance sector to effectively analyze risk, reduce costs, create new products, and increase the efficiency of existing products (Cappiello, 2018).

Compared to Fintech, insurtech aims to improve the services provided to individuals rather than businesses (OECD, 2018). However, the use of technological innovations and digitalization in the insurance sector is not solely attributed to technological progress, as is the case in finance. The evolving technology-oriented preferences of millennials and Generation Z and their quest to reduce costs in the insurance sector are also among the factors accelerating the digitalization process (Yazıcı, 2022).

In insurance, the processes generally start with product development and consist of managerial phases such as value chain, pricing and underwriting, distribution and claims management. This process is handled with two different approaches: classical and modern (Yazıcı, 2022). The classical approach is based on creating a product and risk profile suitable for the identified segments. At this stage, insurance companies create a general profile with tables such as underwriting and mortality tables based on actuarial formulas according to risk and insured's characteristics such as age and gender (Chowdhury et al., 2019).

According to modern approach, on the other hand, products are developed in micro-segments or personalized dimensions, and often the customer can even design products in line with their own preferences (Yazıcı, 2022). Technological innovations such as intelligent analysis techniques, predictive modeling and connected telematics devices, cloud technology, ML, IoT, etc. enable insurers to create products and set premiums based on actual risk profiles rather than standards as in the classical approach, thus enabling the creation of personalized insurance models (Cao et al., 2020).

Insuretech plays an important role in improving the insurance ecosystem and solving common problems in the industry (Xu, 2017). Although Insuretech is making rapid progress as an emerging industry, the application of the technology in the insurance has long been of great interest. Stoeckli et al. (2018) predicted that the use and advancement of technology in data acquisition and analysis would lead to better solutions in insurance. Based on this, it can be said that the first applications of technology in this sector were limited to data analysis (Cappiello, 2018). However, today, a wide range of technological innovations are used for different purposes in different areas of it.

Yan et al. (2018) stated that big data, internet of things, car-networking and blockchain technologies are the top 4 innovations transforming the insurance industry. Yao et al. (2021) stated that the wide range of technological innovations, including blockchain, AI, internet of things, cloud computing, big data, smart vehicles, driverless cars, drones and

wearable devices, will profoundly affect the insurance industry in different areas such as product development, marketing and distribution of products and services, business operations and customer relations.

The fact that the insurance relies heavily on data acquisition and data analysis for risk assessment brings big data and blockchain technologies to the forefront among these technological innovations (OECD, 2018). Big data technology helps to analyze and process data and draw conclusions that will enable decision-making and strategic business development (Chowdhury, Mayilvahanan and Govindaraj, 2020). Data mining plays an important role in areas such as risk assessment, fraud, product development, customer profiling (Awotunde et al., 2021).

Recently, analyses on large data sets have also been used for fraud detection and ML has come to the forefront in this regard (Rawat et al., 2021). Moreover, AI is a technology used as a supportive technology in all processes in the insurance industry. In addition to accelerating insurance processes and increasing efficiency, AI has also been an innovation that has been used effectively in risk selection and pricing strategies (Larson & Sinclair, 2021).

Furthermore, digitalization in insurance is used effectively not only in the development of new products but also in increasing the efficiency of existing products and improving existing risk premium setting practices (Rawat et al., 2021). For example, telematics devices are used to determine risk premiums by setting appropriate pricing according to risk groups (OECD, 2018). Particularly in motor vehicle insurance, these innovations allow for accurate and personalized pricing by collecting driving measurement data such as the driver's location, speed, driving frequency, behavior in dangerous areas, braking rates, etc., instead of limited and general information such as car model and driver age (Eling & Lehmann, 2017). Indeed, technological innovations enable new products to be developed and product portfolios to be expanded by insuring risks that were not covered by insurance until now (Stoeckli et al., 2018).

2.2.5. Asset Management

Progress based on technology-based innovations in finance is seen in banking, insurance, payments systems and asset management (Metha et al. 2019). The introduction of technological innovations in asset management started later than digitalization in banking (Deliotte, 2016). The technological progress in this field is based on the use of Information Technology (IT) tools for digital investment advice (Kordela, 2018). During this period, digital-based technological innovations were used by investment professionals to recommend specific portfolios based on investors' risk and return levels (Kordela, 2018). After the 2008 GFC, digital asset management, like Fintech in general, experienced rapid growth (Sironi, 2020).

The transformation in asset management is not only a technology-driven change, but also a transformation in terms of demand, where new participants are added and the need for innovation and progress emerges with the increase in the asset portfolio under management (Boreiko & Massarotti, 2020). Metha et al. (2019) attributes the dynamics of the transformation to households' increasing cash, gaps in financial literacy and increasing life expectancy.

Cocca (2016) describes two types of innovation used effectively in asset management. The first one is the establishment of virtual communication with the investor by transferring face-to-face meetings, which is the traditional advisory activity, to digital channels. The second is the virtualization of advisory content, which is also referred to as robo-advisory. Robo-advisory is based on AI as a driving technology that has caused serious transformations in Fintech (Isaia & Oggero, 2022).

Various factors such as the increase in international regulations to protect investors such as the US Financial Industry Regulatory Authority, the UK Retail Distribution Supervision, the European Market Financial Products Directive, the widespread use of mobile phones, mobile financial applications, smartphones and internet access, the increasing awareness and sophistication of retail investors, and the considerable growth of assets under advisory have facilitated the spread of Robo-Advisors internationally (Boreiko & Massarotti, 2020).

Kordela (2018) defines robo-advisory as computer programs that support financial asset and wealth management advisors. One of the detailed definitions in the literature is put forward by Sironi (2020). Sironi (2020) defines robo-advisory as automated investment

solutions that deal with individuals guiding them through the valuation process and shaping their investment behavior towards the emerging goal-oriented decision-making method, using digital tools that emphasize enhanced customer experience, appropriately supported by portfolio rebalancing techniques using trading algorithms based on passive investment and diversification strategy. The striking phrase in Sironi's definition is goal-based decision making. Goal-based decision making puts individuals at the center of investment decision-making processes and considers the real risk for individuals not as market fluctuations but as the possibility of not achieving their personal goals (Sironi, 2020).

Goal-based asset management can be defined as a process that focuses on both the short- and long-term targets of investors, rather than risk/return trade-offs or comparing your performance to traditional market benchmarks such as the Standard & Poor's (S&P) 500 (Das, 2019). Goal-based investing heralds a serious transformation in asset management as it moves asset management away from the advisor-centered approach of modern portfolio theory to a client-centered hierarchy of goals (Shefrin & Statman, 2000). Robo-advisory is important in terms of institutionalizing the goal-oriented investment approach and making it accessible to financial advisors and end investors (Sironi, 2020).

The adoption and widespread use of robo-advisory services within the sector has been quite slow (Boreiko & Massarotti, 2020). Belanche et al (2019) attribute the late adoption of robo-advice to the reluctance of clients who want to invest their funds in investment instruments to delegate a process that is carried out by communicating with individual financial advisors to AI and robot technology that they are not used to. Furthermore, gaps in service security and digital literacy also affect widespread adoption (Lee et al., 2021).

2.2.6. Others

Today, Fintech offers solutions that increase transparency, efficiency, and security in different fields besides banking, insurance, and asset management with its different instruments (Breidbach et al., 2020). Blockchain (Bonneau et al., 2015; Risius & Spohrer, 2017), crowdfunding platforms (Coakley & Huang, 2020; Langley & Leyshon, 2021) and regtech (Arner, Barberis, et al., 2017b; Grassi & Lanfranchi, 2022) applications have had an impact on many different areas from financial markets to regulations.

With the security, transparency and efficiency it provides, blockchain, which has become well-known with Bitcoin, is the basis of many innovations used in areas such as auditing,

insurance, logistics, supply chain finance (Bonneau et al., 2015). Contrary to popular belief, blockchains and cryptocurrencies are two different things (Das, 2019). A blockchain is a decentralized ledger with decentralized verification, immutable and trusted, and also decentralized on a P2P network (Yan & Zhou, 2022; Zhang et al., 2016). Similar to fiat currencies, cryptocurrency is a medium of exchange, legally a security and an asset class (Androulaki et al., 2013; Bonneau et al., 2015; Miers et al., 2013). Transactions on cryptocurrency are recorded on the blockchain (Brennan et al., 2019)

Cryptocurrencies have come into the center of attention with the widespread use of bitcoin (Burniske & Tatar, 2018). The software and processes related to Bitcoin were first defined by Satashi Nakamoto in 2008 and are currently operated by the "network". The main purpose of Bitcoin or other coins, also known as altcoins (alternative coins), is to reduce transaction costs in an intermediary-free environment by removing financial institutions as intermediaries (Burniske and Tatar, 2018). In addition, the virtuality of cryptocurrencies and their easy accessibility, which is not dependent on any central or regional authority, allows cryptocurrencies to become a global financial asset that can be accessed from multiple locations around the world while providing unlimited production (Gandal et al., 2021).

Although the lack of a central authority may lead investors to think that cryptocurrencies are insecure, this feature also makes cryptocurrencies traceable (Bonneau et al., 2015). Androulaki et al. (2013) states that the flexibility, divisibility, easy access, portability, liquidity and low transaction costs of cryptocurrencies accelerate their widespread use and adoption. Although the awareness of cryptocurrencies has increased in the last 10 years, cryptocurrencies have been in the financial system since the 1980s, with the first examples being Digicash and Ecash (W. Yan & Zhou, 2022). However, the early examples failed to solve the problem of double spending by allowing multiple spending with the same digital key (Bonneau et al., 2015).

Bitcoin has become widespread and well-known by solving the double-spending and Byzantine General's problem (how do you establish trust between parties that do not know anything about each other?) that its predecessors failed to solve (Nofer et al., 2017). In these ways, bitcoin is a borderless, network-secured currency that is not influenced by any central financial institution or government (Brennan et al., 2019) .

Coins other than Bitcoin, such as Ethereum, Ripple, Binance, Cardano, Litecoin, Monero, Zcash are known as altcoins (Nofer et al., 2017). Although altcoins are all part of the cryptocurrency market, they have different characteristics (Crosby et al., 2016).

Altcoins are divided into those that have an independent distributed ledger and those that do not and follow bitcoin's open source protocols with minor changes to the underlying code (Narayanan et al, 2016). Ethereum and Ripple are examples of coins in the first category, with an independent distributed ledger, while Litecoin is one of the main coins in the second category (W. Yan & Zhou, 2022). Most cryptocurrencies are pseudo-anonymous while using smart contracts to protect users (Nofer et al., 2017). However, cryptocurrencies and markets have been discussed for their security and decentralization by Barber et al. (2012), Corbet et al. (2018).

Crowdfunding platforms are another innovation where fintech has led to significant changes in finance (Cai, 2018). There are different definitions of crowdfunding in the literature (Coakley & Huang, 2020; Cumming & Schwienbacher, 2018; Lacasse et al., 2016; Langley & Leyshon, 2021; Mollick, 2014). Lambert and Schwienbacher (2010) define crowdfunding as an announcement to solicit funds in the form of donations or in exchange for some kind of reward and/or voting rights to support initiatives and activities for specific purposes.

Mollick (2014) offers a different perspective and defines crowdfunding in the context of entrepreneurship as an attempt by entrepreneurial individuals and/or groups to fund their ventures with small contributions from a relatively large number of individuals using information technologies other than traditional financial intermediaries. This definition also refers to the disruptive impact of crowdfunding, as a disruptive innovation, on the intermediation functions of traditional financial institutions.

Langley (2016), on the other hand, defines crowdfunding as activities in which the resources provided by individuals who want to utilize the funds they have are brought together and transferred to individuals, institutions, small and medium-sized enterprises, projects, charities, and charities that request funds through online platforms. With this definition, Langley (2016) paved the way for the classification of crowdfunding into 5 categories. Coekley and Huang (2020) define crowdfunding as the financing of projects by a large number of individuals through digital platforms that serve as electronic marketplaces.

In the functioning of crowdfunding instruments, those who request funds usually announce these needs through social media, while requests are usually communicated on a project basis (Langley, 2016). The most important feature of crowdfunding is that the funds are not provided by any bank, official organization, government or any other financial institution (Mollick, 2014). In this case, crowdfunding requires the maturity matching and debt leverage required by banking (Mollick, 2014).

There are different classifications of crowdfunding (Belleflamm et al., 2010; Langley, 2016). Belleflamme et al.(2010) categorized crowdfunding into two groups: investment-based crowdfunding and reward- and donation-based crowdfunding. The first group, investment-based crowdfunding, consists of equity-based, royalty-based and lending-based crowdfunding, while the second group, donation-based crowdfunding, does not provide any monetary return, but usually gives tokens to investors as a reward (Belleflamm et al., 2010). Langley (2016) mentions 5 types of crowdfunding economics in general. These are donation, reward, fixed income, equity and peer to peer (P2P).

Reward based crowdfunding is a flexible financial model and can be a product, a work of art or another bonus depending on the size of the investment (Cai, 2018). It is based on the idea that in exchange for donations raised for a specific project, the project owner offers small non-financial rewards to the funders (Belleflamm et al., 2010).

Donation-based crowdfunding is often used by non-governmental organizations to raise funds for specific social projects (Rijanto, 2021; Zhang et al., 2016).

Equity based crowdfunding on the other hand, enables SMEs that have difficulty finding funding from traditional financial institutions and organizations and the public to access the necessary equity capital through an internet platform (Moritz et al., 2015). Although it brings financial risk for investors, equity crowdfunding is seen as a Fintech instrument that can be very effective in funding ideas and innovation, financing entrepreneurs, contributing to economic growth and democratizing investment supply and demand (Wasiuzzaman et al., 2021).

Fixed income based crowdfunding, similar to equity funding, refers to a crowdfunding tool similar to VC based on the use of fixed interest rate instruments such as debentures and minibonds in return for funds raised for equity offerings and project financing (Langley, 2016). In equity and fixed based income crowdfunding, funders are referred to as investors, not supporters, backers or fans as in reward based or donation (Cai, 2018).

P2P lending is the most widely known crowdfunding instrument. Along with equity crowdfunding, P2P lending is one of the for-profit crowdfunding instruments (Coakley & Huang, 2020) and, similar to banks, it performs a loan-like function by providing financing to those in need of funds (Thakor, 2020). The 2008 global financial crisis led to a decline in trust in traditional financial institutions (Knell & Stix, 2015; Sapienza & Zingales, 2012) and increased and tighter financial regulations and restrictions on the distribution of funds have led to the widespread use of P2P lending platforms (Thakor, 2020). P2P lending involves mass and financial institutions providing loans to small businesses or consumers (Langley, 2016). P2P lending markets are a simple online platform that brings together individuals looking to invest and SMEs in need of funding (Coakley & Huang, 2020). SMEs pay a fee to participate and benefit from this platform, while investors who want to lend funds do not need to pay any fee (Langley, 2016).

Technological innovations such as data mining (Mehrban et al., 2020), extraction of textual features from borrowers' characteristics (Zhang et al., 2021), big data technology (Guo et al., 2019), and deep learning (Huang et al., 2020) are used in risk assessments to minimize the risk assumed by funders, which is the most critical issue in P2P crowdfunding. P2P markets were first introduced in the United States and the UK, which have developed and efficient financial markets and effective law enforcement, and subsequently spread to North America, Europe, Asia and Oceania (Esposti, 2014; Suryono et al., 2020).

As financial systems evolve from know-your-customer to know-your-data with intech, emerging innovations reveal weaknesses in existing business models and increase the burden on traditional financial institutions and organizations (Anagnostopoulos, 2018). Moreover, the burden on regulatory and supervisory authorities to monitor effectively and efficiently is also increasing. The dominance of data in finance and the audit burden it brings necessitates a completely new regulatory paradigm that will extend far beyond the financial sphere (Arner, et al., 2017).

There is increasing pressure in finance to move away from regulations designed to address human behavior to regulations that aim to oversee technology-driven financial transactions and processes (Grassi & Lanfranchi, 2022). This pressure has necessitated the emergence of fintech, which focuses on making regulations more effective and efficient than the status quo, as well as Regtech, which supports and complements Fintech (Arner, et al., 2017b). Regtech is an acronym for regulatory and technology, and includes

any use of technology to automate compliance, oversight and regulatory processes by transforming structured and unstructured data into meaningful, reportable and decision-useful information for both regulators and businesses (Arner et al., 2016).

Although the emergence of Fintech and its spread in the markets necessitate the development of Regtech, the reasons that triggered the emergence of both are different from each other. Arner et al. (2017b) state that the reasons for the emergence of Regtech are the increase in the demand for additional data and information by the supervisory institutions after the global financial crisis, AI, deep learning, data science innovations that allow data to be structured, and the quest of financial institutions and organizations to reduce compliance costs, the desire of regulators to increase the efficiency of audit mechanisms to ensure financial stability and market integrity created the need for Regtech.

The factors that accelerate the emergence and adoption of Fintech are; The lack of confidence in the financial sector, especially in the USA and the EU, and the need for alternative financing sources as a result of the tight regulations in the financial sector after the crisis, the evaluation of the skills of financial experts who lost their jobs after the crisis in start-up and technology companies is listed as the widespread use of the internet and technology, especially mobile and smartphones (Arner, et al., 2017a).

Nevertheless, especially after the 2008 GFC, Fintech emerged as a response to the bottom-up demands led by IT firms and start-ups, while Regtech emerged as a response to top-down institutional demand (Anagnostopoulos, 2018). Therefore, Regtech covers three different market participants (Arner, et al., 2017a). The first of these is financial institutions and organizations. Financial institutions and organizations needed technology more with the increasing regulations with the financial crisis. Similarly, regulators' need for technology is increasing to fulfill their monitoring, auditing, and enforcement requirements in rapidly developing, deepening, and big data-based markets. Finally, governments and policymakers will need Regtech to create the infrastructure necessary to rapidly transform and regulate financial systems based on technological innovations, analysis of emerging data, demand for transparency, transaction speed, and volume (Arner et al., 2016).

Another important effect of Fintech on the financial industry is the emergence of the Decentralized Finance (DeFi) movement, which aims to transfer power to users by taking

power from intermediaries, that is, traditional financial institutions and organizations, in the financial field, which is also pioneered by Blockchain technology (Sert, 2022).

Chen and Bellavitis (2020)and Cong and He (2019) claimed that applications that are not dependent on a central authority such as blockchain and cryptocurrencies can lead to the emergence of a new financial system that will allow financial transactions to take place more freely and directly. In this respect, DeFi is a blockchain-based financial infrastructure built on public smart contract platforms such as Ethereum, Bitcoin, and Blockchain (Buterin, 2014). In particular, DeFi does not rely on intermediaries and central institutions but instead provides a solution to the trust problem between parties based on open protocols and decentralized applications (Schär, 2021).

The mainstay of all DeFi protocols is smart contracts (Schär, 2021). Smart contracts, on the other hand, refer to small applications that are usually stored on a blockchain and executed in parallel by a large set of validators (Ahluwalia et al., 2020). The most important effect of DeFi in the financial system is on the intermediary function (Buterin, 2014). The effect of DeFi on the mediation function is shaped by two main streams in the literature (X. Yang et al., 2020). The first of these is that DeFi is a progress that will ensure financial democratization by neutralizing the intermediary function (Zetzsche et al., 2020). This view also refers to the disruptive innovation aspect of DeFi and predicts a radical change within the system (Tripathy & Jain, 2020). This view, which rejects a third party and intermediary in financial transactions, also considers disintermediation among the main features of DeFi (Ahluwalia et al., 2020)

The basis of DeFi's destructive effect is the possibility of creating a free, open financial system in which traditional intermediary institutions and organizations have limited or completely disappeared, thanks to the blockchain (Chen & Bellavitis, 2020; Perlman, 2019). As a matter of fact, Blockchain technology eliminates intermediaries with the decentralized platforms it provides, enabling P2P transactions to be carried out without the need for a third party (X. Yang et al., 2020). Accordingly, Tripathy & Jain (2020) and (Schär, 2021) argue that in the Defi environment, where traditional intermediary institutions such as banks and exchanges disappear, cryptocurrencies and smart contracts will replace these institutions. Another trend that deals with the effect of DeFi on the mediation function focuses on the transformative effect of DeFi rather than its destructive effect. This view supports that DeFi will not abolish financial intermediation and that a

decentralized system cannot create a monopoly by concentrating power in one organization (Zetzsche et al., 2020).

CHAPTER 3. APPLICATION OF CONSTRUCTING GLOBAL FINTECH INDEX

Composite indicators are widely used in social and economic studies and have recently come to the fore as a method of systematic inquiry and knowledge discovery (OECD, 2008). The ever-increasing diversity of information can increase the complexity and the difficulty of interpreting phenomena. This situation may lead to the need for a composite indicator that will cover all the necessary information about a subject that is generally multidimensional in nature (M. Greco et al., 2016). In the abundance of indicators that come with technological innovations, expressing multidimensional phenomena in the form of a single number that gathers them under a single umbrella can also facilitate the understanding of complex concepts (Saltelli, 2007). Along with the need for a composite indicator; How to create an indicator that will express the facts expressed in different dimensions with a single number?, What aspects of the concept it expresses? How to combine the different dimensions in a way that can be interpreted by the public? These questions also provide a detailed explanation of the concept of "composite indicators"(Booysen, 2002).

Composite indicators are increasingly recognized as a useful tool for comparative analysis of countries' performance in economic, financial, technological, environmental and social sphere, for policy-making and for informing the public (M. Greco et al., 2016; OECD, 2008). Interpreting composite indicators is much easier than trying to find a common trend in many separate indicators. Composite indicators have proven to be useful in ranking countries in benchmarking studies. However, if composite indicators are poorly constructed or misinterpreted, they can lead to misleading or unsound policy conclusions (Sharpe, 2004). Although there does not seem to be a single official definition to explain the concept of a "composite" indicator, the literature in this field offers a wide variety of definitions (Greco et al., 2016).

Saisana and Tarantola (2016) define composite indicators as a mathematical combination of individual indicators representing different dimensions of a concept whose description is the object of the analysis. The construction of composite indicators includes the selection of indicators, compensation of missing values, choice of aggregation and weighting methods etc., which require subjective judgment. Freudenberg (2003) defines composite indicators as "synthetic indices of multiple individual indicators". In Nardo et

al. (2005), another handbook on composite indicators prepared by the European Commission, composite indicators are described as a useful tool for policy-making and public communications to convey information about countries' performance in areas such as the environment, economy, society or technological development.

One of the most comprehensive studies on the objectives and construction of composite indicators is the Handbook on the Construction of Composite Indicators, prepared in 2008 by statisticians from the OECD and the Joint Research Center (JRC) of the European Commission. (Greco et al., 2019). This Methodology and User's Guide is the first of its kind and has become a widely used standard for the development of composite indicators, describing in detail the methods and steps involved.

OECD (2008) defines an indicator as "a quantitative or qualitative measure or metric that evaluates progress towards a goal or target". OECD (2008) also states that "a composite indicator is formed when individual indicators are compiled into a single index based on a model underlying the multidimensional concept being measured". According to Barone et al. (2011) "composite indicators are indicators whose values are derived from the values of their components, and these components can themselves be composite indicators, leading to a hierarchy of indicators. Therefore, composite indicators are ideal for measuring complex and multidimensional concepts and phenomena that cannot be captured by a single indicator. While these generally accepted definitions are sound in that they take into account the quantitative and complex aspects of developing composite indicators, they are quite inadequate in that they focus only on the technical and statistical aspects of constructing composite indicators Greco et al., 2016).

Rachel Gisselquist, a researcher at the World Institute for Development Economics Research at the United Nations University, offers a broader scope and purpose in her definition of composite indicators. According to Gisselquist (2014), composite indicators combine various criteria in different ways to obtain a single score or rating. In this way, "composite indicators" or "indices" enable the assessment and comparison of multiple phenomena or dimensions of a complex, multidimensional concept. Such metrics can be useful tools for analyzing governance, assessing development priorities, generating scientific knowledge and influencing policy makers, but some are better tools than others and some are better suited to specific purposes than others. Gisselquist's definition encompasses the previous definitions' emphasis on the multidimensional and multilevel characteristics of composite indicators, while at the same time adding objectives and

decision-making processes to the scope of composite indicators. It is the purpose of composite indicators to simplify the decision-making process, but they can also be used for the purpose of influencing someone or making something happen. In addition, Gisselquist touches on the scientific knowledge creation dimension, arguing that composite indicators are more than just monitoring and reporting.

There are many different definitions of composite indicators in the literature. While a common model can be created by combining them, the number of applications of composite indicators from social aspects to governance and environment is constantly increasing rapidly (Bandura, 2011). Bandura (2011) identifies more than 400 formal composite indices that rank or evaluate a country according to some economic, political, social or environmental criteria. In a complementary report by the UNDP, Yang et al.(2018) documents more than 100 composite measures of human development.

However, their widespread adoption by global institutions such as the OECD, the WB, the IMF, the EU, and others has drawn the attention of media and policymakers around the world to the composite indicators and the benchmarking and information they provide (Saltelli 2007. However, composite indicators have not always been this popular and their use was once subject to severe criticism (Sharpe, 2004).

Considering this aspect, the advantages and disadvantages of composite indicators can be listed as follows (Saisana & Tarantola, 2016):

Advantages of composite indicators

- Simplifies the work of decision makers by summarizing multidimensional and complex problems
- It is more practical and easier to interpret a single indicator rather than trying to find the trend of different indicators individually
- Offers the possibility to compare countries on complex issues
- Provides an assessment of the progress of countries over time on complex issues
- Simplifies public communication by making complex issues more understandable

Disadvantages of composite indicators

- If poorly structured or misinterpreted, it can be misleading with incorrect policy messages
- If not used in conjunction with indicators, it can invite simplistic policy conclusions.
- If the various stages (e.g. selection of indicators, choice of model, weights) are not transparent and not based on sound statistical or conceptual principles, they may be suitable for instrumental use (e.g. they can be constructed to support the desired policy).
- It can hide serious failures in some aspect of the phenomenon and thus make it difficult to determine the appropriate corrective action.
- Ignoring the hard-to-measure dimensions of performance can lead to wrong policies.
- The choice of indicators and weights can be manipulated by policy makers. Policy makers may tend to hide serious failures in some aspects of the phenomenon, thus increasing the difficulty in determining appropriate corrective action.
- If difficult-to-measure dimensions of performance are ignored, it can lead to wrong policies.

Most of the disadvantages of composite indicators are due to the subjectivity of some stages in the construction of these indicators. While it may seem idealistic to assume that this debate will be resolved (Nardo et al., 2005), composite indicators are still attracting the attention of policy makers and the public and are applied in different fields such as sustainability (Environmental Sustainability Index) (Huang et al., 2018; Pissourios, 2013), innovation and technology (Summary Innovation Index, Innovative Capacity Index, The Networked Readiness Index etc.) (Grupp & Schubert, 2010), finance (National Financial Conditions Index etc.) (Braga et al., 2014; Brave & Butters, 2011) and environment (Air Quality Index, Environmental Performance Index, Natural Capital Index etc.) (Wiréhn et al., 2015). The subjectivity of constructing composite indicators and the possibility of manipulating the outcome if the procedures followed are not clearly and reasonably justified for everyone are often criticized (Grupp & Schubert, 2010). Trying to find a solution to this problem, the OECD (2008) defines a ten-step process,

namely a “checklist”, in order to establish a common guideline and increase the transparency and robustness of the process as a basis for the development of composite indices. This checklist is noted to help the developer better understand the benefits and drawbacks of each option and to provide the necessary consistency in the overall steps of creating a composite index (S. Greco et al., 2019). According to OECD (2008)’s guide for creating composite indicators, the process of constructing composite indicators is “developing a theoretical framework”, “variable selection”, “imputation of missing data”, “multivariate analysis”, “normalisation of data”, “weighting and aggregation” is addressed as “uncertainty and sensitivity” and “presentation”

In this part of the study, based on the OECD (2008) guidelines for constructing composite indicators, the steps followed were determined as follows: 1- Defining the concept to be measured (FinTech) 2- Indicator selection and data collection 3- Normalizing the data 4- Grouping the indicators 5- Weighting the indicators 6- Construction of Global Fintech Index 7- Interpretations of the results and visualization 8- Policy path trajectory for Fintech development based on Reinforcement Learning (RL)

3.1. Defining the Concept of FinTech

Composite indicators are often used to summarize a concept consisting of a different set of individual indicators and/or variables (Booysen, 2002; Greco et al., 2016). In practice, integrating different variables in a way that accurately reflects economic, environmental, financial or technological reality can be quite challenging (Albo et al., 2019). This process, which consists of different stages, requires understanding and defining what it is to be measured as a starting point. A theoretical framework is needed to provide a basis for the selection of components and weights, combining individual indicators into a meaningful composite (Dialga and Giang, 2017). Ideally, this framework will allow for variables to be selected, combined, and weighted to reflect the dimensions or nature of the phenomenon being measured (Greco et al., 2019). The variables chosen should carry information about the principal components and be based on a paradigm of the phenomenon being analyzed. It is this framework that shows which variables to include and how to weight them (Nardo et al., 2005).

The strengths and weaknesses of composite indices are largely due to the quality of the underlying variables that summarize complex information that is valuable to the observer (Saltelli, 2007). Before selecting the indicators that will make up the composite index, a

precise definition of the concept to be measured should be established (OECD, 2008). This process is important because it forms the basis for the selection of the indicators that will form the index. When defining the exact concept to be measured, answering questions such as “What is the purpose of the index?”, “What is the exact definition of the phenomenon it aims to measure?”, “What role does it play in the context of decision making and problem solving?” can facilitate the definition phase (Greco et al., 2019).

In this methodological context, firstly, the definition of Fintech is presented within the framework of the literature review and the theoretical scope in the Chapter 1.

There is no agreed definition of "FinTech", which is a combination of the words "Finance" and "Technology" (Milian et al., 2019). This is understandable for innovation based on a rapidly evolving concept such as technology (Liu et al., 2020). However, some institutions and organizations and academics have developed definitions for it. Fintech definitions in the literature can generally be grouped around three different classifications. The first of these definitions is the approaches that express Fintech as companies that create technologies used in finance and are mostly start-ups (Haddad & Hornuf, 2019; Laidroo & Avarmaa, 2020). This approach is based on the assumption that Fintech businesses are start-ups, ignoring large financial service providers that use new digital technologies or offer similar services (Haddad & Hornuf, 2019).

Another approach defines Fintech as a combination of different business models using financial innovation and technologies (Lee & Shin, 2018; Liu et al., 2020). These business models reduce the cost of financial transactions, facilitate access to financial services and improve the quality of services and products (International Organization of Securities Commisssions (IOSCO), 2017).

Finally, Fintech is defined in terms of financial technology, innovation and digital technologies that enable the creation of financial products, business models and processes. The broadest definition in this context is the Financial Stability Board (2017). According to this definition, Fintech is "technologically enabled financial innovation that can result in new business models, practices, processes or products that have a significant impact on financial markets and institutions and the provision of financial services".

Accordingly, as the starting point of the Global Fintech Index, “Fintech” is technological, digital-based financial innovations and applications that support the sustainability of traditional financial institutions/organizations, improve their products and services, also

cause a disruptive impact and radical changes with the new challenging products and services in financial markets and industry.

3.2. Indicator Selection and Data Collection

There are a number of criteria to be considered in the selection of indicators and these criteria also affect the reliability of the composite indicator (Nardo et al., 2005). Data selection, availability and reliability, statistically significant aggregation and interpretation are among the important constraints of this step (Liberati et al., 2020; Wong, 2006). Due to all these constraints and the impact of indicator selection on the reliability of the composite index, the selection of indicators is a process that needs to be carefully evaluated.

Herein, different evaluation criteria have been proposed for indicator selection processes. For example, the OECD's (2008) user guide on the construction of composite indicators emphasizes that indicators should be selected on the basis of their analytical robustness, measurability, country coverage, relevance to the phenomenon being measured, and interrelationships. In cases where data are insufficient, the use of proxy variables is offered as a solution. Nevertheless, the use of survey data offers valuable opportunities to extend existing data sources for measuring indicators. However, it is also important to recognize that the use of survey data requires significant effort to ensure the robustness and consistency of modeled values across areas and over time (Liberati et al., 2020; Wong, 2006).

There are two general approaches to indicator selection. In the deductive approach, known as the theoretical approach, indicators focus on selecting the most appropriate indicator based on theory, while in the data-driven deductive approach, data accessibility and data availability are the main selection criteria (Greco et al., 2019).

Selection criteria is a guiding exercise to determine whether an indicator should be included in the overall composite index, based on the definitions of the concept and subgroups to be measured. This stage should be as precise as possible and accurately describe the phenomenon being measured, i.e. the input, output or process (OECD, 2008).

After defining the phenomenon to be measured within its theoretical framework, the next step is to collect the most complete and high quality data set possible. The strengths and weaknesses of composite indicators are largely due to the quality of the underlying variables (Greco et al., 2016). Ideally, variables should be selected on the basis of their

suitability, analytical robustness, timeliness, accessibility, etc. In general, composite indicators use two types of variables: soft data and hard data (Nardo et al., 2005).

In line with the aims of the study and the definitions of the concept and subgroups, the subjective data collected through the survey are called "soft" data, while the statistical data collected by independent organizations are called "hard" data Greco et al., 2016).

Given the scarcity of internationally comparable quantitative (hard) data, composite indicators often include qualitative (soft) data from surveys or policy reviews (OECD, 2008). Proxy measures can be used when the desired data are not available or when cross-country comparability is limited (Nardo et al., 2005; OECD, 2008). This stage of constructing a composite indicator should be based on analytical soundness, measurability, country coverage and the relevance and interrelationship of the indicators to the phenomenon being measured.

In this dissertation, a theory-driven approach was followed in the selection of indicators. Within the scope of this approach, it is aimed to understand the determinants by using the definition of Fintech, and to determine and select indicators with scientific validity and impartiality that can express them. Moreover, we have tried to consider as many dimensions of Fintech as possible and to keep the number of indicators as large as reliable and data accessible in order to express the real situation.

Identifying the determinants of Fintech requires the selection of indicators based on a multifaceted and comprehensive literature review. In this respect, the fact that the selected indicators are included in the literature also constitutes the theoretical infrastructure of the study. This theoretical background also means that the indicators that are the determinants of Fintech will represent current conditions in the best possible way. Furthermore, attention has been paid to ensure that the selected indicators are clear, measurable at regular intervals, and easily understandable by policy makers and decision makers. During the selection of indicators, a detailed literature review was conducted on the one hand and the availability of data on the other. As a result, some indicators were not included in the study due to the unavailability of data.

As a result of the detailed literature review, a data pool consisting of 146 variables covering 170 countries between 1996 and 2021, which can be categorized under financial, economic, social and technological headings, has been created. The database also includes proxy indicators for some variables. As a result of the indicator selection based

on the availability, usability and reliability of the data, and the statistically meaningful integration and interpretation of the data by taking into account the maximum year, country and variable for each country, 53 indicators covering 120 countries for 2021 were finally determined to construct a composite indicator.

In *Table 8*, the indicators determined to construct the Global FinTech Index and the theoretical basis on which it is based are given.

Table 8

Measurement Units and Data Sources of Indicators for FinTech Index

Variable	Units	Source	Reference
Urban population	% of total population	The Internet Inclusive Index of Economist	Holland, FinTech, (2015)
Labour force participation rate	Labor force participation rate, total (% of total population ages 15+) (modeled ILO estimate)	International Labour Organization	E&Y (2016), Haddad & Hornuf (2019)
Level of literacy	% of population	The Internet Inclusive Index of Economist	Panos & Wilson (2020)
Education attainment	Years of schooling	The Internet Inclusive Index of Economist	Mendonça & Grimpe (2016)
Government e-inclusion strategy	Qualitative rating 0-2, 2=best	The Internet Inclusive Index of Economist	Feyen et al. (2021)
Support for digital literacy	Qualitative rating 0-3, 3=best	The Internet Inclusive Index of Economist	Razvan (2021),OECD (2021)
Number of commercial bank branches	Per 100,000 adults in the population	World Bank	Chinoda & Mashamba (2021), Haddad & Hornuf (2019)
Soundness of banks	(1 = extremely low—banks may require recapitalization, 7 = extremely high—banks are generally healthy with sound balance sheets).	IMF	He et al. (2017); Blaseg & Koetter (2015); Guiso et al. (2013); Schindele & Szczesny(2016)
Financing of SMEs	1–7 Score	The Global Competitiveness Report (World Economics Forum)	Haddad & Hornuf (2019), Cumming (2018)
VC investment	1–7 Score	The Global Competitiveness Report (World Economics Forum)	Haddad & Hornuf (2019), Cumming (2018)
Domestic market size index	1–7 (best) scale	The Global Competitiveness Report (World Economics Forum)	Laidroo & Avarma (2020)
Corporate Tax Rate	%	OECD	Haddad & Hornuf (2019)
R&D expenses	% of GDP	OECD	Groh & Wallmeroth (2016), Glavina et al. (2021)

ICT service export	% of service export	World Bank	Groh & Wallmeroth (2016)
Number of startup	% of labor force	Statista	Haddad & Hornuf (2019)
Mobile -cellular telephone subscription	Per 100 inhabitants	The Internet Inclusive Index of Economist	Haddad & Hornuf (2019),Glavina et al. (2021)
Internet users (percent of household)	% of household	The Internet Inclusive Index of Economist	Haddad & Hornuf (2019), Glavina et al. (2021)
Mobile phone cost	% of monthly GNI per capita	The Internet Inclusive Index of Economist	Glavina et al. (2021)
Fixed-line monthly broadband cost	% of monthly GNI per capita	The Internet Inclusive Index of Economist	Glavina et al. (2021)
Government initiatives to make Wi-Fi available	Qualitative rating 0-2, 2=best	The Internet Inclusive Index of Economist	Glavina et al. (2021)
Private sector initiatives to make Wi-Fi available	Qualitative rating 0-2, 2=best	The Internet Inclusive Index of Economist	Haddad & Hornuf (2019), Laidroo & Avarma (2021), Glavina et al. (2021), Schidler, (2017); Ernest & Young (2016), Pollari (2016), Guo et al.(2021), The Inclusive Internet Index (2021)
Network coverage 3G	% of population	The Internet Inclusive Index of Economist	Haddad & Hornuf (2019), Laidroo & Avarma (2019), Glavina et al. (2021); Ernest & Young (2016), Pollari (2016), Guo et al.(2019), The Internet Inclusive Index (2021)
Urban electricity access	% of population	The Internet Inclusive Index of Economist	The Inclusive Internet Index (2021)
Rural electricity access	% of population	The Internet Inclusive Index of Economist	The Inclusive Internet Index (2021)
ATMs per 100,000 adults	Per 100,000 adults	World Bank	Haddad & Hornuf (2019)
e-Finance content	Qualitative rating 0-2, 2=best	The Internet Inclusive Index of Economist	Glavina et al. (2021)
Number of crypto owners	% of population	Statista	Milian et al. (2019)
e-Commerce safety	%	The Internet Inclusive Index of Economist	Gai et al. (2018), The Inclusive Internet Index (2021)
Trust in online privacy	%	The Internet Inclusive Index of Economist	Gai et al. (2018), The Inclusive Internet Index (2021)
Trust in Government websites and apps	%	The Internet Inclusive Index of Economist	Gai et al. (2018), The Inclusive Internet Index (2021)
Trust in Non-government websites and apps	%	The Internet Inclusive Index of Economist	Gai et al. (2018), The Inclusive Internet Index (2021)
Affordability of financial services	1–7 (best) scale	World Bank	Gershenson et al.(2021), Guo et al. (2019), Global Financial Inclusion Database (2021)
Availability of financial services	1–7 (best) scale	World Bank	Gershenson et al.(2021), Guo et al. (2019), Global Financial Inclusion Database (2021)
Financial services meeting business needs	1–7 (best) scale	World Bank	Gershenson et al.(2021), Guo et al. (2019), Global Financial Inclusion Database (2021)
Ease of access to loans	1–7 (best) scale	World Bank	Gershenson et al.(2021), Guo et al. (2019), Global Financial Inclusion Database (2021)

Regulation	1-10 (best) scale	Fraser Institute	Rau (2017), Navaretti et al. (2017), Haddad & Hornuf (2019), Dorfleitner and Hornuf (2017), Glavina et al. (2021), Groh and Wallmeroth (2016), Giaquinto and Bortoluzzo (2020)
Corruption perception index	0-100 (best) scale	Transperancy Agency	Rau (2017), Navaretti et al. (2017), Haddad & Hornuf (2019); Dorfleitner & Hornuf (2017),, Glavina et al. (2021), Groh and Wallmeroth (2016), Giaquinto and Bortoluzzo (2020)
Legal rights index capturing the legal protection of borrowers and lenders	1-10 (best) scale	Fraser Institute	Rau (2017), Navaretti et al. (2017), Haddad & Hornuf (2019), Dorfleitner & Hornuf (2017),Glavina et al. (2021), Groh & Wallmeroth (2016), Giaquinto & Bortoluzzo (2020)
Privacy regulations	Qualitative rating, 0-2 (best)	The Internet Inclusive Index of Economist	Rau (2017), Navaretti et al. (2017), Haddad & Hornuf (2019), Dorfleitner & Hornuf (2017),, Glavina et al. (2021), Groh &Wallmeroth (2016), Giaquinto & Bortoluzzo (2020)
Financial Development Index	0-1 (best) scale	IMF	Laidroo & Avarmaa (2019)
Sound money	1-10 (best) scale	Fraser Institute	Haddad & Hornuf (2019)
Freedom to trade internationally	1-10 (best) scale	Fraser Institute	Haddad & Hornuf (2019)
GDP per capita	GDP per capita (current US$)	World Bank	Haddad & Hornuf (2019), Yartey (2007), Lee & Shin (2018)
Fixed-line broadband subscribers	Per 100 inhabitants	The Internet Inclusive Index of Economist	Haddad & Hornuf (2019), Glavina et al. (2021)
Average fixed broadband upload speed	Mbps	The Internet Inclusive Index of Economist	Haddad & Hornuf (2019), Laidroo & Avarma (2019), Glavina et al. (2021), Ernest &Young (2016), Pollari (2016), Guo et al.(2021)
Average fixed broadband download speed	Mbps	The Internet Inclusive Index of Economist	Haddad & Hornuf (2019), Laidroo & Avarma(2019), Glavina et al. (2021), Ernest &Young (2016), Pollari (2016), Guo et al.(2021)
Average mobile upload speed	Mbps	The Internet Inclusive Index of Economist	Haddad & Hornuf (2019), Laidroo & Avarma(2019), Glavina et al. (2021), Ernest &Young (2016), Pollari (2016), Guo et al.(2021)
Average mobile download speed	Mbps	The Internet Inclusive Index of Economist	Haddad & Hornuf (2019), Laidroo & Avarma(2019), Glavina et al. (2021), Ernest &Young (2016), Pollari (2016), Guo et al.(2021)
Made digital payments in the past year (% age 15+)	The percentage of population age 15+	World Bank, Global Findex Database	Millian et al. (2019), Gershenson (2021)

Secured internet servers	Per 1 million people	Financial Access Survey (IMF)	Gai et al. (2017), The Internet Inclusive Index (2021)
Digital skills among populations	1–7 (best) scale	World Bank	Giaquinto & Bortoluzzo (2020), The Internet Inclusive Index (2021)
University industry collaboration in R&D	1–7 (best) scale	World Bank	Laidroo & Avarma(2019), Glavina et al. (2021)
e-Commerce content	0-100 (best) scale	The Internet Inclusive Index of Economist	Milian et al. (2019), The Internet Inclusive Index (2021)

3.3. Normalization

The composite indicator may consist of a combination of variables with different units of measurement. In this case, when constructing an index as a composite indicator, the variables should be placed on a common basis in order to avoid confusion of measurement units (OECD, 2008).

The different normalization methods used in the construction of composite indicators are given in *Table 9* (OECD, 2008). In the study, for the normalization of the data of the countries, it is aimed to distribute the data between 0 and 1. For this purpose, the "min-max" method "according to the lowest maximum observation value" in *Table 9* was selected and used in the scaling of the data since it allows all indicators to be aggregated between 0 and 1.

Table 9

Normalizations Methods

Method	Equation
1.Ranking	$I_{qc}^{t} = Rank\,(X_{qc}^{t})$
2.Standardisation (or z-scores)	$I_{qc}^{t} = \frac{X_{qc}^{t} - X_{qc=\hat{c}}^{t}}{\sigma_{qc=\hat{c}}^{t}}$
3.Min – Max	$I_{qc}^{t} = \frac{X_{qc}^{t} - min_c(X_q^{t_0})}{max_c(X_q^{t_0}) - min_c(X_q^{t_0})}$
4. Distance to a reference country	$I_{qc}^{t} = \frac{X_{qc}^{t}}{(X_{qc=\hat{c}}^{t_0})}$ *or* $I_{qc}^{t} = \frac{X_{qc}^{t} - X_{qc=\hat{c}}^{t_0}}{X_{qc=\hat{c}}^{t_0}}$
5. Categorical scales	*Example:* $I_{qc}^{t} = \begin{cases} 0 & if \quad x_{qc}^{t} < P^{15} \\ 20 & if \;\; P^{15} \le x_{qc}^{t} < P^{25} \\ 40 & if \;\; P^{25} \le x_{qc}^{t} < P^{65} \\ 60 & if \;\; P^{65} \le x_{qc}^{t} < P^{85} \\ 80 & if \;\; P^{85} \le x_{qc}^{t} < P^{95} \\ 100 & if \;\; P^{95} \le x_{qc}^{t} \end{cases}$
6. Indicators above or below the mean	$I_{qc}^{t} = \begin{cases} 1 & if \;\; w > (1+p) \\ 0 & if \;\; (1-p) \le w \le (1+p) \\ -1 & if \;\; w < (1-p) \end{cases}$ *Where* $w = x_{qc}^{t} / x_{qc=\hat{c}}^{t}$
7. Cyclical indicators (OECD)	$I_{qc}^{t} = \frac{x_{qc}^{t} - E_t\,(x_{qc}^{t})}{E_t(\lvert x_{qc}^{t} - E_t(x_{qc}^{t})\rvert)}$
8. Balance of opinions (EC)	$I_{qc}^{t} = \frac{100}{N_e} \sum_{e}^{Ne} sgn_e\left(x_{qc}^{t} - x_{qc}^{t-1}\right)$
9. Percentage of annual differences over consecutive years	$I_{qc}^{t} = \frac{x_{qc}^{t} - x_{qc}^{t-1}}{x_{qc}^{t}}$

Source: OECD(2008)

3.4. Grouping The Indicators of Global FinTech Index

It should be determined that the sub-indicators and the nested model structure of the composite indicator are sufficient and appropriate for the definition of the concept to be measured (Greco et al., 2016; Nardo et al., 2005). This determination process can be carried out by using "expert opinion", which is based on asking the expert which variable defines the concept correctly, or by statistical methods such as Principal Component Analysis (PCA), Factor Analysis (FA) or Crombach Alpha (CA) coefficient to be used based on the data (Freudenberg, 2003; Greco et al., 2019).

In this dissertation, the data-driven methods PCA and CA were used to group the data. PCA is used as a variable reduction technique when variables are highly correlated, reducing the number of variables to a smaller number of principal components that explain most of the variation in the variables.

PCA was applied using R Studio to identify the subgroups of the GFI. The 53 indicators listed in *Table 8* were used in the analysis. These indicators were normalized to obtain a mean of 0 and a deviation of 1 due to the requirement that the data should have a normal distribution before the analysis and made suitable for analysis (Bucherie et al., 2022; Maadooliat et al., 2015). After the nominalization of the variables, PCA was applied on 53 selected variables. The explained variances associated with each component are presented in *Table 10.*

Table 10

Percentage of Variance Explained with PCA for Each Indicator

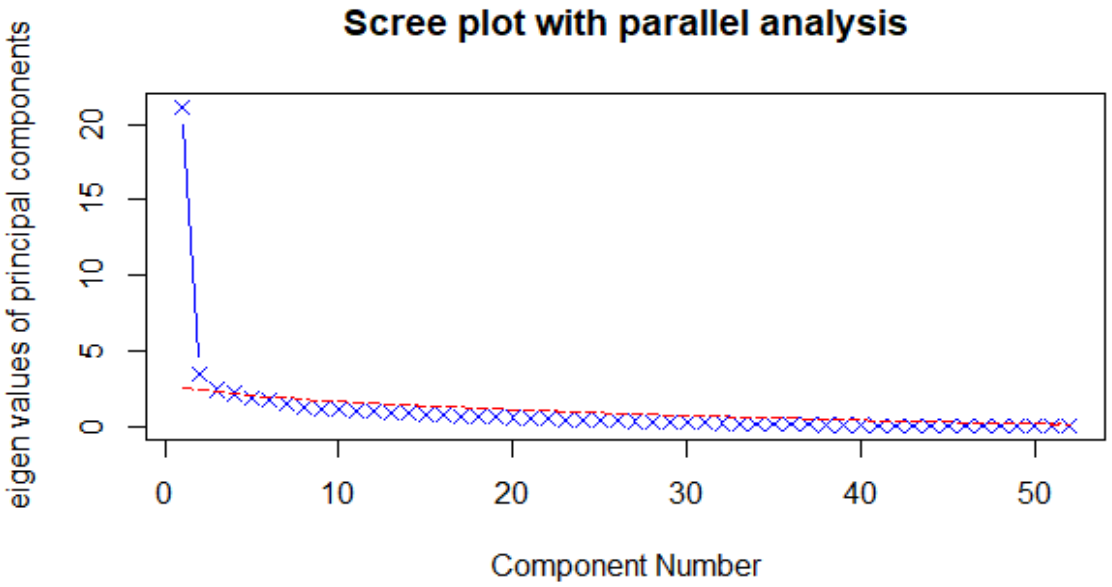
Number of Component (n)	% variance explained	cumulative % explained
1	0.4087	0.4087
2	0.06554	0.47425
3	0.04592	0.52017
4	0.04137	0.56154
5	0.0353	0.5968
6	0.0324	0.6292
7	0.02913	0.65838
8	0.02435	0.68273
9	0.02269	0.70542
10	0.0219	0.7273
11	0.01892	0.74625
12	0.01854	0.76479
13	0.01751	0.7823
14	0.01659	0.79889
15	0.01488	0.81377
16	0.01459	0.82836
17	0.01319	0.84156
18	0.01282	0.85438
19	0.01207	0.86645
20	0.01162	0.87806
21	0.01096	0.88902
22	0.00922	0.89825
23	0.00861	0.90686
24	0.00815	0.91501
25	0.00766	0.92267
26	0.00703	0.9297
27	0.00665	0.93634
28	0.00637	0.94271
29	0.00562	0.94833
30	0.00525	0.95358
31	0.00469	0.95827
32	0.00441	0.96268
33	0.0041	0.9668
34	0.00368	0.97046
35	0.00353	0.97399
36	0.00325	0.97724
37	0.00294	0.98017
38	0.00241	0.98259
39	0.00214	0.98473
40	0.00201	0.98673
41	0.00171	0.98844
42	0.00156	0.99001
43	0.00149	0.99149
44	0.00136	0.99286
45	0.0013	0.9942
46	0.00112	0.99528
47	0.00107	0.99634
48	0.00089	0.99724
49	0.00074	0.99797
50	0.00068	0.99865
51	0.00053	0.99919
52	0.00045	0.99964
53	0.00036	1

Source: Results obtained by the Author via R Studio

However, *Figure 11* below shows the Eigenvalues obtained for each component as a result of PCA analysis.

Figure 11

Eigenvalues of The Components Obtained from PCA



Source: Results obtained by the Author via R Studio

Eigenvalues explain the importance of a factor and the factor with the highest eigenvalues is considered the most significant, while factors with eigenvalues greater than 1 are also considered significant (Reckien et al., 2018). Therefore, according to *Figure 11*, there are three main factors.

PCA also allows interpreting the variation between variables by generating correlation-based principal components while preserving the total variation (Tarasewicz & Jönsson, 2021). The first PC (Principle Component) has the largest amount of variance, followed by the following PCs and so on in descending order. As a result of the PCA analysis conducted on 53 variables, 3 main components were identified. The component values determined based on correlation are given in *Tablo 11*.

Table 11

Loading Factors of Indicators Related to Each Principal Component

Indicators	RC1	RC2	RC3
Urban population	0.27	0.61	0.35
Labour force participation rate	0.21	-0.51	0.11
Level of literacy	0.28	0.76	0.29
Education attainment	0.49	0.68	0.3
Government e-inclusion strategy	0.02	0.38	0.2
Support for digital literacy	0.32	0.22	0.22
Number of commercial bank branches	0.25	0.56	-0.05

Soundness of banks	0.31	0.23	0.59
Financing of SMEs	0.39	0.4	0.7
VC investment	0.43	0.24	0.73
Domestic market size index	0.12	0.52	0.39
Corporate Tax Rate	-0.31	-0.31	-0.06
R&D expenses	0.59	0.21	0.38
ICT service export (% of service export)	0.19	-0.1	0.12
Number of startup	-0.67	-0.08	-0.33
Mobile -cellular telephone subscription	0.31	0.52	0.2
Internet users (percent of household)	0.45	0.73	0.37
Mobile phone cost	-0.18	-0.61	-0.23
Fixed-line monthly broadband cost	-0.02	-0.45	-0.11
Government initiatives to make Wi-Fi available	0.12	0.73	0.27
Private sector initiatives to make Wi-Fi available	0.27	0.42	0.13
Network coverage 3G	0.23	0.71	0.34
Urban electricity access	0.05	0.79	0.32
Rural electricity access	0.15	0.83	0.39
ATMs per 100,000 adults	0.41	0.55	0.12
e-Finance content	0.29	0.53	0.17
Number of crypto owners	0.12	0	0.32
e-Commerce safety	0.08	0.03	0.27
Trust in online privacy	-0.26	-0.01	0.28
Trust in Government websites and apps	0.04	-0.38	0.35
Trust in Non-government websites and apps	-0.15	-0.41	0.23
Affordability of financial services	0.31	0.27	0.78
Availability of financial services	0.39	0.34	0.68
Financial services meeting business needs	0.32	0.26	0.81
Ease of access to loans	0.24	0.24	0.84
Regulation	0.74	0.38	0.19
Corruption perception index	0.75	0.28	0.42
Legal rights index capturing the legal protection of borrowers and lenders	0.34	-0.12	0.03
Privacy regulations	0.34	0.51	-0.06
Financial Development Index	0.59	0.48	0.42
Sound money	0.54	0.26	0.23
Freedom to trade internationally	0.64	0.34	0.21
GDP per capita	0.77	0.25	0.38
Fixed-line broadband subscribers	0.72	0.52	0.2
Average fixed broadband upload speed	0.66	0.24	0.11
Average fixed broadband download speed	0.75	0.36	0.28
Average mobile upload speed	0.44	0.3	0.24
Average mobile download speed	0.59	0.33	0.28
Made digital payments in the past year (% age 15+)	0.68	0.44	0.26
Secured internet servers	0.71	0.08	0.2
Digital skills among populations	0.49	0.42	0.51
University industry collaboration in R&D	0.55	0.25	0.58
e-Commerce content	0.61	0.64	0.33
SS Loadings	**9.009**	**7.53**	**6.4**
Proportion Variance	**0.19**	**0.18**	**0.14**
Cumulative Variance	**0.19**	**0.38**	**0.52**
Proportion Explained	**0.37**	**0.35**	**0.27**
Cumulative Proportion	**0.37**	**0.73**	**1.00**

*Mean item complexity = 1.8

**Test of the hypothesis that 3 components are sufficient.

Source: Results obtained by the Author via R Studio

As a result of PCA analysis, absolute loadings greater than 0.75 are classified as "strong", loadings between 0.75 and 0.50 are classified as "moderate", loadings less than 0.30 are classified as "weak", and variables with weak loadings are not included in the analysis.

In this respect, PCA is also seen as a way to reduce and simplify variables (de Sherbinin & Bardy, 2015; Reckien et al., 2018). In this regard, "ICT service export (% of service export)" and "e-commerce safety" were excluded from the analysis due to factor loadings lower than 0.3, while "Corporate tax rate", "Trust in online privacy", "Trust in government websites and apps", "Digital skills among population", "University-industry collaboration in R&D" and "e-commerce content" could not be included in any component due to cross-loadings.

The variables in the same group were grouped according to the CA value. CA measures the internal consistency of the indicator variable, allowing both the grouping of data and the simplification of data by eliminating data that assesses the relationship between data (OECD, 2008).

As a result of the CA analysis, a standardized CA value of 0.7 is considered valid for normalized indicators (OECD, 2008). Accordingly, CA analysis was performed for the variables in 3 factors excluding the eight variables eliminated as a result of PCA analysis and the groups with the highest standardized alpha values were formed. The results of the CA analysis are presented in *Appendix 2***.**

Whereby the CA analysis, the variables "Privacy Regulation" and "Legal rights index capturing the legal protection of borrowers and lenders" were excluded from the analysis due to their failure to ensure internal consistency and validity.

In consequences of PCA and CA analyses, the 53 variables obtained in the wake of the literature review based on the theoretical approach were reduced to 43 variables and grouped under 3 basic factors. With the help of CA values, sub-groups of the 3 main factors were determined. The final version of the Global Fintech Index to be constructed with the help of PCA and CA analyses is given in *Table 12*

Table 12

Global FinTech Index

FINTECH INDEX		
FINTECH READINESS INDEX	**FINTECH INFRASTRUCTURE INDEX**	**FINACIAL EFFICIENCY INDEX**
POLICY AND REGULATION READINESS	**FINANCIAL INNOVATION**	**ACCESS TO FINANCE FOR ENTREPRENEURIAL ACTIVITY**
Regulation	ATMs per 100,000 adults	Soundness of banks
Corruption perception index	e-Finance content	Financing of SMEs
Support for digital literacy	Domestic market size index	VC investment
ECONOMIC READINESS	Number of commercial bank branches per 100,000 adults in the population	Financial services meeting business needs
Sound Money	**SOCIAL INFRASTRUCTURE**	**FINANCIAL INCLUSION**
Freedom to trade internationally	Urban Population	Affordability of financial services
GDP per capita	Labour force participation rate	Availability of financial services
Financial development index	Level of literacy	Ease of access to loans
TECHNOLOGICAL READINESS	Education Attainment	Number of Crypto owners
R&D expenses	Government e-inclusion strategy	
Made or received digital payment	**ICT INFRASTRUCTURE**	
Number of startup/ labor force	Government initiatives to make Wi-Fi available	
ICT READINESS	Private sector initiatives to make Wi-Fi available	
Average fixed broadband upload speed	Network coverage (min. 3G)	
Average fixed broadband download speed	Urban electricity access	
Average mobile upload speed	Rural electricity access	
Average mobile download speed	Trust in Non-government websites and apps	
Secured internet servers	**ICT USAGE AND AFFORDABILITY**	
Fixed line broadband subscribers	Mobile telephone subscription per 100 people	
	Internet user	
	Mobile phone cost	
	Fixed line monthly broadband costs	

Source: GFI Model contructed by Author

While the naming of the sub-groups such as "Policy and Regulation Readiness" (Haddad & Hornuf, 2019; Herck Giaquinto & Bortoluzzo, 2020; Navaretti et al., 2018; Rau, 2018), “Economic Readiness” (Haddad & Hornuf, 2018), “Technological Readiness” (Groh and Wallmeroth, 2016; Glavina et al., 2021), “ICT Readiness” (Lavidroo & Avarmaa, 2019), "Financial Innovation" (Milian et al., 2019), "Social Infrastructure" (Laidroo & Avarma, 2019; Glavina et al., 2021), “ICT Infrastructure” (Haddad & Hornuf, 2019; Laidroo &

Avarma, 2019; Glavina et al., 2021; Pollari, 2016; Guo et al, 2021), “ICT Usage and Affordability” (Haddad & Hornuf, 2019; Laidroo & Avarma, 2019; Glavina et al., 2021; Pollari, 2016; Guo et al, 2021), “Access to Finance for Entrepreneurial Activity” (Haddad & Hornuf, 2018), “Financial Inclusion” (Gershenson et al., 2021; Guo et al., 2019) is based on the mentioned studies, it also benefited from wordcloud analysis, which is part of the bibliometric analysis in Chapter 1, as well as Milian et al's (2019) systematic review paper on Fintech.

However, in the initial construction phase of the composite indicator "Risk and Security" (Gai et al., 2017), based on The Inclusive Internet Index (2021), the variables "e-Commerce safety", "Trust in online privacy", "Trust in Government websites and apps", "Trust in Non-government websites and apps" were evaluated as a sub-group under "Financial Efficiency" as a topic addressed in the literature on Fintech.

However, as a result of PCA and CA analyses, "e-commerce safety" was excluded from the analysis due to factor loadings lower than 0.3, "Trust in online privacy" and "Trust in government websites and apps" could not be included in any component due to cross loading. Therefore, "Risk and Security" was not included in the model as a separate heading.

The final version of the model is presented in *Table 12*, while detailed definitions of the subgroups and variables are provided in the next section.

3.5. Global Fintech Index Model

3.5.1. FinTech Readines Index

It is an indicator that expresses the endownments such as human capital, policies and regulations, financial conditions, economic and technical infrastructure that support a country's development on financial technology and innovation. Therefore, this composite indicator consists of the subgroups of countries' policy and regulation readiness, economic readiness, technological readiness and ICT readiness.

3.5.1.1. Policy and Regulation Readiness

FinTech formation is positively associated with the presence of a flexible and transparent regulatory environment and institutions that enhance innovation. Therefore, “Policy and

Regulation Readiness" reveals the level of countries on the legal infrastructure and policies that accelerate the development of Fintech.

3.5.1.1.1. Regulation. "It assesses the extent to which regulation limits the freedom of exchange in credit, labor, and product markets in a specific country". "A higher rating indicating that countries have less control on interest rates, more freedom to market forces to determine wages and establish the conditions of hiring and firing, and lower administrative burdens".

3.5.1.1.2. Corruption Perception Index. "It ranks countries according to their perceived public sector corruption that is evaluated by the experts opinion".

3.5.1.1.3. Support for Digital Literacy. "Assesses the existence of a strategy that supports digital literacy whereby the government plan or strategy should address courses in ICT skills, computer science, programming, or other classes where computers are mandatory in the curriculum".

3.5.1.2. Economic Readiness

Economic readiness indicates the state of the economic environment and key economic indicators that affect the development of Fintech in countries.

3.5.1.2.1. Sound Money. "It contains components such as money growth, standard deviation of inflation, inflation, and freedom to own foreign currency bank accounts. To earn a higher rating, a country must follow policies and adopt institutions that lead to low rates of inflation and avoid regulations that limit the ability to use alternative currencies".

3.5.1.2.2. Freedom to Trade Internationally. "It comes from the Fraser Institute database and measures a wide variety of restraints that affect international exchange, including tariffs, quotas, hidden administrative restraints, control on exchange rates, and the movement of capital".

3.5.1.2.3. GDP per Capita . "GDP per capita provides a basic measure of the value of output per person, which is an indirect indicator of per capita income".

3.5.1.2.4. Financial Development Index. "Relative ranking of countries on the depth, access, and efficiency of their financial institutions and financial markets."

3.5.1.3. Technological Readiness

It includes indicators expressing the technical infrastructure that supports the potential of countries in Fintech.

3.5.1.3.1. R&D expenditures. "It is defined as the total expenditure (current and capital) on R&D carried out by all resident companies, research institutes, university and government laboratories, etc., in a country".

3.5.1.3.2. Number of Startup Divided by Labor Force. "The number of fintech startups in a given country and year divided by labor force".

3.5.1.3.3. Made or Received Digital Payments in The Past Year (% age 15+). "The percentage of individuals who has age grater than 15 and use mobile financial payment instruments such as a debit or credit cards in the past twelve months".

3.5.1.4. ICT Readines

ICT readiness examines the quality and breadth of available ICT equipments required for access and development of FinTech.

3.5.1.4.1. Average Fixed Broadband Upload Speed. "Measure of average fixed-line broadband upload speed".

3.5.1.4.2. Average Fixed Broadband Download Speed. **"**Measure of average fixed-line broadband download speed".

3.5.1.4.3. Average Mobile Upload Speed. "This measures average mobile upload speed. A faster speed is a positive indicator for better performance".

3.5.1.4.4. Average Mobile Download Speed. "This measures average mobile download speed. A faster speed is a positive indicator for better performance".

3.5.1.4.5. Secured Internet Servers. "Secure servers are those servers that use the secure sockets layer protocol to protect communication from unintended recipients. More commonly publicly-trusted TLS/SSL certificates".

3.5.1.4.6. Fixed Line Broadband Subscribers. "Fixed broadband subscriptions refers to fixed subscriptions to highspeed access to the public internet".

3.5.2. FinTech Infrastructure Index

FinTech Infrastructure index examines the quality and breadth of available infrastructure required for access and development of FinTech. Therefore, this composite indicator consists of the subgroups of countries' financial innovation, social infrastructure, ICT infrastructure and ICT usage and affordability.

3.5.2.1. Financial Innovation

Financial innovation refers to the potential of countries to present new financial services, products and technologies. Financial innovation indicator reveals the current potantial of the countries in terms of domestic market size as demand side and the ATMs per 100,000 adults, online banking services and number of commercial bank branches as being among the important actors in the supplier side of the financial innovation through the Fintech development stages.

3.5.2.1.1. ATM per 100,000 Adults. "ATMs are computerized telecommunications devices that provide clients of a financial institution with access to financial transactions in a public place".

3.5.2.1.2. E-Finance Content. "It evaluates whether online banking services are offered by the largest retail bank by number of customers (retail and corporate)".

3.5.2.1.3. Domestic Market Size Index. "It is measured by GDP based on the purchasing-power-parity (PPP) valuation of country GDP, in current international dollar (billions). FinTech formation intensity is greater in countries with stronger home demand".

3.5.2.1.4. Number Of Commercial Bank. Branches per 100,000 Adults in The Population.

3.5.2.2. Social Infrastructure

Social infrastructure refers to factors such as educated people and labour force participation that facilitates the acceptance, adoption and developments of the financial technology.

3.5.2.2.1. Urban Population (% of population). "Urban population refers to people living in urban areas as a percentage of the total population".

3.5.2.2.2. Labour Force Participation Rate. "The labour force participation rates is calculated as the labour force divided by the total working-age population".

3.5.2.2.3. Level of Literacy. "Literate population over 15, expressed as a percentage of the total population".

3.5.2.2.4. Education Attainment. "Mean years of schooling"

3.5.2.2.5. Government E-Inclusion Strategy. "Assesses whether the country has any initiatives or plans that address e-inclusion".

3.5.2.3. ICT Infrastructure

ICT infrastructure represents equipment necessary to implement and operate systems and networks for communications services as well as support applications, digital content, and FinTech applications.

3.5.2.3.1. Government Initiatives to Make Wi-Fi Available. "Assesses whether the network is free to join or not. "Public" means that the Wi-Fi network and associated hotspot(s) must be accessible in a public park, library, public building, airport, train or ferry terminal".

3.5.2.3.2. Private Sector Initiatives to Make Wi-Fi Available. "Assesses whether the network is free to join or not and whether the public Wi-Fi is available to anyone (general population, tourists, etc.) or just to customers of the largest Internet Service ProviderISP in the country".

3.5.2.3.3. Network Coverage (min. 3G). "Percentage of the population covered by at least a 3G mobile network refers to the percentage of inhabitants that are within range of at least a 3G mobile-cellular signal; irrespective of whether or not they are subscribers".

3.5.2.3.4. Trust in Non-government Websites and Apps. "To what extent do you trust the information you receive from the following sources online?"

3.5.2.3.5. Urban Electricity Access. "Access to electricity is calculated as the percentage of population with access to electricity".

3.5.2.3.6. Rural Electricity Access. "Access to electricity is calculated as the percentage of population with access to electricity".

3.5.2.4. ICT Usage And Affordability

Technology is one of the most fundamental components of FinTech. Therefore, its development largely depends on the widespread use of technology by individuals, businesses and governments. In this context, ICT usage and affordability includes technology usage and access costs necessary for the development of FinTech.

3.5.2.4.1. Mobile Telephone Subscription per 100 People. "Mobile cellular telephone subscriptions are subscriptions to a public mobile telephone service".

3.5.2.4.2. Internet Users. "Percentage of households with Internet".

3.5.2.4.3. Mobile Phone Cost . "Monthly cost of a 1 GB postpaid mobile broadband data plan, expressed as a percentage of monthly GNI per capita".

3.5.2.4.4. Fixed-Line Monthly Broadband Cost. "Price of fixed-line monthly broadband to the consumer as a percentage of monthly income."

3.5.3. Financial Efficiency Index

Availability of funding for FinTechs at different stages of maturity and through various funding sources is critical for a leading FinTech hub.This index consists of the "Access to Finance for Entrepreneurial Activity" and "Financial Inclusion"

3.5.3.1. Access to Finance for Entrepreneurial Activity.

"It is the ability of business to access financial services such as payment, deposit , credit. The availability of external financing is positively associated with the number of start-ups, which is an important indicator of entrepreneurship, as well as innovation and financial technology".

3.5.3.1.1. Soundness of Banks. "The soundness of a bank indicates the capabilities of its capital adequacy, asset quality, liquidity, and profitability to cope with adverse market conditions".

3.5.3.1.2. Financing of SMEs. "In a country, to what extent can SMEs Access finance they need for their business operations through the financial sector?".

3.5.3.1.3. Venture Capital Investment. "Venture capital is a subset of private equity (i.e. equity capital provided to enterprises not quoted on a stock market) and refers to equity investments made to support the pre-launch, launch and early stage development phases of a business".

3.5.3.1.4. Financial Services Meeting Business Needs. ”In reporting country, to what extent are financial services meeting for businesses?”.

3.5.3.2. Financial Inclusion.

Financial inclusion is efforts to make financial products and services accessible and a ffordable to all individuals and businesses, regardless of their personal net worth or company size.

3.5.3.2.1. Affordability of Financial Services. “It indicates that to what extent are financial services affordable for businesses?”.

3.5.3.2.2. Availability of Financial Services. “It represents that to what extent does the financial sector provide a wide range of financial products and services to businesses?”.

3.5.3.2.3. Ease of Access to Loans. “How easy is it to obtain a bank loan with only a good business plan and no collateral?”.

3.5.3.2.4. Number of Crypto Owners (% of population). “The number of adults who own and use at least one cryptocurrency. “Owner” means those who hold the currency in their portfolios but don’t necessarily transact with it”.

3.6. Weighting of Indicators and Subgroups

Weights in composite indicators have two basic meanings (OECD, 2008). One of the most important factors affecting the results of the composite indicators and the country ranking is the determined weights (Greco et al., 2016). A weight is a kind of coefficient that indicates the importance of each criterion in the index relative to the others (OECD, 2008). There is no single agreed weighting method for constructing composite indicators. The weights in the composite indicators used are based on data-based statistical methods such as PCA, FA, Data Envelopment Analysis (DEA), regression analysis or public/expert opinion based methods such as Budget Allocation Process (BAP), Analytical Hierarchy Process (AHP). Regardless of the method used, the determination of weights generally involves value judgments.

Table 13 below summarizes the methods used in weighting composite indicators and their characteristics.

Table 13

Summary of the Weighting Methods

Methodology	Definition	Important	Examples
Equal Weights	It is the most common method to emerge in the development of composite indicators. All variables are assigned the same weight. It does not mean "no weight".	(1) simplicity of construction, (2) a lack of theoretical structure to justify a differential weighting scheme, (3) no agreement between decision makers, (4) inadequate statistical and/or empirical knowledge	Human Development Index (HDI), KOF Globalization Index
Budget Allocation Process	A set of chosen decision makers (e.g. a panel of experts) is given 'n' points to distribute to the indicators, or groups of indicators (e.g. dimensions), and then an average of the experts' choices is used.	Two prerequisites are the careful selection of the group of experts and the total number of indicators that will be evaluated. A rule of thumb is to have fewer than 10 indicators so that the approach is optimally executed cognitively. Otherwise, problems of inconsistency could be introduced.	Internal Market Index, Economic Freedom Indices, 'e-Business Readiness Index
Analytic Hierarchy Process	These are expressed on an ordinal scale with nine levels, ranging from 'equally important' to 'much more important', representing how many times more important one criterion is than another one. The weights elicited with the AHP are less prone to errors of judgement, as discussed in the previous subsection.	Applies cognitive stress on decision makers if the number of indicators is too large.	Composite Cyclical-Performance Index
Multiple Linear Regression Analysis	Multiple linear regression analysis is another approach by which weights can be extracted. The decision maker can go beyond simple statistical correlation and assign weights to the causal link between sub-indicators and a chosen output indicator.	(1) These models assume strict linearity, which is hardly the norm with composite indices, (2) Ifthere was an objective and efective output measure for the sub-indicators to be regressed on, there would not be a need for a composite index in the frst place,(3) According to the authors, an indicator that is generally assumed to capture the wider phenomenon to be studied might be used.	National Innovative Capacity Index (bağımlı değişken: log of patent/broadly accepted variable in the literature)

Principal Component Analysis	Dimension reduction by creating new variables (selecting the most important features that capture maximum information about the dataset). Features are selected based on the variance they cause in the output. The original features of the dataset are converted into Principal Components, which are linear combinations of existing features. The feature causing the highest variance is the first Principal Component. The feature responsible for the second highest variance is considered the second Principal Component, and so on.	PCA is a method of extracting important features (in the form of components) from a large set of variables found in a dataset. Data normalization must be done before applying PCA, otherwise PCA will not be able to find the optimal Principal Components. Loss of Information: Although Principal Components try to cover the maximum variance among features in a dataset, if we do not carefully select the number of Principal Components, it may miss some information compared to the original feature list.	Internal Market Index, Environmental Degradation Index
Data Envelopment Analysis	It uses mathematical programming to measure the relative performance of various units (businesses, institutions, countries, etc.) and therefore evaluate them based on a 'productivity' score. This score is obtained with a ratio calculated for each unit (weighted sum of outputs and weighted sum of inputs) under a minimization/maximization function determined by the developer. Bu using the linear programming formulation, a set of weights (one for each unit) are internally determined to maximize their 'yield' under certain constraints.	The application of DEA to the field of composite indicators is known as the "Benefit of Doubt" approach (BOD) and was originally proposed to evaluate macroeconomic performance. In the BOD approach, the composite indicator is defined as the ratio of a country's actual performance to its benchmark performance.	Technology Achievement Index

Source: (OECD, 2008)

Three different index values were obtained by using three different methods, which are among the subjective and objective approaches, at the stage of weighting the indicators.

While Equal Weighting (EW) and PCA were used as objective methods, the opinions of academics who had knowledge and/or studied on Fintech and experts from different positions in different application areas of Finfech were taken as the subjective approach. The weight determination stages based on expert opinion was carried out on the basis of the "Budget Allocation Process".

3.6.1. Equal Weighting

The equal weighting method means that in a composite indicator divided into subgroups and multiple dimensions, the weights between groups and indicators will have equal

importance (OECD, 2008). This method is preferred because of its ease of calculation, lack of a theoretical framework for choosing different methods, inadequacies in statistical and empirical information, and alleged objectivity (Decancq & Lugo, 2012; OECD, 2008). In this regard, by assigning equal weight to the three main components of the Global Fintech Index, they were included with equal weight based on the number of indicators in the subgroups.

The weight coefficients assigned within the scope of equal weighting in the study are included in *Appendix 3*.

3.6.2. Budget Allocation Process

Treating all indicators equally with the equal weight method may cause the relative importance of the indicators to be underestimated (Freudenberg, 2003) Nonetheless, the definition of equal weighting as an objective method is open to debate (Greco et al., 2016). Considering these criticisms made to the equal weighting method, the budget allocation process, which also takes into account the importance of the indicators in the index, is included in the study as another weighting method based on expert opinion.

In order to eliminate the confusion arising from the multidimensional and complex nature of the concept to be measured with the budget allocation process method, and not to adversely affect the evaluation results, an expert opinion questionnaire was prepared in which what is meant to be explained by each indicator is explained in detail to the experts..

In addition, the expert opinion survey shared with the experts of the field is included in *Appendix 1*.

Before the expert opinion survey, detailed information about the FinTech definition on which the study was based, the purpose of the study and the method to be used were shared with the experts.

Afterwards, experts were asked to distribute n=100 points to the subgroups and indicators in the expert opinion survey, taking into account the importance of the indicators and subgroups, which they evaluated within the framework of their expertise. In the scoring system, 0 indicates the “lowest” and “least insignificant” value for the indicator, while 100 indicates “very important” as the “highest” scale.

The most critical and important point of the BAP method is to identify experts in the field. In studies based on expert opinion, the sample size should be determined in advance

(Young & Casey, 2019) . While there is no specific "rule" for determining sample size, researchers should collect data of sufficient quality to answer the research question. As the number of experts increases, the answers converge and reliability increases. The existing literature on composite indicator construction suggests that there is no strict requirement for a minimum sample size for analysis. Some studies have used sample sizes ranging from four to nine (Darko et al., 2019).

In additon, “purposive sampling” method was used in the selection of experts in the study, where the researcher deliberately selects participants who are knowledgeable about the phenomenon. Among the available experts, suitable ones were purposively selected for the purpose of the study.

It is also important to get the opinions of experts from different locations on the subjects where the performances of the countries are compared with the related concept. In this context, the evaluation of 20 experts working in different geographies and different positions, who are theoretical and practical practitioners of the subject, was taken.

The sectors, positions and location information of the experts are given in *Table 14*. After the evaluations of the experts, weights were determined for each subgroup by taking the arithmetic averages of the scores determined by the them according to the BAP. In accordance with the expert profile table, the table containing the scores assigned by each expert to the indicators and the weights obtained as a result of the expert's opinion is given in *Appendix 4.*

Table 14

Profile of the Experts

Number	Sector	Position	Years of experience	Location
1	Computing or IT	Chief Executive Officier (CEO)	More than 20	England
2	FinTech	Chief Operation Officier (COO)	More than 20	United States of America
3	Academics	Academician	From 11 to 15	Iran Islamic Republic
4	Accountancy, banking or finance	Manager	From 11 to 15	Denmark
5	Accountancy, banking or finance	Manager	More than 20	Turkey
6	Accountancy, banking or finance	Manager	From 11 to 15	Turkey
7	Computing or IT	Manager	More than 20	United Arab Emirates
8	Computing or IT	Consultant	From 16 to 20	Turkey
9	Sotfware	Developer	From 0 to 5	Turkey
10	Business, consultancy or management	Chief Executive Officier (CEO)	From 0 to 5	Turkey
11	Academics	Academician	From 16 to 20	Turkey
12	Academics	Academician	From 11 to 15	Czehia
13	Accountancy, banking or finance	Chief Executive Officier (CEO)	From 16 to 20	Germany
14	Computing or IT	Chief Technology Officier (CEO)	From 0 to 5	United States of America
15	Business, consultancy or management	Consultant	More than 20	Turkey
16	Academics	Academician	More than 20	Turkey
17	Computing or IT	Manager	From 0 to 5	Poland
18	Academics	Academician	From 11 to 15	France
19	Business, consultancy or management	Chief Executive Officier (CEO)	From 5 to 10	Turkey
20	Academics	Academician	More than 20	Finland

3.6.3. Principle Component Analysis

While the subjectivity of participatory approaches based on expert opinion has been criticized by statistical and objective methods based on secondary data, multiple regression analysis, PCA or FA, DEA and mixed approaches consisting of combinations of these methods have also come to the fore in composite indicator construction (Decancq & Lugo, 2012; S. Greco et al., 2019). In the perspective of these criticisms, PCA was used as another data-driven, objective, statistical method. The reason for not using Data Envelopment Analysis is that there is no Global FinTech index in the literature that can express the "output" value that should be used in application, which is formed in the context of the Fintech's definition used in the study. Despite the indicator values that can be used as inputs, the lack of an output value that can show the Fintech ranking of the countries has prevented the DEA from being preferred.

Moreover, another objective and statistical method, Multivariate Regression, was not used to determine the weights, again due to the lack of a dependent variable to be regressed on the sub-indicators and to represent the composite indicator. The problem of not needing a composite indicator if there is an output to represent a composite indicator is also one of the most important criticisms brought to Multivariate Regression analysis (Greco et al., 2019; Saisana & Tarantola, 2016).

Under these constraints, another weighting method in the study was the PCA analysis, which was carried out using the determined indicator values within the scope of the specified definition of Fintech. When PCA is used as a weight determination method, factor loads of the first component are used as weights (Bucherie et al., 2022).

The weights determined as a result of the PCA analysis are included in Appendix 5.

3.7. Contruction of Global Fintech Index

Regardless of the methodology used to determine the weights, aggregation is the next step in index construction after the weights are determined. In the contruction of composite indicators, there are different approaches under the heading of aggregation methods in the collection phase, as in weighting. Among these, additive methods, a-non compensatory multicriteria approach and geometric aggregation stand out.

The aggregation method in the study is the summation of weighted and normalized sub-indicators, which is one of the most widely used methods in the literature (Becker et al., 2017; Bucherie et al., 2022). The equation of the aggregation method used is given below.

$$FinTech\ Index = \sum_{j=1}^{d} w_j \text{ x } x_{kj} \qquad (3.7)$$

d indicates the total aggregated indicator, and d=43;

w_j is the weight which is determined for the each indicators and sub-groups

k represents the countries

x_{kj} indicates the normalized value of the k.

Using the aggregation method above, "Global FinTech Index" was calculated for 120 countries for 2021 with equal weight, expert opinion and PCA. Within the scope of guiding policy makers and providing policy recommendations, which is one of the main objectives of the development of composite indicators, the "World Bank Country Classification by Income Group" classification was used in order to interpret the indicator

more accurately for countries, and the index results were analyzed in four different income classifications: "low", "lower-middle", "upper middle" and "high".

3.8. Interpretations of The Results and Visualization

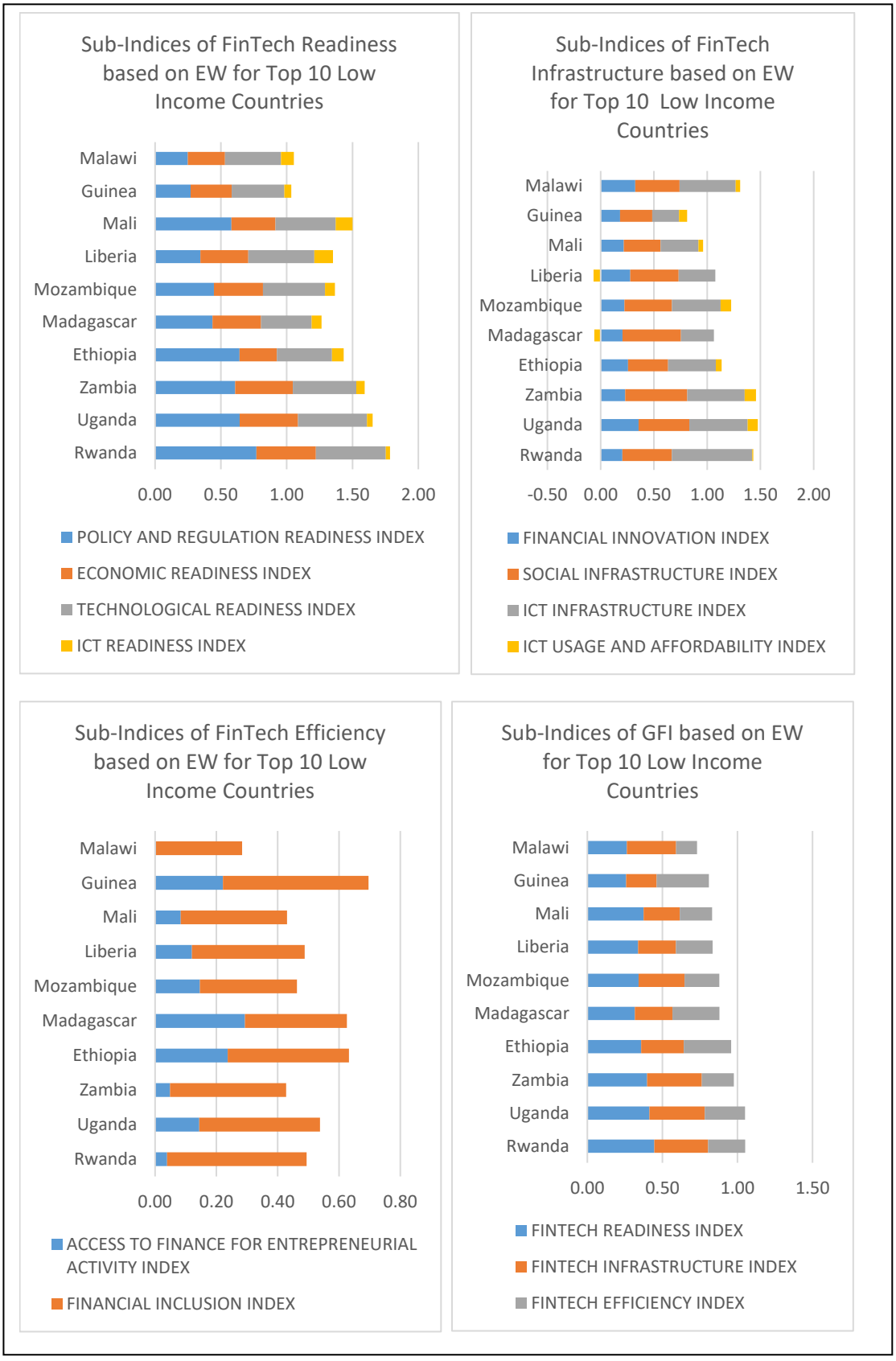
3.8.1. Global Fintech Sub-Indices for Top 10 Low-Income Countries based on Equal Weight

In the study, three different methods, namely “EW”, “PCA” and “BAP” were used to calculate the GFI.

Figure 12 below shows the sub-index values of Top 10 Low Income countries calculated with the equal weight method of GFI.

Figure 12

Sub-Indices' Values of GFI based on EW for Top 10 Low-Income Countries



Source: Results obtained by the Author

According to *Figure 12*, when the GFI sub-index values calculated according to the EW method are evaluated for the top 10 low-income countries classification, Rwanda, Uganda and Zambia are the three leading countries in the group. Rwanda has the highest value in all subgroups except "ICT Readiness", "ICT Usage and Affordability", "Financial Innovation" and "Access to Finance for Entrepreneurial Activity".

Nevertheless, among the top 10 low-income countries, Malawi and Guinea have the lowest "Policy and Regulation Readiness Index" value, which also indicates the non-existence of transparent and flexible regulations for the development of FinTech and the acceleration of innovations.

When the countries take into account with "Economic Readiness" and "Technological Readiness", although the index values are close to each other, the countries with the highest values are Rwanda, Ethiopia and Uganda, while the countries with the lowest values among the top 10 countries are Malawi and Madagascar, respectively.

According to the "ICT Readiness Index", Liberia, Mali and Ethiopia are the first three countries in the group. The common feature of these countries is that the "ICT Infrastructure", "ICT Usage and Affordability" and "Financial Innovation" indices are the sub-groups with the lowest values since they are directly related to income level.

Nevertheless, when the "Financial Innovation Index" is considered, the countries with the highest index values are Uganda, Malawi and Liberia.

When the "Social Infrastructure Index" value, which refers to the social infrastructure that affects the acceptance, adoption and development of financial instruments based on financial technology, is considered, Zambia, Madagascar and Uganda are the countries with the highest index values.

"ICT Infrastructure", "ICT Usage and Affordability" indices are generally low in all countries in the group, but the first three countries with the highest value for "ICT Infrastructure Index" are Rwanda, Uganda and Zambia. The lowest index values among the top 10 countries belong to Madagascar, Liberia and Mali. These countries with the lowest index values are the three countries with the lowest "ICT Usage and Affordability Index" in parallel with the "ICT Infrastructure Index". The three countries with the highest "ICT Usage and Affordability Index" values among low-income countries are Uganda, Zambia and Mozambique.

Moreover, Madagascar and Guinea have the highest "Access to Finance for Entrepreneurial Activity Index" in the low income country group.

Malawi has the lowest "Financial Inclusion Index" value among the top 10 countries. Guniea and Madagascar are the countries with the highest values in the "Financial Inclusion Index" as well as in the "Access to finance for entrepreneurial activity index".

When the "Fintech Readiness Index" consisting of "Policy and Regulation Readiness", "Economic Readiness", "Technological Readiness" and "ICT Readiness" sub-group indices is evaluated, Rwanda, Uganda and Zambia are the top three countries with the highest index values.

According to the "FinTech Infrastructure Index" consisting of "Financial Innovation", "Social Infrastructure", "ICT Infrastructure" and "ICT Usage and Affordability" sub-groups; Rwanda, Uganda and Zambia are the top three countries.

Guinea, Ethiopia and Madagascar are among the countries with the highest index values when the "Fintech Efficiency Index", which consists of "Access to Finance for entrepreneurial Activity" and "Financial Inclusion" subgroups, is taken into account.

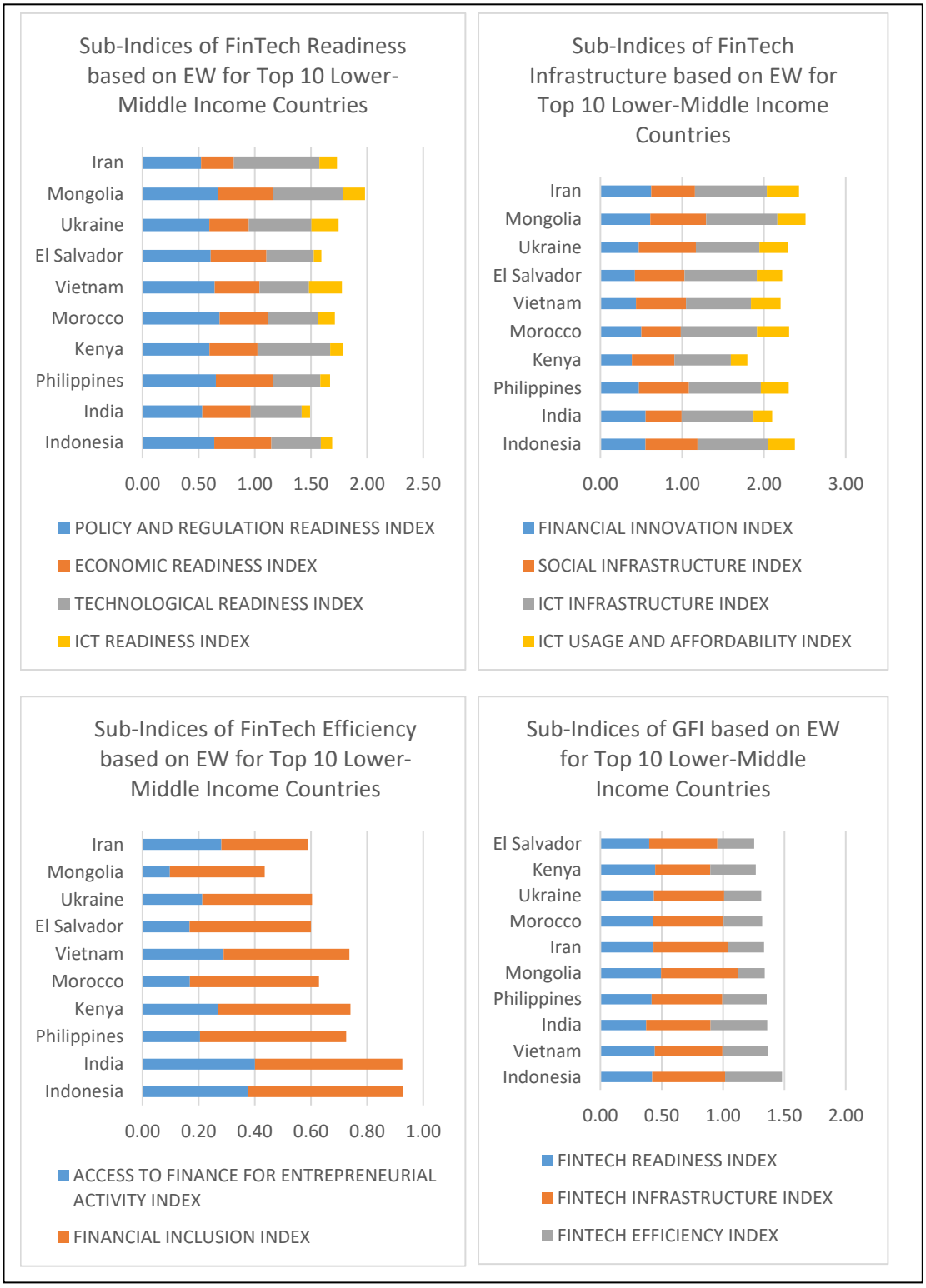
3.8.2. Global Fintech Sub-Indices for Top 10 Lower-Middle Income Countries based on Equal Weight

Figure 13 below shows the GFI sub-index values of the Top 10 Lower-Middle Income countries calculated with the equal weight method.

Sub-Indices' Values of GFI based on EW for Top 10 Lower-Middle Income Countries

Figure 13

Sub-Indices' Values of GFI based on EW for Top 10 Lower-Middle Income Countries



Source: Results obtained by the Author

Acording to *Figure 13*, when GFI sub-index values calculated according to the EW method are evaluated for the first 10 low-middle income countries, Indonesia, India, Philipines and Kenya stand out with high index values among the countries in the group.

Nevertheless, among the top 10 low-middle income countries, Morocco, Mongolia and Philippines are the three countries with the highest Policy and Regulation Readiness Index values.

When the countries in this group are evaluated in terms of "Economic Readiness", although the index values are close to each other, Philipines and Indonesia have the highest values. While Iran has the lowest index value among the top 10 countries in terms of "Economic Readiness Index", it has the highest "Technological Readiness Index" and "Financial Innovation Index".

In terms of "ICT Infrastructure Index", Morocco, Iran, India, Philipines are the countries with the highest index values.

In general, countries in this country group have the lowest values in "ICT Readiness", "ICT Usage and Affordability" and "Access to Finance for Entrepreneurial Activity", which are also directly related to income level.

In the "Access to Finance for Entrepreneurial Activity" sub-group, which is critical for the development of start-ups, which are among the creators of innovation, one of the main pillars of Fintech, the countries with the highest index values are Indonesia and India. These countries are the two leading countries in the group in terms of access to financial products (Financial Inclusion Index), not only at the firm level but also at the individual level.

Moreover, considering the "Financial Innovation Index", Iran, Mongolia, Indonesia and India stand out as the countries with the highest index values.

For the "Social Infrastructure Index", Ukraine, Mongolia and Indonesia are the countries with the highest index values. The countries with the lowest index values among the top 10 countries in this area are Kenya, Morocco and India.

For the "ICT Infrastructure Index", the top three countries with the highest value in the group are Morocco, El Salvador and India. The lowest index values among the top 10 countries belong to Kenya, Ukraine and Vietnam.

Among the countries in the Lower-Middle Income group, the three countries with the highest "ICT Usage and Affordability Index" values are Iran, Morocco and Vietnam. Furthermore, India, Indonesia and Vietnam have the highest Access to Finance for Entrepreneurial Activity Index values in the lower-middle income country group, while Mongolia and El-Salvador have the lowest index values among the top 10 countries.

In the "Financial Inclusion Index", Indonesia, India and Philippines are the countries with the highest values.

When the "Fintech Readiness Index" consisting of "Policy and Regulation Readiness", "Economic Readiness", "Technological Readiness" and "ICT Readiness" sub-group indices is evaluated, Mongolia, Kenya and Vietnam are the top three countries with the highest index values.

According to the "FinTech Infrastructure Index" consisting of "Financial Innovation", "Social Infrastructure", "ICT Infrastructure" and "ICT Usage and Affordability" sub-groups; Mongolia, Iran and Indonesia are the top three countries.

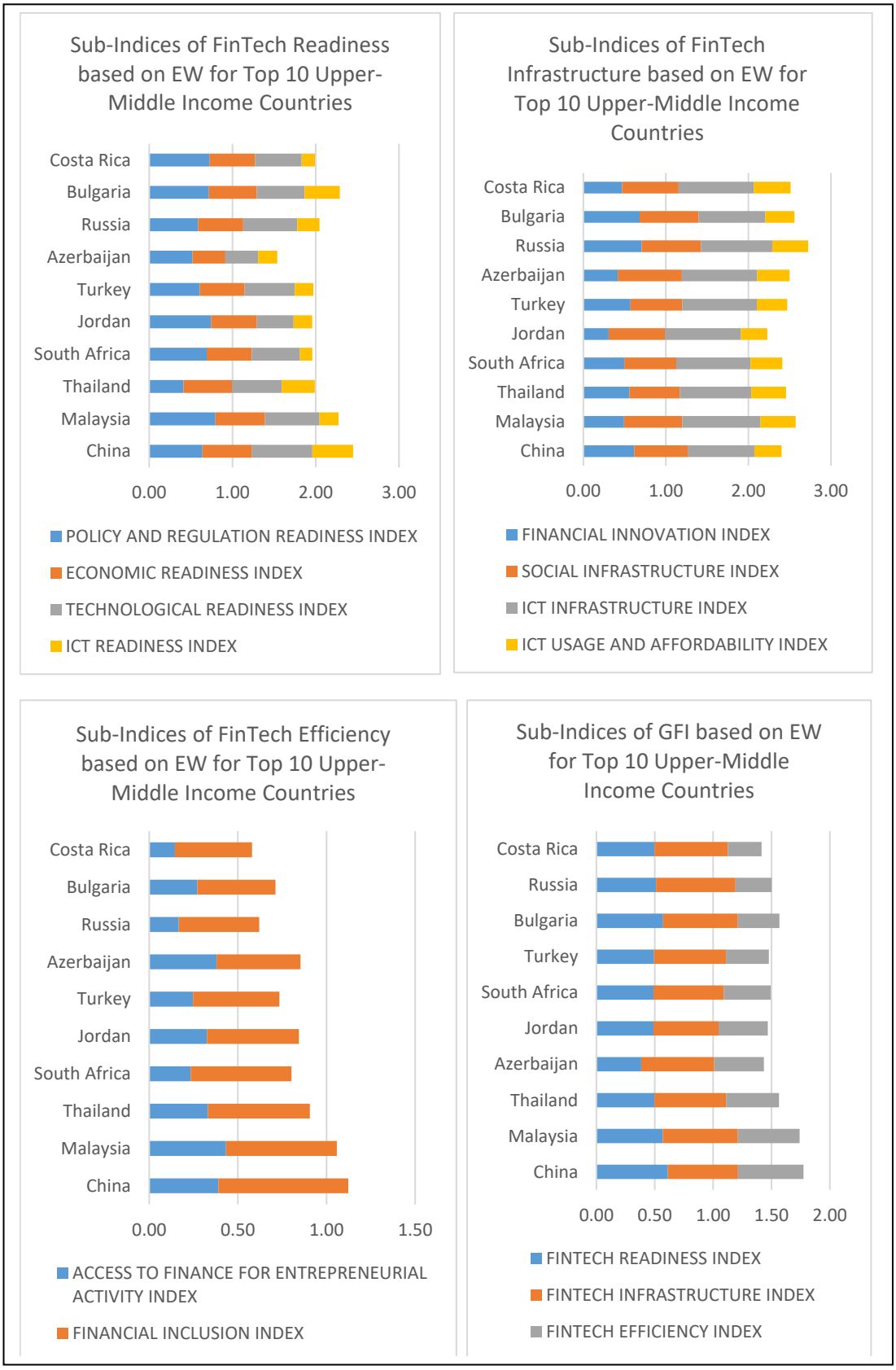
Considering the "Fintech Efficiency Index" consisting of "Access to Finance for entrepreneurial Activity" and "Financial Inclusion" subgroups; Indonesia, India and Kenya are the countries with the highest index values.

3.8.3. Global Fintech Sub-Indices for Top 10 Upper-Middle Income Countries based on Equal Weight

Figure 14 below shows the GFI sub-index values of the Top 10 Upper-Middle Income countries calculated with the equal weight method.

Figure 14

Sub-Indices' Values of GFI based on EW for Top 10 Upper-Middle Income Countries



Source: Results obtained by the Author

According to *Figure 14*, when GFI sub index values calculated with the EW method for the top 10 high-middle income countries, China, Malasia, Bulgaria and Thailand stand out with high index values among the countries in this group. The countries with the highest "Policy and Regulation Readiness Index" values are Malaysia, Bulgaria and Jordan.

China, Malaysia and Thailand stand out as the top three countries with high "Economic Readiness Index" values. In the same sub-index category, the countries with the highest "Technological Readiness Index" values are China, Malaysia and Russia.

In terms of "ICT Readiness Index", China, Bulgaria and Thailand are the top three countries in this area while for "Financial Innovation Index", Russia, Bulgaria and China are among the top three countries.

For the "Financial Innovation Index" subgroup, Russia, Bulgaria and China are among the top three countries.

In respect of the "Social Infrastructure Index", Azerbaijan, Russia and Bulgaria are the countries with the highest index values. The countries with the lowest index values among the top 10 countries in this area are South Africa, Thailand and Turkey.

For the "ICT Infrastructure Index", the top three countries with the highest value in the group are Malaysia, Jordan and Azerbaijan. Among the countries in the Upper-Middle Income group, the three countries with the highest "ICT Usage and Affordability Index" values are Costa Rica, Russia and Malasia.

Moreover, Malasia, China and Azerbaijan have the highest "Access to Finance for Entrepreneurial Activity Index" in that income group while China, Malaysia and Thailand have the highest "Financial Inclusion Index".

Considering the "Fintech Readiness Index" consisting of "Policy and Regulation Readiness", "Economic Readiness", "Technological Readiness" and "ICT Readiness" sub-group indices, China, Bulgaria and Malaysia are the top three countries with the highest index values.

According to the "FinTech Infrastructure Index" consisting of "Financial Innovation", "Social Infrastructure", "ICT Infrastructure" and "ICT Usage and Affordability" sub-groups; Russia, Malasia and Bulgaria are the top three countries.

When the "Fintech Efficiency Index" which consists of "Access to Finance for entrepreneurial Activity" and "Financial Inclusion" subgroups is taking into account China Malasia and Thailand have the highest index values.

3.8.4. Global Fintech Sub-Indices for Top 10 High Income Countries based on Equal Weight

Figure 15 below shows the sub-index values of the GFI for the top 10 High Income countries calculated with the equal weight method.

Figure 15

Sub-Indices' Values of GFI based on EW for Top 10 High Income Countries

Source: Results obtained by the Author

According to *Figure 15*, GFI sub index values with the EW method for the top 10 high-income countries, United States, Switzerland, Singapore and Japan stand out with high index values among the countries in this group.

The countries with the highest "Policy and Regulation Readiness Index" values are New Zealand, Singapore and Denmark.

Switzerland, United States and Singapore are the top three countries with high "Economic Readiness Index" values. In the same sub-index category, the countries with the highest "Technological Readiness Index" values are Japan, Germany and Austria. In terms of "ICT Readiness Index", Singapore, Denmark and South Korea are the top three countries in this field.

Considering the "Financial Innovation Index", South Korea, United States and Japan are among the top three countries. According to the “Social Infrastructure Index”, which includes the social factors that directly affect the acceptance, adoption and development of fintech instruments; Australia, Qatar, Austria and New Zealand are the countries with the highest index value in their country group.

For the "ICT Infrastructure Index", the top three countries with the highest value in the group are Qatar, Australia and Japan. Among the countries in the High Income group, the three countries with the highest "ICT Usage and Affordability Index" values are Hong Kong, United Arab Emirates and Qatar.

Moreover, United States, Finland and Germany have the highest "Access to Finance for Entrepreneurial Activity Index" in the high income country group, while United States, Singapore and United Kingdom have the highest "Financial Inclusion Index". When the "Fintech Readiness Index” which consists of "Policy and Regulation Readiness", "Economic Readiness", "Technological Readiness" and "ICT Readiness" sub-group indices is evaluated, Switzerland, Denmark and Singapore are the top three countries with the highest index values.

According to the "FinTech Infrastructure Index", which is composed of "Financial Innovation", "Social Infrastructure", "ICT Infrastructure" and "ICT Usage and Affordability" sub-groups; Australia, Japan, United States are the top three countries.

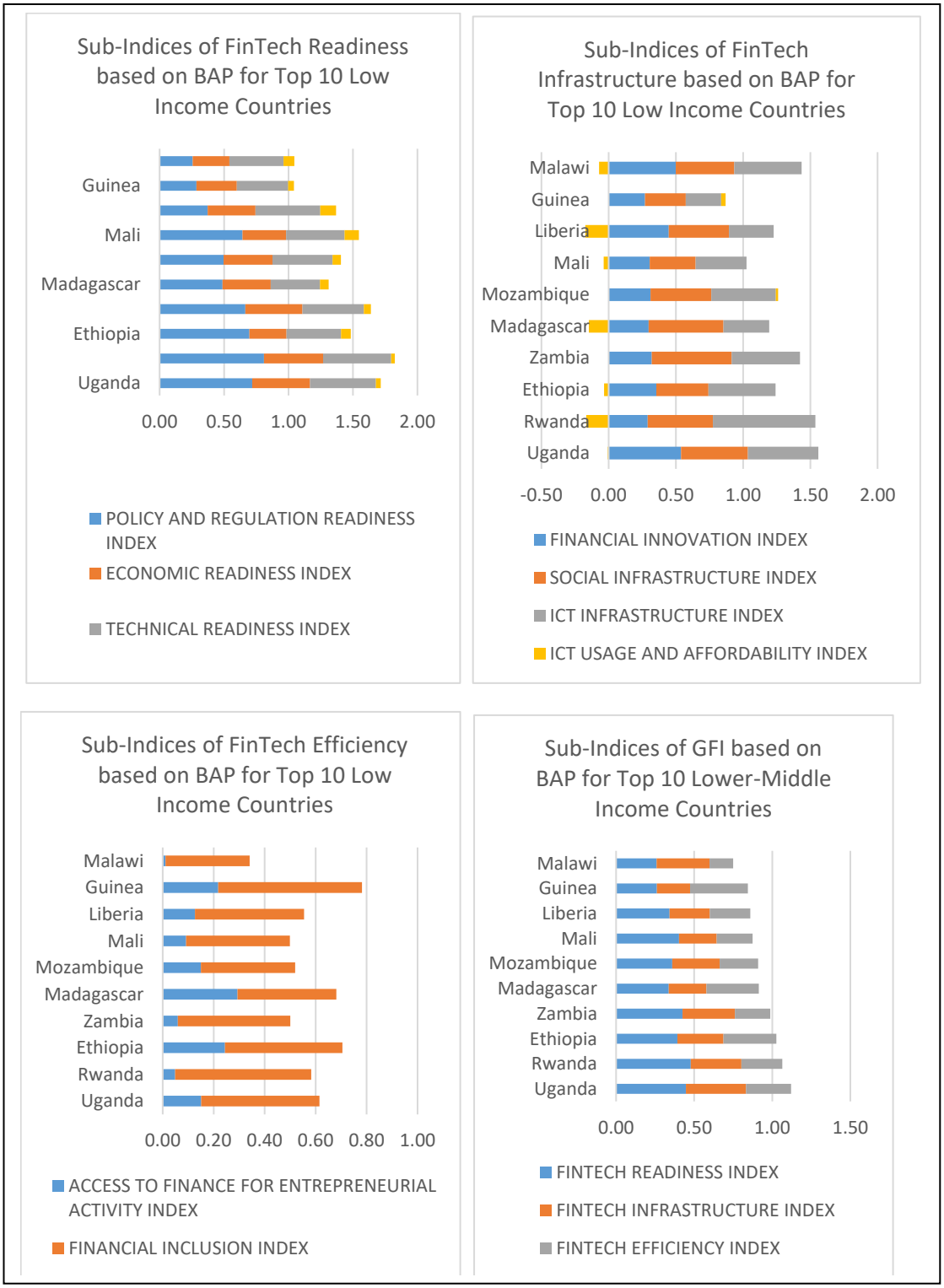
Considering the "Fintech Efficiency Index" consisting of "Access to Finance for entrepreneurial Activity" and "Financial Inclusion" subgroups; United states, Singapore and Finland are the countries with the highest index values.

3.8.5. Global Fintech Sub-Indices for Top 10 Low-Income Countries based on BAP

Figure 16 below shows the sub-index values of the Top 10 Low Income countries calculated by GFI's BAP.

Figure 16

Sub-Indices' Values of GFI based on BAP for Top 10 Low Income Countries



Source: Results obtained by the Author

According to *Figure 16*, by taking into account the GFI sub index values based on the BAP for the top 10 low-income countries, Rwanda, Ethiopia and Zambia are the leading countries in the group.

In addition, among the top 10 low-income countries, Malawi and Guinea have the lowest "Policy and Regulation Readiness Index", which also indicates the existence of transparent and flexible regulations for the development of FinTech and the acceleration of innovation. The top three countries for this index value are Rwanda, Uganda and Ethiopia.

For the low income countries in terms of "Economic Readiness" and "Technological Readiness", although the index values are close to each other, the countries with the highest values are Rwanda, Uganda and Zambia, while the countries with the lowest values among the top 10 countries are Malawi, Guinea and Madagascar, respectively.

According to the "ICT Readiness Index", Liberia and Mali are the leading countries in their group.

The common feature of the countries in this group is that the "ICT Infrastructure", "ICT Usage and Affordability" and "Financial Innovation" indices are the sub-groups with the lowest values since they are directly related to income level. In particular, countries with the lowest "ICT Usage and Affordability Index" values among the 120 countries for which the index is calculated are in the low-income group.

Nevertheless, considering the "Financial Innovation Index", the countries with the highest index values are Zambia, Madagascar and Uganda.

When the "Social Infrastructure Index" value, which refers to the social infrastructure that affects the acceptance, adoption and development of financial instruments based on financial technology, is considered, Zambia, Madagascar and Uganda are the countries with the highest index values. While the "ICT Infrastructure" and "ICT Usage and Affordability" indices are generally low in all countries in the group, the top three countries with the highest value for the "ICT Infrastructure Index" are Rwanda, Uganda and Zambia. The lowest index values among the top 10 countries belong to Sudan, Liberia and Madagascar. The three countries with the highest "ICT Usage and Affordability Index" values among low-income countries are Sudan, Guinea and Mozambique.

Moreover, Madagascar, Ethiopia and Guinea have the highest "Access to Finance for Entrepreneurial Activity Index" in that classification. Mozambique and Sierra Leone have

the lowest "Financial Inclusion index" values among the top 10 countries. Guniea, Ethiopia and Madagascar are the countries with the highest values in the "Financial Inclusion Index" as well as in the "Access to finance for entrepreneurial activity index".

The "Fintech Readiness Index" which is consisting of "Policy and Regulation Readiness", "Economic Readiness", "Technological Readiness" and "ICT Readiness" sub-group indices is considering, Rwanda, Uganda and Zambia are the top three countries with the highest index values.

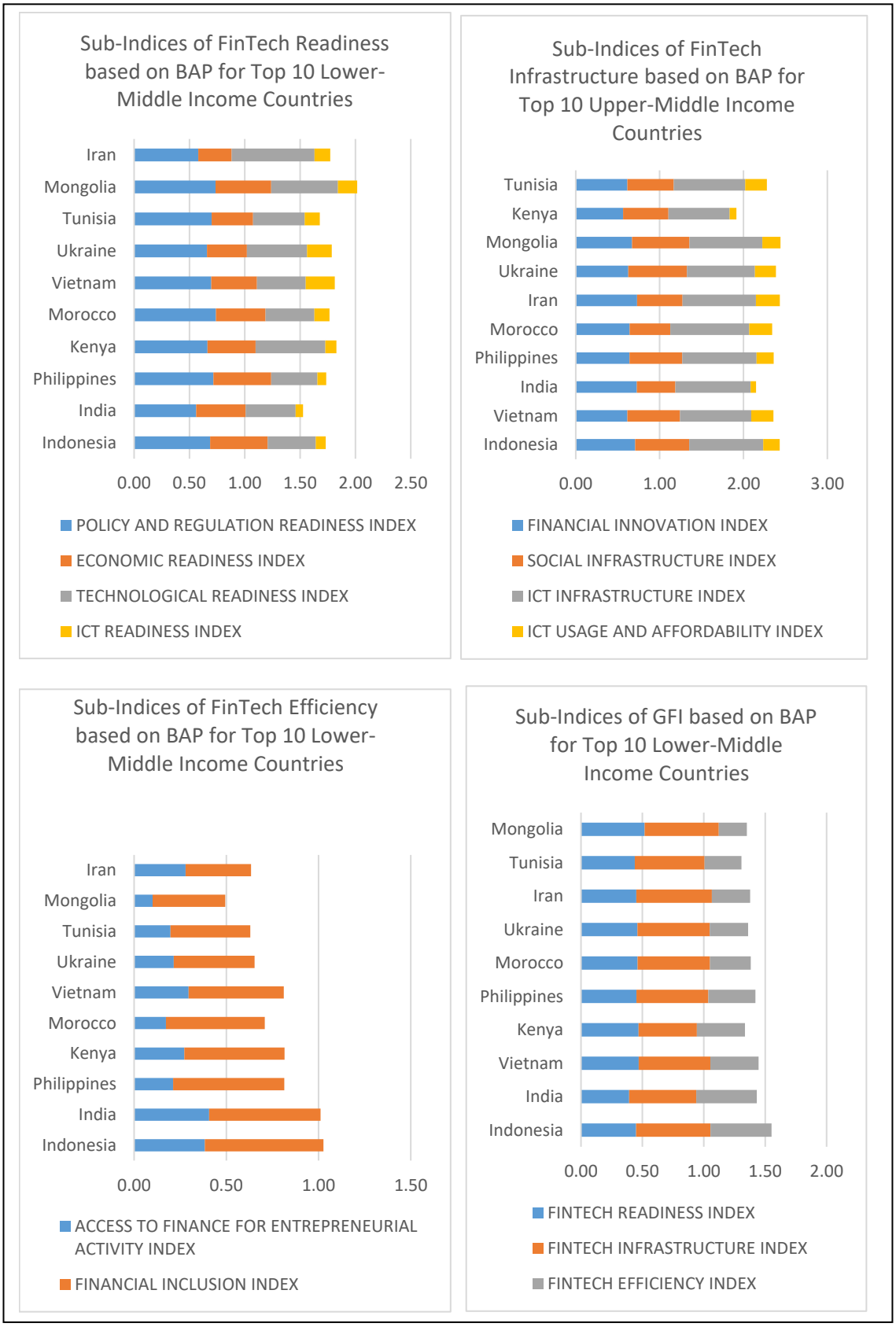
According to the "FinTech Infrastructure Index" consisting of "Financial Innovation", "Social Infrastructure", "ICT Infrastructure" and "ICT Usage and Affordability" sub-groups; Uganda, Malawi and Zambia are the top three countries. Guinea, Ethiopia and Madagascar are among the countries with the highest index values when the "Fintech Efficiency Index" consisting of "Access to Finance for entrepreneurial Activity" and "Financial Inclusion" subgroups are taken into account.

3.8.6. Global Fintech Sub-Indices for Top 10 Lower- Middle Income Countries based on BAP

Figure 17 below shows the sub-index values of the top 10 Lower-Middle Income countries calculated with the Budget Allocation Process method of GFI.

Figure 17

Sub-Indices' Values of GFI based on BAP for Top 10 Lower-Middle Income Countries



Source: Results obtained by the Author

According to *Figure 17*, when GFI sub-indices calculated according to the BAP for the top 10 low-middle income countries, Indonesia, India, Vietnam, and Philipines stand out with high index values among the countries in that group.

Meanwhile, among the top 10 low-middle income countries, Morocco, Mongolia and Philippines are the three countries with the highest Policy and Regulation Readiness Index.

When "Economic Readiness" is taken into account, although the index values are close to each other, the Philippines, Indonesia and Mongolia have the highest values. While Iran has the lowest index value among the top 10 countries in terms of "Economic Readiness Index", it has the highest "Technological Readiness Index" and "Financial Innovation Index".

In terms of "ICT Infrastructure Index", Morocco, India, Philipines and Indonesia are the countries with the highest index values.

In general, countries in this country group have the lowest values in "ICT Readiness", "ICT Usage and Affordability" and "Access to Finance for Entrepreneurial Activity", which are also directly related to income level.

In terms of "Access to Finance for Entrepreneurial Activity", which is one of the main pillars of Fintech and critical for the development of start-ups, which are among the source of innovation, the countries with the highest index values are India and Indonesia. These countries are at the forefront in terms of access to financial products (Financial Inclusion Index) within their group, at the firm level and individually.

Nevertheless, considering the "Financial Innovation Index", Iran, India, Indonesia and Mongolia stand out as the countries with the highest index values.

For the "Social Infrastructure Index", Ukraine, Mongolia and Indonesia are the countries with the highest index values. The countries with the lowest index values among the top 10 countries are Kenya, Morocco and India.

For the "ICT Infrastructure Index", the top three countries with the highest value are Morocco, India and Philippines. The lowest index value among the top 10 countries belongs to Vietnam, Ukraine and Kenya.

Among the countries in the Lower-Middle Income group, the three countries with the highest "ICT Usage and Affordability Index" values are Iran, Morocco and Vietnam.

Moreover, India, Indonesia and Vietnam have the highest Access to Finance for Entrepreneurial Activity Index score, while Mongolia and Tunisia have the lowest among the top 10 countries. For the "Financial Inclusion Index", Indonesia, India and Philippines are the countries with the highest values.

"Fintech Readiness Index" consisting of "Policy and Regulation Readiness", "Economic Readiness", "Technological Readiness" and "ICT Readiness" sub-group indices Mongolia, Vietnam and Kenya are the top three countries with the highest index scores.

According to the "FinTech Infrastructure Index" consisting of "Financial Innovation", "Social Infrastructure", "ICT Infrastructure" and "ICT Usage and Affordability" sub-groups; Iran, Indonesia and Mongolia are the top three countries.

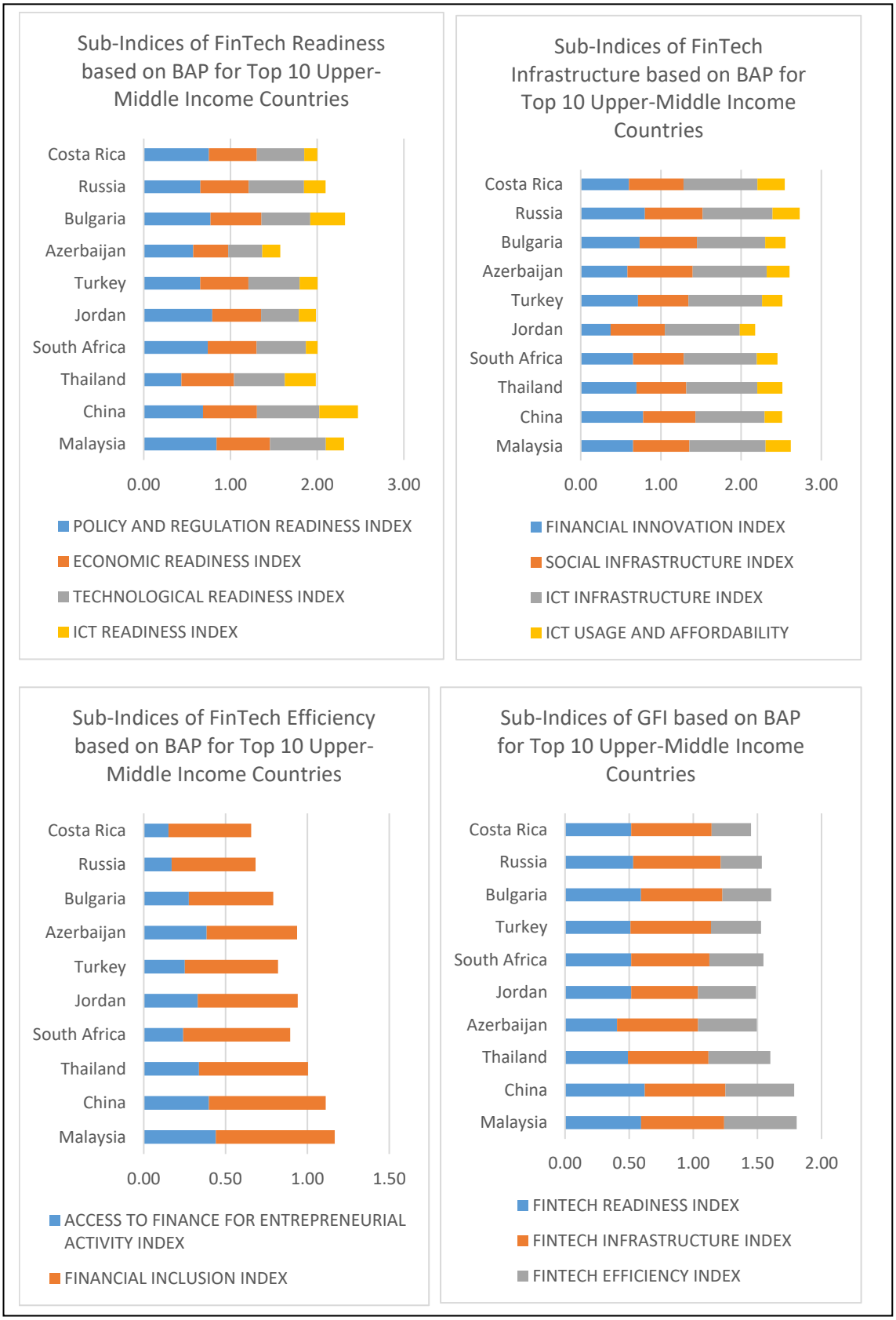
Considering the "Fintech Efficiency Index" comprising "Access to Finance for entrepreneurial Activity" and "Financial Inclusion" sub-groups; Indonesia, India, Vietnam and Kenya are the countries with the highest index scores.

3.8.7. Global Fintech Sub-Indices for Top 10 Upper- Middle Income Countries based on BAP

Figure 18 below shows the sub-index values of GFI for the Top 10 Upper-Middle Income based on the Budget Allocation Process method.

Figure 18

Sub-Indices' values of GFI based on BAP for Top 10 Upper-Middle Income Countries



Source: Results obtained by the Author

Considering the GFI sub-index scores for the top 10 high-middle income countries according to *Figure 18*, Malaysia, China, Bulgaria and Thailand stand out among the countries.

The countries with the highest "Policy and Regulation Readiness Index" are Malaysia, Jordan and Bulgaria. China, Malaysia and Thailand appear as the top three countries with high "Economic Readiness Index" scores.

In the same sub-index category, the countries with the highest "Technological Readiness Index" scores are China, Malaysia and Russia.

In terms of "ICT Readiness Index", China, Bulgaria and Thailand are the top three countries in this group.

Taking into account the "Financial Innovation Index", Russia, China and Bulgaria are among the top three countries. For the "Social Infrastructure Index", Azerbaijan, Russia and Bulgaria are the countries with the highest index scores. The countries with the lowest index values among the top 10 countries are South Africa, Thailand and Turkey.

When we consider the "ICT Infrastructure Index", the top three countries with the highest values are Malaysia, Jordan and Azerbaijan.

Among the countries in the Upper-Middle Income group, Costa Rica, Russia and Malasia have the highest "ICT Usage and Affordability Index" scores. Moreover, Malaysia, China and Azerbaijan have the highest "Access to Finance for Entrepreneurial Activity Index" in the upper-middle income country group, while Malaysia, China and Thailand have the highest "Financial Inclusion Index".

According to the "Fintech Readiness Index" consisting of "Policy and Regulation Readiness", "Economic Readiness", "Technological Readiness" and "ICT Readiness" sub-group indices, China, Malasia and Bulgaria are the top three countries with the highest index scores.

As regards the "FinTech Infrastructure Index" consisting of "Financial Innovation", "Social Infrastructure", "ICT Infrastructure" and "ICT Usage and Affordability" sub-groups; Russia, Malasia and Bulgaria are the top three countries.

Considering the "Fintech Efficiency Index" consisting of "Access to Finance for entrepreneurial Activity" and "Financial Inclusion" subgroups; China, Malasia and

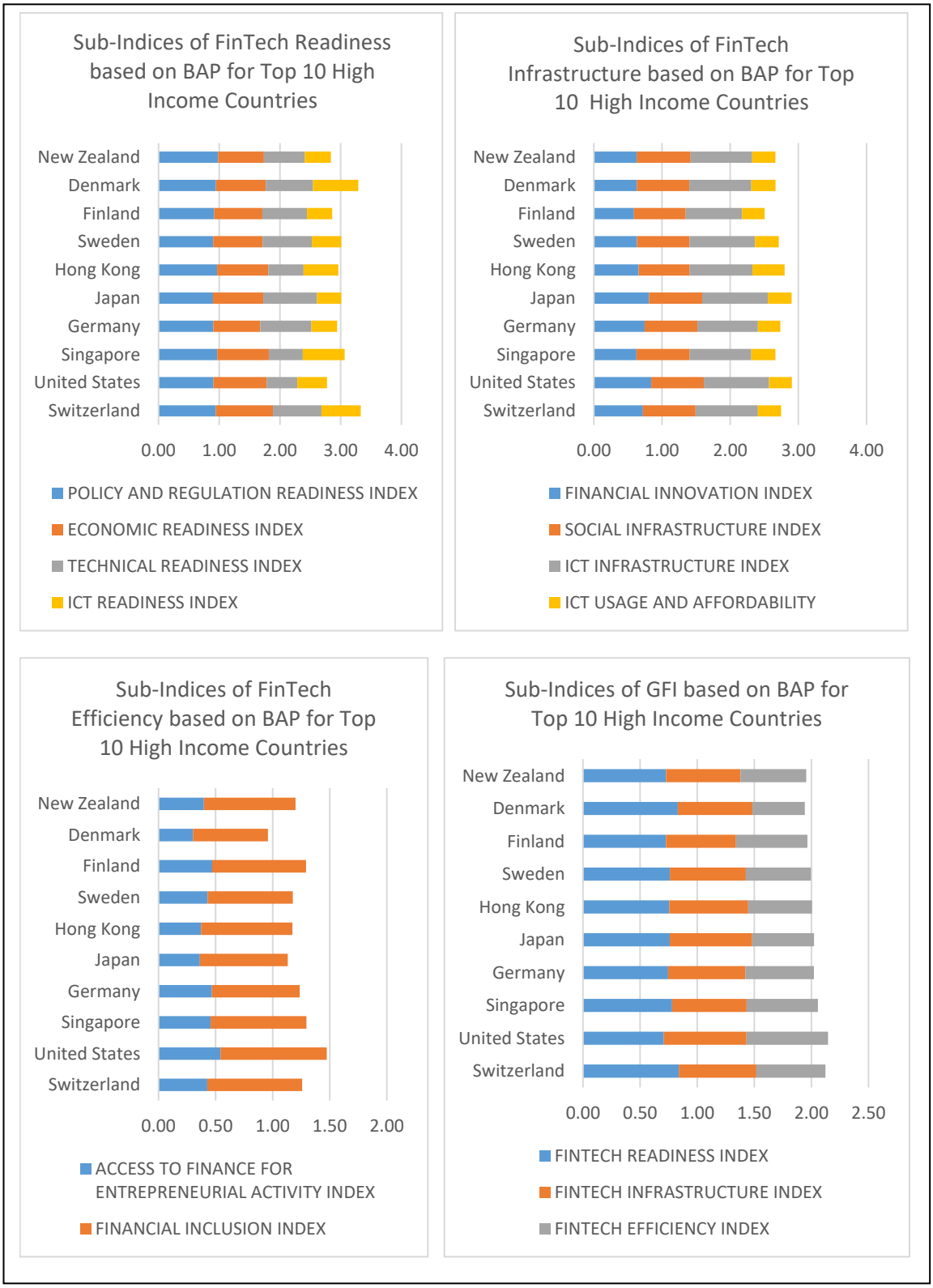
Thailand are the countries with the highest index values. Sub-Indices' Values of GFI based on BAP for Top 10 High Income Countries

3.8.8. Global Fintech Sub-Indices for Top 10 High Income Countries based on BAP

Figure 19. below shows the sub-index values of GFI for the Top 10 High Income countries based on BAP.

Figure 19

Sub-Indices' Values of GFI based on BAP for Top 10 High Income Countries



Source: Results obtained by the Author

According to *Figure 19*, when the GFI based on the BAP is analyzed for the top 10 high-income countries, Switzerland, the United States, Singapore and Germany stand out with high index scores.

The countries with the highest "Policy and Regulation Readiness Index" scores are New Zealand, Singapore and Hong Kong.

Switzerland, United States and Singapore stand out as the top three countries with high "Economic Readiness Index" scores. In the same sub-index category, the countries with the highest "Technological Readiness Index" values are Japan, Germany and Sweden.

When the "ICT Readiness Index" is analyzed, Denmark, Singapore and Switzerland rank in the top three.

In terms of "Financial Innovation Index", United States, Japan and Germany are among the top three countries. According to the "Social Infrastructure Index", which includes social factors that directly affect the acceptance, adoption and development of fintech instruments; New Zealand, Singapore, Japan and Germany are the countries with high index scores within their country group. “For the ICT Infrastructure Index", the top three countries are Japan, Sweden and United States.

Among the countries in the High Income group, the three countries with the highest "ICT Usage and Affordability Index" values are Hong-Kong, Denmark and Singapore.

Moreover, United States, Finland and Germany have the highest "Access to Finance for Entrepreneurial Activity Index" in the high income country group, while United States, Singapore and Switzerland have the highest "Financial Inclusion Index".

When we consider the "Fintech Readiness Index", which consists of "Policy and Legislative Readiness", "Economic Readiness", "Technological Readiness" and "ICT Readiness" sub-group indices, the countries with the highest index values are Switzerland, Denmark and Singapore.

According to the "FinTech Infrastructure Index" consisting of "Financial Innovation", "Social Infrastructure", "ICT Infrastructure" and "ICT Usage and Affordability" sub-groups; United States, Japan, Hong Kong are the top three countries.

Considering the "Fintech Efficiency Index" consisting of "Access to Finance for entrepreneurial Activity" and "Financial Inclusion" subgroups; United states, Finland and Singapore are the countries with the highest index scores.

3.8.9. Global Fintech Sub-Indices for Top 10 Low, Lower Middle, Upper Middle and High Income Countries based on PCA

Figure 20 below shows the sub-index values of GFI for Low, Lower Middle, Upper Middle and High Income Countries based on PCA.

Figure 20

Sub-Indices for Low, Lower Middle, Upper Middle and High Income Countries based on PCA

Source: Results obtained by the Author

According to *Figure 20*, GFI scores based on the PCA method for the first 10 low-income country ; Rwanda, Uganda, Zambia and Mali stand out as the countries with the highest index value for the "Fintech Readiness Index" which consists of "Policy and Regulation Readiness", "Economic Readiness", "Technological Readiness" and "ICT Readiness" sub-groups. According to the "FinTech Infrastructure Index", which consists of "Financial Innovation", "Social Infrastructure", "ICT Infrastructure" and "ICT Usage and Affordability" sub-groups; Rwanda, Uganda, Zambia and Malawi are the countries ranked first.

Considering the "Fintech Efficiency Index" consisting of "Access to Finance for Entrepreneurial Activity" and "Financial Inclusion" subgroups; Etiophia, Madagascar, Uganda and Liberia are the countries with the highest index scores.

According to *Figure 18*, when the GFI sub-index values calculated according to PCA are taken into account for the low-middle income country; Ukraine, Vietnam, Morocco stand out as the countries in the first ranks with the highest index values according to the "Fintech Readiness Index" scores.

According to the "FinTech Infrastructure Index"; Ukraine, Iran, Indonesia are the countries in the first place.

Considering the "Fintech Efficiency Index", Indonesia, India, Vietnam and Philippines are the top 10 countries with the highest index scores.

According to *Figure 18*, the GFI sub-index scores according to PCA for the high-middle income countries, China, bulgaria, Malaysia and Thailand stand out as the first countries with the highest index values of the "Fintech Readiness Index" .

According to the "FinTech Infrastructure Index"; Russia, Bulgaria, Costa Rica, Malaysia are the countries ranking first.

Considering the "Fintech Efficiency Index"; Malaysia, China, Thailand and Jordan are the top 10 countries with the highest index value.

When the GFI sub-index values calculated according to the PCA method according to *Figure 18* are evaluated for high-income country classification, Singapore, Switzerland, Denmark and United States are the countries with the highest "Fintech Readiness Index" value.

According to the "FinTech Infrastructure Index", South Korea, Canada, Japan and Hong Kong are the leading countries.

Considering the "Fintech Efficiency Index", the United States, Finland, Singapore and Switzerland are the top 10 countries with the highest index values.

3.8.10. Global FinTech Index for Top 10 Low Income Countries based on EW, BAP and PCA

Three different Global Fintech index scores were obtained by weighting the sub-indices consisting of sub-indicators using "Equal Weight", "Budget Allocation Process" and "Principle Component Analysis" methods. The calculated Global FinTech Index values are considered within the scope of the World Bank's country classification according to income level (Low, Lower Middle, Upper Middle, High).

Table 15 shows the scores of the Global FinTech Index calculated by EW, BAP and PCA methods for low-income countries.

Table 15

Global Fintech Index for Top 10 Low-Income Countries based on EW, BAP and PCA

Country	EW		BAP			PCA		
	Ranking	GFI	Country	Ranking	GFI	Country	Ranking	GFI
Rwanda	1	35.06	Uganda	1	37.64	Rwanda	1	31.98
Uganda	2	35.03	Rwanda	2	36.19	Uganda	2	31.88
Zambia	3	32.55	Ethiopia	3	34.66	Zambia	3	29.55
Ethiopia	4	31.94	Zambia	4	33.34	Liberia	4	25.23
Madagascar	5	29.33	Madagascar	5	30.89	Ethiopia	5	24.09
Mozambique	6	29.3	Mozambique	6	30.57	Mozambique	6	23.6
Liberia	7	27.81	Mali	7	29.88	Madagascar	7	23.22
Mali	8	27.69	Liberia	8	29.03	Mali	8	22.97
Guinea	9	26.99	Guinea	9	28.32	Burkina Faso	9	20.06
Malawi	10	24.43	Malawi	10	24.65	Malawi	10	19.85

Source: Results obtained by the Author

According to *Table 15*, the index scores obtained by equal weighted and BAP differ between 24 and 37.64 for the top 10 low-income countries, while the index values based on the PCA are between 19 and 31.98. The GFI scores varies between 0-100 and the index value approaching 0 indicates that the Fintech development level of the country is low. In this respect, it can be said that the Fintech development levels of low-income countries are also in the weak category.

As a result of the index scores calculated according to the three methods, Rwanda, Uganda, Zambia and Ethiopia are the top 4 countries with the highest value in the ranking based on the equal weighted method. Although the rankings of the index scores for all

three methods are close to each other, similar to the equal weighted method, Uganda, Rwanda, Ethiopia and Zambia are the first countries with high index scores based on the Budget Allocation Process. For the index scores based on the PCA analysis, similar results were obtained with the Equal Weighted method, and even the ranking of the top three countries taken as a result of PCA gave the same ranking with the Equal Weighted method. In the index ranking obtained by the PCA method, unlike other methods, Burkina Faso is the top 10 country instead of Guinea.

3.8.11. Global FinTech Index for Top 10 Lower-Middle Income Countries based on EW, BAP and PCA

The scores and ranking of the Global FinTech Index based on EW, BAP and PCA methods for low-middle-income countries are given in *Table 16.*

Table 16

Global Fintech Index for Top 10 Lower-Middle Income Countries based on EW, BAP and PCA

Country	EW		BAP			PCA		
	Ranking	GFI	Country	Ranking	GFI	Country	Ranking	GFI
Indonesia	1	49.36	Indonesia	1	51.03	Ukraine	1	45.59
Vietnam	2	45.44	Vietnam	2	47.69	Indonesia	2	45.45
India	3	45.36	India	3	47.03	Vietnam	3	44.29
Philippines	4	45.21	Philippines	4	46.76	Mongolia	4	43.50
Mongolia	5	44.67	Morocco	5	45.53	Iran	5	43.21
Iran	6	44.49	Iran	6	45.22	Philippines	6	42.26
Morocco	7	43.98	Ukraine	7	44.82	Morocco	7	41.76
Ukraine	8	43.72	Mongolia	8	44.70	Tunisia	8	40.14
Kenya	9	42.22	Kenya	9	44.49	India	9	39.29
El Salvador	10	41.80	Tunisia	10	43.01	Lebanon	10	39.26

Source: Results obtained by the Author

According to *Table 16*, the index values calculated according to the BAP and equally weighted are distributed between 41 and 51.03 for the top 10 low-middle income countries, while the index scores based on the PCA are between 39 and 45.59. In this regard, it can be stated that lower-middle-income countries have a low-middle level of Fintech development, similar to their income levels.

As a result of the index scores for all three methods, Indonesia, Vietnam, India and Philippines are the first 4 countries with the highest value in the ranking calculated with the equally weighted method. As a result of the index scores obtained pursuant to the three methods, Indonesia, Vietnam, India and Philippines are the first four countries with the highest value in the ranking based on the equally weighted method. Ukraine,

Indonesia, Vietnam and Mongolia ranked first in the index values calculated according to the PCA analysis results.

3.8.12. Global FinTech Index for Top 10 Upper-Middle Income Countries based on EW, BAP and PCA

Table 17 shows the GFI calculated by EW, BAP and PCA methods for upper middle income countries.

Table 17

Global Fintech Index for Top 10 Upper-Middle Income Countries based on EW, BAP and PCA

Country	EW		BAP			PCA		
	Ranking	GFI	Country	Ranking	GFI	Country	Ranking	GFI
China	1	59.14	Malaysia	1	59.98	China	1	63.59
Malaysia	2	58.03	China	2	59.54	Bulgaria	2	63.14
Bulgaria	3	52.26	Bulgaria	3	53.44	Malaysia	3	61.83
Thailand	4	52.14	Thailand	4	52.75	Thailand	4	59.52
Russia	5	50.07	South Africa	5	51.17	Russia	5	56.33
South Africa	6	49.79	Russia	6	50.52	Turkey	6	51.35
Turkey	7	49.26	Turkey	7	50.44	Costa Rica	7	51.09
Jordan	8	48.96	Jordan	8	49.63	Jordan	8	51.08
Azerbaijan	9	47.85	Azerbaijan	9	48.83	South Africa	9	50.53
Costa Rica	10	47.18	Costa Rica	10	47.86	Brazil	10	49.48

Source: Results obtained by the Author

According to *Table 17*, the index values calculated according to the equally weighted and BAP methods differ between 47 and 59 for the top 10 upper middle income countries, while the index values calculated by PCA analysis are between 49 and 64.

Considering the index values, Turkey, Costa Rica, Jordan, South Africa, Brazil, Azerbaijan can be considered as medium in terms of Fintech development. Russia, Thailand, Bulgaria, Malasia and China, on the other hand, have a higher index value than the countries in the list, but contrary to their income levels, Fintech development of them can be interpreted as countries at the middle level.

Although the ranking of the index values calculated pursuant to the three methods is close to each other, the top countries for all of them are China, Malaysia, Bulgaria and Thailand. Despite the fact that the index scores and rankings of all three methods are close to each other, results of PCA analysis, unlike the other two methods, Brazil has replaced Azerbaijan in the list of the top 10 countries.

Turkey ranks 7th among the top 10 countries in the index list obtained from the Equal weighted and BAP methods, while it ranks 6th in the index list calculated according to the PCA method.

3.8.13. Global FinTech Index for Top 10 High Income Countries based on EW, BAP and PCA

The scores of the Global FinTech Index calculated by EW, BAP and PCA methods for high-income countries are presented in *Table 18.*

Table 18

Global Fintech Index for Top 10 High Income Countries based on EW, BAP and PCA

Country	EW		BAP			PCA		
	Ranking	GFI	Country	Ranking	GFI	Country	Ranking	GFI
United States	1	71.55	Switzerland	1	71.50	Switzerland	1	98.72
Switzerland	2	69.62	United States	2	71.43	Singapore	2	97.95
Singapore	3	67.10	Singapore	3	69.16	United States	3	94.18
Japan	4	66.31	Germany	4	67.73	Denmark	4	93.70
Germany	5	65.43	Japan	5	67.63	Hong Kong	5	88.78
Hong Kong	6	65.20	Hong Kong	6	67.19	Sweden	6	86.71
Sweden	7	65.20	Sweden	7	66.97	Netherlands	7	86.70
New Zealand	8	63.75	Finland	8	66.01	Canada	8	86.12
Netherlands	9	63.30	Denmark	9	65.58	Germany	9	83.03
Denmark	10	63.26	New Zealand	10	65.51	Japan	10	82.77

Source: Results obtained by the Author

According to *Table 18,* the index acquired with respect to the BAP and equally weighted differ between 63 and 71.55 for the top 10 high-income countries, while the index scores based on the PCA analysis are between 82 and 98.72. Concordantly, the top 10 high-income countries pursuant to PCA also have a high level of Fintech development. However, considering the EW and BAP values, it can be said that countries belonging to the high income group also have a FinTech development at the upper middle level.

Although the ranking of the index scores of the first 10 countries calculated in compliance with the three methods is close to each other,and also Switzerland, United states and Singapore are the countries that are in the first three places for all methods. The index scores obtained by the PCA, unlike the other two methods, Canada was listed in the top 10 countries instead of New Zealand. While Finland replaces Netherland among the top 10 countries in the index list calculated according to BAP, it is not among the top 10 countries rankings obtained for all other two methods.

CHAPTER 4. POLICY PATH TRAJECTORY FOR GLOBAL FINTECH DEVELOPMENT BASED ON REINFORCEMENT LEARNING

The main purposes of composite indicators are to be an effective tool for policy makers and academics by providing a comparative indicator between countries in fields such as technology, society and economy. The creation of composite indicators is also important for reasons such as revealing the determinants of the phenomenon to be measured, ease of interpretation, simplifying complex and difficult to understand concepts, allowing countries to progress in critical social, economic, technological, etc. issues and to see their shortcomings, and raising awareness by providing citizens with information on complex issues due to their easy comprehensibility.

In this part, as the main objective of the composite indicators, it is aimed to make policy recommendations that will enable countries to address their weaknesses by increasing their development in the field of FinTech within the framework of the determinants and indicators revealed by the Global FinTech Index.

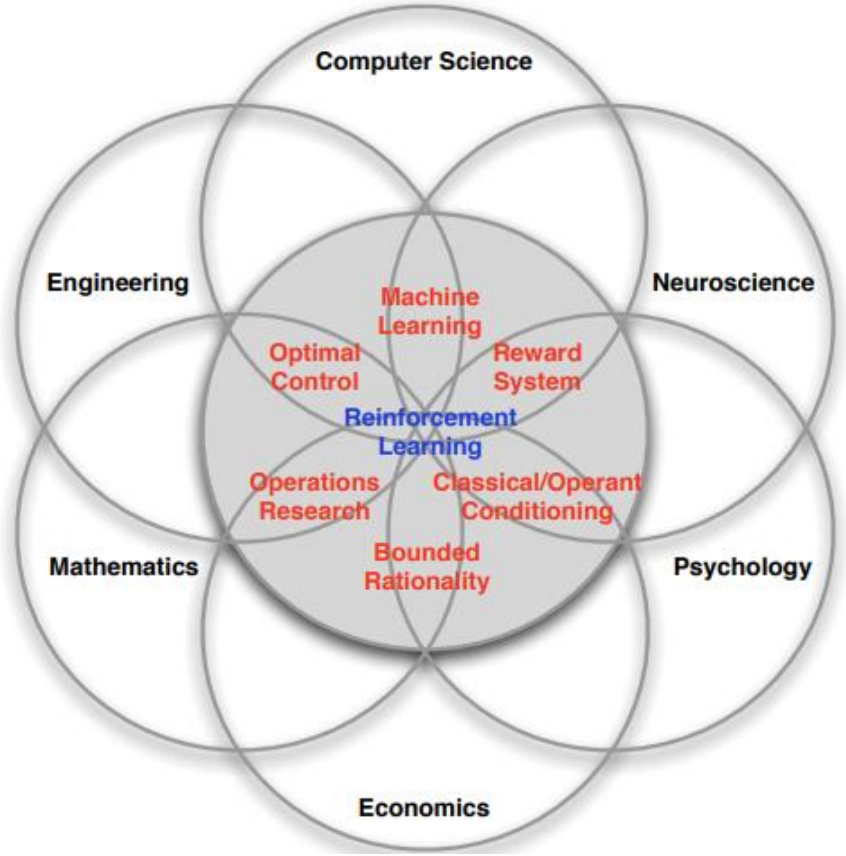
For this purpose, the policies determined within the scope of the indicators were analyzed with RL as a ML method and recommendations were made to increase the FinTech developments of the countries.

4.1. Reinforcement Learning

Reinforcement learning sits at the nexus of different sciences, from engineering and computer science to neuroscience, psychology and economics (Silver, 2015). An illustration of how reinforcement learning is connected to other sciences is shown in *Figure 21* below.

Figure 21

Connection between RL and Other Sciences



Source: Silver (2015)

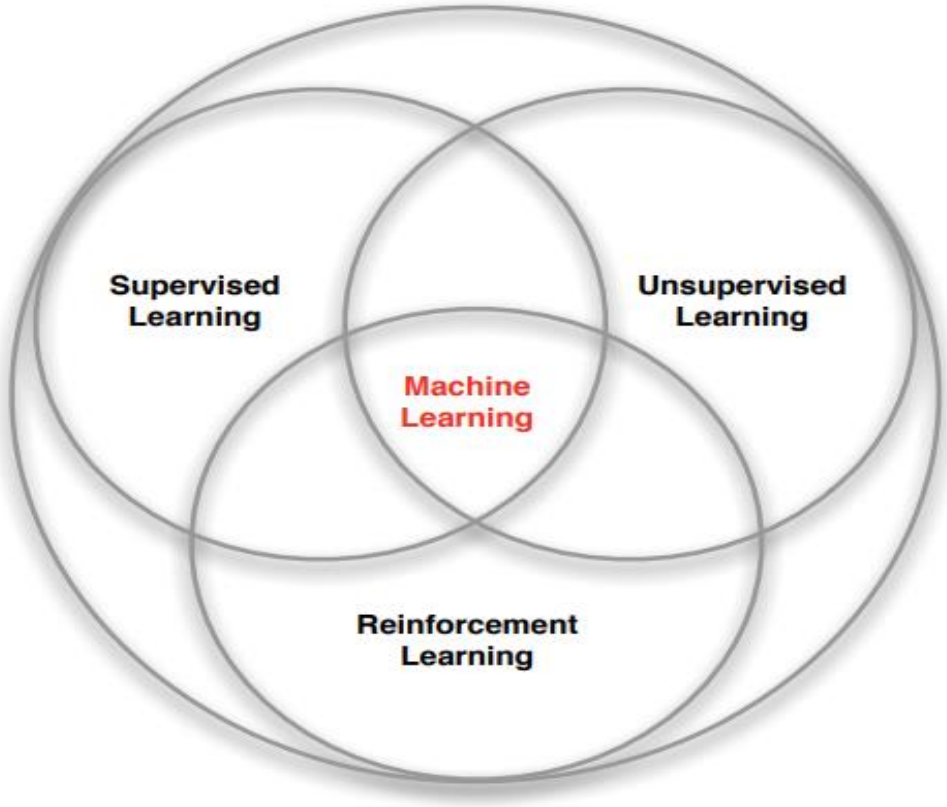
As can be seen from *Figure 21*, RL is a ML method that is used by many different disciplines and has many application areas. The common point of all these sciences and the fields they are related to reinforcement learning is that they all work on the same problem. The common field of study of all these sciences is the science of decision making. The science of decision-making connects all different disciplines and brings them to a common denominator. This common denominator is the process by which individuals make optimal decisions with the information they obtain. The fundamental question is why people make decisions and why they try to maximize utility?.

One of the common tools used in decision-making processes today is ML, a type of artificial neural networks. ML is a branch of AI and computer science that uses data and algorithms to mimic the way humans learn and gradually increases accuracy.

RL is one of the sub-branches of ML that takes place together with supervised and unsupervised learning. The relationship between ML, types and RL is given in *Figure 22.*

Figure 22

ML and its types



Source: David Silver (2015)

As can be seen in *Figure 22*, although different types of ML have different features from each other, they also have common features.

Supervised learning is a type of learning in which data is labeled and models are created in order to train algorithms that classify data and accurately predict outcomes (Urbanowicz & Moore, 2009). While this type of learning consists of the learner and the teacher, the teacher asks the learner to create rules by showing examples. After the teaching process is completed, the learner reveals the solution of the problem to be solved by following the rules learned. Classification and regression are the most well-known supervised learning methods. In this type of learning, training data is used to train the models and test data is used to test the them (Urbanowicz & Moore, 2009).

Unsupervised learning is used to cluster unlabeled datasets and analyze ML algorithms without labeled data, unlike supervised learning by trying to extract meaningful information from the data (Silver, 2015). Once learning occurs, subsequent learning continues indefinitely. Unlike supervised learning, which tries to extract meaningful

information from the data, this type of learning is used to cluster unlabeled datasets without labeled data and to analyze ML algorithms.

In RL, there is no supervisor. While the learner performs the learning process on its own, the rules it learns are not fixed but dynamic. As in unsupervised learning, once the rule is learned, it does not continue indefinitely and the rule is changed when necessary. RL is a type of learning that maps actions that will maximize the scalar feedback signal towards the goal (Silver, 2015). In short, it is a ML approach that learns in a goal-oriented way (to achieve maximum reward). In this type of learning, the learning machine, called agent, obtains different scalar reward signals with different responses to the situations it encounters (McCallum, 1995). In this case, agent aims to reach the maximum reward through trial and error (Szita, 2012). In this process, similar to many types of ML, the learning machine is not dictate which actions to perform. Instead, the machine uses trial and error to discover which actions provide the most reward (Sutton & Barto, 2015).

Another characteristic of reinforcement learning is that it is essentially a closed loop problem in that the actions of the learning system influence subsequent inputs (Li et al., 2019). However, in reinforcement learning, in the most challenging situations, actions can influence not only the immediate reward but also the next situation and the next rewards (Sutton & Barto, 2015).

The following features of reinforcement learning distinguish this type of learning from other types of ML.

- Being closed loop in a fundamental way
- The absence of a direct instruction and a teacher on what actions to take, i.e. the learner does the learning on his/her own. The use of reward and punishment instead of instruction.
- The consequences of actions, including reward signals, occur over long periods of time. This so-called feedback process occurs immediately in supervised learning, whereas in reinforcement learning the feedback is delayed.
- While the decision made in the other two types of learning does not affect the next decisions, in reinforcement learning, a decision made now affects future decisions.

Examples of the use of reinforcement learning are given below.

- Taking a helicopter from a starting point to a destination point,
- In backgammon, developing a policy to beat the player who knows best,
- Development of optimal investment strategies,
- Building human-like robots,

These can be shown as examples of reinforcement learning.

4.1.1. Components of the Reinforcement Learning

In general, a reinforcement learning system has 4 elements (Sutton & Barto, 2015).

These are policy, reward signals, value function and the environment

4.1.1.1. Policy

The reward signal defines the goal in RL(Silver, 2015). Nevertheless, it can also be defined as an agent's behavior function. A policy is the behavior of the learning machine, the agent, at a given time, and is also a map that leads from situation to action (Singh et al., 2022). In other words, it is a map that leads to actions to be taken in situations, or a mapping towards actions. This is similar to the reaction to stimuli or association in psychology (Sutton & Barto, 2015). If the situation is considered as an effect, the agent's reaction to it can be considered as "action". Policies specify the actions an agent can take in a given situation and can be deterministic or stochastic.

Deterministic policy representing as $a = \pi(s)$

a indicates action

s represents state or situation and,

pi shows the policy

Stochastic policy representing as

$$\pi(a|s) = P[At = a|St = s] \qquad (4.1)$$

4.1.1.2. Reward Signals

Reinforcement is one of the most important components of learning. The reward signal defines the goal in RL (Silver, 2015). At each time step, the environment sends a signal to the agent indicating the reward (Xu et al., 2022) . The agent's main objective is to maximize the reward in the long run (Singh et al., 2022). A reward expressed as Rt is a scalar feedback signal and not a vector. By following the best rules, the best path, the learner arrives at the goal they want to reach. Rt is the feedback signal that will guide the learner. In that sense, the reward signal expresses situations that may be good or bad for the agent and transmits these signals from the environment to the agent. Reinforcement learning is fundamentally based on the reward hypothesis, which states that the entire goal is to maximize the total expected reward. Because the main goal is for the agent to obtain the maximum reward through the signals. The reward to the agent at any given time depends on the agent's actions and the current state of its environment. However, reward signaling is the primary way to change policy. If an action chosen by the policy results in a low reward, the policy can change the reward by choosing another action in the future.

4.1.1.3. Value Function

The value function expresses the sum of the rewards that an agent can expect from the current state and the subsequent states (Silver, 2015). Rewards express what is good or bad in the moment, whereas state value expresses what is good or bad in the long run (Mishra & Moustafa, 2023). A situation can have a low reward but a high value. This is because the low-reward situation is followed by other situations with high rewards. The opposite is also possible, where a situation of high rewards is followed by a situation of consistently low rewards (Sutton and Barto, 2015).

$$v\pi(s) = E\pi\ Rt+1 + \gamma Rt+2 + \gamma\ 2Rt+3 + ... \mid St = s \qquad (4.2)$$

There are two value functions, the value function for the states (V) and the value function for the state-action pair (Q).

4.1.1.4. The Environment

The fourth and final element of some reinforcement learning systems is an optional environmental model (Sutton & Barto, 2015). The model is a simulation of the environment and allows the agent to estimate the reward and the consequences of an

action before taking it (Silver, 2015; Sutton and Barto, 2015). In this way, inferences about the environment can be made and a change in the agent's behavior can occur with planning.

Moreover, one of the examples that most clearly summarizes the problem of reinforcement learning is the patient-doctor relationship. As part of the treatment administered by the doctor to the patient, patients take medication and as a result, tests are analyzed to see the effect of the medication. In other words, looking at the patient's test results and interpreting the tests is observation. The increase or decrease in the values as a result of the treatment represents the reward. The treatment applied is defined as an action. If the patient's health deteriorates (negative reward) according to the applied treatment (action), a different approach will be taken (action). The value function is the function that indicates the state the patient is in or whether the decision we have made (action) is a good or bad decision. This is where reinforcement learning differs from supervised learning. In supervised learning, the learner takes the same action after learning, regardless of the observation, since there is no reward or punishment. Once learning has taken place, the learned fixed rule is applied unchanged regardless of the observation.

Reinforcement learning is dynamic. The action applied varies according to the reward or punishment that occurs after the action is taken.

In Reinforcement learning, the environment will give a reward or a penalty to the algorithm, depending on the situation to observe the state of it. The Agent will decide the policy to follow in the next step based on the reward or punishment given. In accordance with the strategy applied, the observed environment will transition to the new state. New policies will be determined and actions will be taken according to new observations after the situation changes. The cycle goes observation, reward, action. For this reason, it is important to first determine the action, state and rewards in the problem to be addressed.

The situation is the self-knowledge that allows us to decide which strategy to apply next. As in the case of the patient, the patient's condition depends on what kind of treatment he or she has received in the past.

$$H_t = O_1, R_1, A_1 \ldots A_{t+1}, O_t, R_t \qquad (4.3)$$

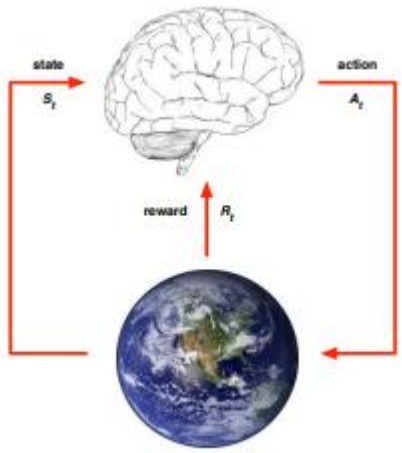
$$S_t = f(H_t) \qquad (4.4)$$

In these equations, “H” shows the History of observations, rewatds and actions while R indicates the Rewards and ones for all, S represents the State.

The relationship between the basic components of Reinforcement Learning and how it works is given in *Figure 23.*

Figure 23

The relationship between the basic components of Reinforcement Learning



Source: Silver (2015)

At each step t the agent takes the Action, At , and gets Observation, Ot and scalar Reward, Rt.

The history can be defined as the sequence of observations, actions, rewards

$$H_t = O_1, R_1, A_1, ..., A_{t-1}, O_t, R_t \text{ i.e.} \quad (4.5)$$

What will occure next is related to the history and the agent choses actions while the environment determines observations/rewards.

State is the information as a tool to designate what occurs next.

Formally, state is a function of the history:

$$S_t = f(H_t) \quad (4.6)$$

Different methods are used in decision-making processes under the components of reinforcement learning. In the study "Monte Carlo Control", one of the Monte Carlo methods based on the assumption that we do not have complete information about the environment, is used to estimate value functions and to put forward the most appropriate policies.

4.1.2. Monte Carlo Control

Monte Carlo methods are experience-based methods that sample situations, actions and rewards as they interact with the environment (Wei et al., 2021; Yoo et al., 2021). The value of a state is the cumulative discounted reward, i.e. the expected return, expected from subsequent states starting from that state and then following a given policy (Sutton & Barto, 2015). Monte Carlo methods are also a way of solving reinforcement models, taking into account average sample returns (Liu, 2021). One way to estimate expected returns based on experience would be to average the returns we get from observing a situation. Underlying all Monte Carlo methods is the expectation that as we interact more with the environment and observe higher returns, the average will converge to the expected value (Wei et al., 2021). In other words, Monte Carlo methods learn value functions and optimal policies from experience in the form of case studies. In the presence of well-defined returns, Monte Carlo methods can be defined only for episodic tasks. This means that experiences are divided into episodes, and all episodes eventually end, no matter which action is chosen (Sutton & Barto, 2015). Value estimates and policies are changed only after the completion of an episode. Monte Carlo methods are therefore incremental in the episodic sense, but not in the step-by-step sense.

The Monte Carlo method has different features such as

- the assumption that we do not have complete information about the environment

- required experience with example state sequences, actions and rewards from online or simulated interaction with an environment,

- learning from the online experience is more effective because it does not require prior knowledge of the dynamics of the environment but can still achieve optimal behavior

- advantages of learning from simulated experience

and unlike other methods, these led to its selection as the method of the study (Sutton and Barto, 2015; Silver, 2015; Liu et al., 2022).

Also in line with the objective of the study, Monte Carlo estimation can be used in control, i.e. to approximate optimal policies. Therefore, this study utilizes the "Monte Carlo Control" method in order to determine the optimal policies that are effective on the development of Fintech on a country basis.

The general idea of Monte Carlo Control is similar to generalized policy iteration. In Generalized Policy iteration, both an approximate policy and an approximate value function are determined (Sutton & Barto, 2015). The value function is iteratively modified to converge to the value function of the current policy (Silver, 2015). These two types of change work against each other to some extent, as each creates a moving target for the other, but together they lead to the optimization of both the policy and the value function (Sutton & Barto, 2015)

For the method, alternating full policy evaluation and policy refinement phases are performed, starting with a policy $\pi 0$ and ending with the optimal policy and the optimal action-value function (Wei et al., 2021)

4.2. Application of Reinforcement Learning for Global Fintech Index

In Section 3, GFI values were calculated by three different methods: EW, BAP and PCA. In this section, it is aimed to propose a policy path that will enable countries to address their weaknesses by increasing their development of FinTech, taking into account the index values based on EW and BAP. The reason why only EW and BAP are considered in the analysis is that PCA consists of three main breakdowns, while the other two methods include subgroups and the policy path is defined through them. As a matter of fact, policy recommendations are constructed with sub-categorizations in mind, and the GFI model obtained from PCA does not have the necessary sub-group definition to propose a policy pathway. RL, a form of ML, was used to make policy recommendations that will enable countries to address their weaknesses by increasing their development of FinTech through the determinants revealed by the GFI. Reinforcement Learning problems are based on the identification of State(s), Action (A), rewards (R) and policy (π) and value function components.

In this context, as the first stage of the analysis, "States" (s), "actions" (A), "rewards" (R), "policy" (π) and value fuction were identified based on the index model constructed in Section 3.

4.2.1. Defining the States

State is generally the information used to determine what will happen in the future and is a history function. Taking an example from the patient-doctor relationship in Section 4.1.1.4, state refers to the patient's observable state and disease history, while the observed

state of the patient determines which treatment the doctor will choose (action). In this regard, state can be a function of history.

History refers to a succession of observations, actions and rewards.

For example;

$$Ht= O1, R1, A1,\ldots, At-1, Ot, Rt \quad (4.7)$$

$$St= f(Ht) \quad (4.8)$$

In the study, the factor that determines which policy the decision maker (i.e. the policymaker) will implement (which action he/she will take) is the GFI value of the relevant country. In this respect, countries' index values ranging from 0 to 100, calculated according to EW and BAP, were determined as the "States" .

The GFI value ranging between 0-100 was divided into 24 different states, taking into account the index values that countries can take.

The table defining the identified "states" is given in *Table 19.*

Table 19

Definitions of States

INDEX	STATE
0-15	1
15-18	2
18-21	3
21-24	4
24-27	5
27-30	6
30-33	7
33-36	8
36-39	9
39-42	10
42-45	11
45-48	12
48-51	13
51-54	14
54-57	15
57-60	16
60-63	17
63-66	18
66-69	19
69-72	20
72-75	21
75-78	22
78-81	23
81-100	24

Source: Results obtained by the Author

For GFI, which takes values between 0-100, "0" is the lowest index score and indicates the lowest level of FinTech development, while "100" is the highest index value and indicates high level of sophistication.

As seen in *Table 19*, the GFI, which has a value between 0-100, is divided into 24 different states. Countries with an index score between 0-15 are in State (1), while other states are determined by increasing 3 points until the end state of State (24). State(24), the terminator state, refers to index scores between 81-100.

The key question for the policy maker, i.e. the decision maker (agent), is to determine what actions (policies) should be taken to bring a country's Fintech index score closer to a terminal state.

4.2.2. Determining the Action, Reward and Policy

Policy refers to the set of sequential actions that an agent can take to move from its current state to the target state. In this respect, policy is the set of strategies that the agent chooses from the set of possible actions. This policy can be defined as a simple action or as a lookup table that covers all cases. If the action taken in the situation is considered as an effect, the environment responds with a reaction (reward). Policies are characterized as dynamic as the agent evaluates the situation and looks for actions it can take.

The reward is the score the agent receives from the environment for an action it has performed, but the main goal of the learning agent is to maximize the rewards it receives in the long run. Moreover, the reward is the value that determines how good or bad the action taken was, and rewards can also cause the agent to change its policy over time. If a low score is obtained after an action is taken, it may be preferable to take a different action in the same situation, taking into account the low reward received in the future. In any state, even if the action is followed by a low reward, the agent may prefer that actions, since the long-run goal is to maximize the total returns.

In this regard, by using the combinations of the sub-groups, 15 different actions that will affect the Fintech development of the countries were composed by interviewing 4 experts (2 private sector, 2 academicians) whose expertise were utilized in the construction of the index with the BAP method. The interview used to be assessed the impact of the actions on the index values, their cost and feasibility in a comparative manner and to score them.

Table 20, which shows the action determined based on the GFI index model, the index sub-group and the rewards associated with the actions, is given below.

Table 20

Definitions of Actions, Policies and Rewards based on GFI

Actions	Actions and Related Sub-groups	References	Rewards
1	SUPPORTS FOR INCLUSIVE FINANCIAL MARKETS	Cornelli et al. (2021), Edler and Fagerberg (2017), Rau (2018), Navaretti et al.(2018), Cantu and Chui (2020)	65
	Policy and Regulation Readiness Financial Innovation Financial Inclusion		
2	SUPPORTS FOR TECHNOLOGICAL INFRASTRUCTURE	World Economic Forum (2017), Glavina et al. (2021)	80
	ICT Readiness ICT Infrastructure ICT Usage and Affordability Technological Readiness		
3	SUPPORTS FOR START-UPS	Mc Kinsey&Company (2022), McCann and Ortega-Argiles (2013)	100
	Access to Finance for Entrepreneurial Activity Economic Readiness Policy and Regulation Readiness		
4	SUPPORTS FOR FINANCIAL DEVELOPMENT	Cornelli et al. (2021), Haddad & Hornuf (2019), Cantu and Chui (2020)	75
	Economic Readiness Financial Innovation Access to Finance for Entrepreneurial Activity Financial Inclusion		
5	SUPPORTS FOR FINANCIAL INNOVATION	Cornelli et al. (2021), Schindler (2017), Edler and Fagerberg (2017), Adaba & Ayoung (2017)	90
	Financial Innovation Economic Readiness Access to Finance for Entrepreneurial Activity Technological Readiness		
6	REDUCING SUPPORT FOR SOCIAL AND TECHNOLOGICAL INFRASTRUCTURE	World Economic Forum (2017), Frost (2020), Mention (2021)	10
	Social Infrastructure ICT Infrastructure ICT Readiness ICT Usage and Affordability		
7	REDUCING THE SUPPORT FOR START-UPS	Haddad & Hornuf (2019), Mc Kinsey&Company (2022), McCann and Ortega-Argiles (2013)	20
	Policy and Regulation Readiness Economic Readiness Access to Finance for Entrepreneurial Activity Technological Readiness		
8	REDUCING THE SUPPORT FOR ECONOMIC AND SOCIAL INFRASTRUCTURE	Rodstrom (2020), Frost (2020), Mention (2021)	15
	Economic Readiness		

	Social Infrastructure Policy and Regulation Readiness		
9	REDUCING THE SUPPORT FOR FINANCIAL INNOVATION Financial Innovation Economic Readiness Access to Finance for Entrepreneurial Activity Technological Readiness	Cornelli et al. (2021), Schindler (2017), Edler and Fagerberg (2017), Adaba & Ayoung (2017)	30
10	REDUCING THE SUPPORT FOR FINANCIAL EFFICIENCY Access to Finance for Entrepreneurial Activity Financial Inclusion	Zavolokina (2016) , Shuli (2022)	25
11	SUPPORTS FOR FINANCIAL INCLUSION Financial Inclusion Economic Readiness Financial Innovation	Van Hov and Dubus (2019)	45
12	SUPPORTS FOR SOCIAL, POLITICAL AND ECONOMIC ENVIRONMENTS Policy and Regulation Readiness Economic Readiness Social Infrastructure	Rodstrom (2020), Frost (2020), Mention (2021), Rau (2018), Navaretti et al.(2018)	50
13	SUPPORTS FOR FINANCIAL EFFICIENCY Access to Fınance for Entrepreneurial Activity Financial Inclusion	Zavolokina (2016) , Shuli (2022)	60
14	SUPPORTS FOR ICT INFRASTRUCTURE ICT Readiness ICT Infrastructure ICT Usage and Affordability	World Economic Forum (2017), Asongu (2018)	55
15	SUPPORTS FOR POLITICAL AND ECONOMIC READINESS Policy and Regulation Readiness Economic Readiness	Claessens et al.(2018), Mention (2021), Rau (2018), Navaretti et al.(2018)	40

Source: Results obtained by the Author

According to *Table 20*, actions between 1-5 are expected to have a positive impact with minimum cost on countries' Fintech development, while actions between 5-10 are expected to have the opposite effect, slowing down countries' progress. Actions between 10-15% are defined as policies that will have a medium impact.

The rewards for actions that achieve the end-state on GFI at low costs are set between 65-100. In this sense, "Support for Financial Inclusion" has 65 reward points, "Supports for Technological Infrastructure" has 80 points, "Supports for Start-ups" has 100 points, "Supports for Financial Development" has 75 points and "Support for Financial Innovation" has 90 points.

The reward for actions that move away from the termination state or lead to getting there at high costs is set between 10 and 30. In this regard, “Reducing Support for Social and Technological Infrastructure” has 1fgf0 reward points, "Supports for Start-ups" has 20 points “Reducing the Supports for Economic and Social Infrastructure” has 15 points, “Reducing Support for Financial Innovation” has 30 points, “Reducing the Support for Financial Efficiency“ has 25 points.

The rewards for actions that achieve the limiting state on GFI at acceptable costs are set between 40-60. In this respect, the reward points are 45 for "Supports for Financial Inclusion", 50 for "Supports for Social, Political and Economic Environments", 60 for "Supports for Financial Efficiency", 55 for "Supports for ICT Infrastructure" and 40 for "Supports for Political and Economic Readiness".

The identified actions, policies and rewards are common for GFI index values calculated by two different methods, EW and BAP. The same actions, policies and rewards were used for the indices calculated by both methods.

4.2.3. Determining the Action Value Function

The action value function is a quantity (Q(s,a)) that expresses the sum of the long-term rewards of the agent's action in any given situation. Rewards indicate which action is good and which action is bad in the moment, while action value indicates which action is good and which action is bad in the long run. In other words, the action value fuction shows the value of actions for all states. For instance, an action may have a low reward but a high value. This is because it is possible for the action with low reward to be followed by other situations with high reward, and vice versa. In this respect, the action value functions prepared for EW and BAP, which are the two different methods by which index values are calculated, are given in *Table 21* and *Table 22*, respectively.

Table 21

Action Value Fuction of GFI based on EW

STATES	ACTIONS														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	15.821	18.5302	0	0	0	0	0	0	0	0	29.532	0	20.5729	0	0
2	0	0	0	0	0	0	16.9525	0	18.3449	0	0	29.421	0	0	26.6242
3	0	23.9761	0	17.6037	19.5535	0	22.8768	0	0	0	18.5302	25.4337	27.5616	0	0
4	27.752	28.243	29.04	26.699	31.2196	0	13.092	22.8768	25.4187	0	34.3252	27.7051	23.4363	28.243	15.8433
5	31.3811	28.4781	30.2914	34.1341	30.7134	0	0	21.5303	21.733	0	31.3776	26.5302	24.8695	20.4128	24.067
6	23.1953	34.524	33.1245	27.0655	34.4094	22.4793	0	28.4382	31.3811	25.2006	34.3995	31.9076	34.2773	31.5554	30.5841
7	28.6361	28.2019	32.4101	29.3733	35.4855	20.5891	0	27.7285	23.5031	34.8678	31.1345	13.2031	31.4566	32.4371	32.333
8	33.1427	35.6887	16.261	37.5468	34.6747	25.4187	23.0886	14.2615	22.5445	0	33.5816	30.0957	32.7201	25.059	31.8096
9	30.4858	29.6058	38.3423	39.3145	29.862	29.5237	15.7856	26.1831	28.8706	33.9355	38.8138	36.4508	36.0018	36.1445	27.1034
10	40.4245	37.856	37.181	39.3097	38.1036	31.7807	27.9823	25.4528	27.2207	27.6705	38.9286	32.2748	32.1049	33.9945	35.5077
11	43.0022	41.5884	40.4902	37.5025	39.0894	39.603	29.0764	33.7915	27.7439	30.9004	42.2808	41.4537	39.0447	36.74	40.0919
12	39.5637	40.8699	37.0243	42.4378	41.1923	0	30.7534	29.5421	24.9761	39.7494	33.8662	35.3701	39.9142	31.3811	38.4806
13	39.7622	42.2253	36.2784	37.1707	43.4537	0	30.5108	30.8323	32.8153	0	31.3266	41.715	42.4196	37.7794	38.4725
14	46.1441	38.9261	41.4276	56.1822	46.7933	35.8642	33.8736	30.3714	36.9789	38.9654	46.0953	40.6952	45.9807	37.8488	38.2986
15	40.5016	44.3825	37.1232	43.336	38.7625	31.087	25.4187	29.1859	31.6523	31.6159	42.6246	35.823	43.163	41.159	40.8004
16	40.0245	44.9289	41.5453	44.6618	47.6336	37.2836	30.4781	37.0597	20.3053	0	45.9909	45.267	37.6698	43.3343	41.7315
17	47.4425	44.3402	44.146	43.6458	49.0137	51.9142	33.0509	31.7231	35.3564	52.3261	46.3644	46.7737	39.9743	45.0761	43.1583
18	48.2683	47.6733	41.0285	46.2098	47.3136	37.0512	20.9925	37.1658	0	37.4977	48.902	47.2648	53.4747	49.2512	44.5741
19	38.6342	49.2233	48.7239	44.5319	40.7982	0	32.5826	35.8595	40.4799	28.6625	43.2074	43.0787	56.2877	48.8667	43.2629
20	47.3369	48.8206	46.5769	46.1183	47.4528	31.3019	34.6402	38.9573	31.1619	0	46.997	42.9018	53.7464	45.7751	45.3129
21	50.7745	49.9441	49.458	55.7206	41.8338	38.8855	37.4852	42.4944	37.2047	49.3777	49.5403	49.5917	49.4507	43.3268	41.4752
22	45.1079	44.9842	41.6355	49.2553	48.0633	34.8678	34.9459	26.805	31.2624	44.8437	46.0046	43.6292	45.4026	45.4819	42.7833
23	45.0195	46.3404	40.0355	45.7875	42.4876	22.2998	35.6817	45.0541	32.2648	31.0549	48.6717	47.4092	36.0507	47.4814	39.6649
24	31.9137	39.5287	50.2208	35.5524	43.6169	4.5552	18.4904	7.1773	15.7995	12.2518	22.7241	24.7393	30.1454	27.9205	0

Source: Results obtained by the Author

Table 22

Action Value Fuction of GFI based on BAP

STATES	ACTIONS														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	0	0	0	0	0	0	0	0	0	0	0	25.8266	0	0	13.5085
2	0	33.1245	34.5569	33.8969	25.4187	25.4187	25.4187	0	25.4187	0	32.5073	0	27.8894	31.3811	30.5238
3	29.5131	2.8243	0	34.9886	30.6876	22.8768	0	0	0	0	28.243	0	0	29.812	25.4187
4	31.3811	33.2399	0	37.1747	0	25.4187	17.0993	31.4973	25.8454	28.425	26.4969	33.3424	36.1592	0	32.6897
5	26.8738	34.277	0	35.4112	37.4499	28.3999	16.179	31.3811	21.213	18.9811	19.8227	36.8049	32.7205	31.5554	33.5733
6	34.7993	34.1821	34.277	36.1377	39.1825	27.6732	22.0487	21.2586	23.1411	8.4125	37.4506	36.031	38.2578	33.6842	37.4506
7	39.3921	37.5893	39.1907	39.8944	33.0229	29.4685	25.275	32.2954	16.1698	22.6285	38.2685	35.0616	37.4991	35.4241	28.3423
8	38.861	40.5609	35.1153	43.9244	40.8981	22.9612	16.9437	26.7689	0	33.452	30.8957	34.3253	39.47	40.5123	38.3947
9	41.7373	41.8031	40.9081	42.211	33.9408	24.1301	19.4801	30.5113	32.524	18.0645	38.2398	28.7297	39.1414	39.417	35.5112
10	39.4966	42.4543	39.5312	45.9629	40.3324	39.5107	26.0919	37.5475	32.1393	34.9568	43.7561	32.2341	43.8338	42.9449	40.1892
11	40.1081	42.1866	40.7333	45.0314	47.3093	34.7681	23.6473	36.4489	29.8354	10.448	41.7386	31.7184	42.106	36.0508	40.8025
12	45.7614	47.0658	39.9058	46.496	43.1877	32.2399	23.5627	30.1075	17.9114	5.3161	46.6989	43.4407	44.2896	44.8001	42.5247
13	42.0391	48.5275	44.041	48.5771	47.4038	30.6567	29.4007	34.278	34.1708	9.508	46.4081	47.8884	46.5212	45.8251	43.6365
14	48.8967	45.3039	46.9907	46.8069	42.7907	30.5577	29.5439	38.9728	33.1359	10.5304	44.8235	43.3562	40.0533	47.9594	47.4039
15	47.6262	48.5644	47.7878	52.3515	51.2414	30.8615	31.3807	45.2738	40.4027	28.2065	49.1552	44.1007	42.9623	46.3515	44.3603
16	44.7647	49.6796	48.1711	45.3111	40.3107	30.5837	29.9967	35.6532	25.543	12.9591	47.9854	44.0815	50.2196	46.0465	45.8526
17	49.6961	50.9269	50.9098	53.1324	48.8732	38.6529	34.9152	34.0066	39.5758	6.8525	50.9371	46.2512	51.2227	45.2285	47.306
18	45.4755	43.4182	53.4601	50.2999	54.8771	29.6349	31.5786	40.738	35.9718	1.5125	52.2014	54.1313	53.9878	52.6601	48.0489
19	45.6909	48.2888	47.0156	50.3178	53.4281	40.4844	36.8951	45.7074	21.8643	1.1211	45.5177	48.4186	46.5403	46.8379	50.3459
20	53.424	52.4282	50.4502	53.1793	54.5268	46.0964	25.9845	48.8471	38.742	37.8413	51.4583	50.4817	48.2997	45.318	49.4753
21	51.18	49.8876	49.8292	55.0819	47.9656	42.9335	16.0796	45.3811	3.5326	43.3905	48.3026	48.7074	47.6701	52.1577	51.1282
22	52.1017	44.3161	53.2213	52.6128	53.5241	41.3595	16.1364	43.2831	38.742	43.6935	50.6152	49.9835	53.6169	49.3339	48.708
23	51.4539	44.5185	62.1967	51.5617	47.7592	48.2401	31.3683	46.4875	44.7525	58.7998	60.5626	56.9337	64.068	57.1689	65.3743
24	36.0962	45.6887	54.9309	38.4469	50.9436	5.4797	18.7521	8.4994	16.2885	13.8696	24.487	26.5943	32.751	30.9172	22.2296

Source: Results obtained by the Author

The action value fuction tables in *Table 21* and *Table 22* show the actions for the specified state.

Zero values generate episodes, while at the same time sets containing S/A pairs are formed. Due to the randomness of this process, some SA binaries were never used in the algorithm. For instance, no episode was created for action 6 of state 12 and therefore no value was assigned.

The reason for the high number of 0s in the first 3 states is that the number of countries in the first 3 states is small in the sample.

The action value function table also shows the actions that provide the maximum reward to policy makers.

According to *Table 21*, for instance, the action that provides the maximum reward for countries in State 7-10 is Action 4 with values of 39.89, 43.92, 42.21 and 45.96 respectively. A similar interpretation applies to *Table 22*, which is constructed with indices calculated based on the BAP method.

As can be seen in *Table 21* and *Table 22*, the algorithm does not prefer the actions with a low reward score between 6-10, which have a decreasing effect on the GFI of the countries; “Reducing Support for Social and Technological Infrastructure”, “Reducing Support for Start-ups”, “Reducing the Supports for Economic and Social Infrasture” and finally “Reducing the Support for Financial Efficiency”. On the contrary, policies that include actions 1-5 and 10-15, which have the positive and moderate effect on countries' GFI scores, are recommended.

4.2.4. Interpretations of the Results

The Action Value Function, which is determined according to the Equal Weight and BAP methods, identifies the *first* action that each country in four different income groups should take to reach the terminal state.

In this regard, *Table 23* below shows the actions put forward for EW, which is one of the two different methods by which index values are calculated as a result of the value function.

Table 23

Actions for States based on EW

State	Action
1	11
2	12
3	13
4	11
5	4
6	2
7	5
8	4
9	4
10	1
11	1
12	4
13	5
14	4
15	2
16	5
17	10
18	13
19	13
20	13
21	4
22	4
23	11
24	3

Source: Results obtained by the Author

Considering *Table* 23 and *Table 20*, where the actions and rewards are defined, the recommended actions to bring the GFI values based on EW and BAP closer to the terminal state are presented for the four different income categories. In this regard, *Table 24* below presents the recommended first action for low-income countries based on the GFI obtained by the EW method.

Table 24

Suggested Actions for the Low Income Countries Determined as to the EW-based GFI

COUNTRY	GFI	STATE	ACTION	DEFINITION OF ACTION
Rwanda	35.06	8	4	Support for Financial Development
Uganda	35.03	8	4	Support for Financial Development
Zambia	32.55	7	5	Support for Financial Innovation
Ethiopia	31.94	7	5	Support for Financial Innovation
Madagascar	29.33	6	2	Support for Technological Infrastructure
Mozambique	29.30	6	2	Support for Technological Infrastructure
Liberia	27.81	6	2	Support for Technological Infrastructure
Mali	27.69	6	2	Support for Technological Infrastructure
Guinea	26.99	5	4	Support for Financial Development
Malawi	24.43	5	4	Support for Financial Development
Burkina Faso	22.28	4	11	Support for Financial Inclusion
Sierra Leone	21.52	4	11	Support for Financial Inclusion
Congo (DRC)	20.88	4	11	Support for Financial Inclusion
Burundi	17.91	2	12	Support for Social, Political and Economic Environment
Niger	16.84	2	12	Support for Social, Political and Economic Environment
Sudan	14.51	1	11	Support for Financial Inclusion

Source: Results obtained by the Author

According to *Table 24*, for Rwanda, Uganda, Guinea and Malawi, which are in the low income group, action 4 "Supports for Financial development" was determined by the algorithm. In this respect, these countries may need to focus on improving the economic infrastructure to increase financial development and increasing financial efficiency in order to bring their GFI closer to the terminator state.

For Zambia and Ethiopia, which are at the same income level, action 5, "Support for Financial Innovation", was assigned by the algorithm. In this context, in order to get their GFI values closer to the terminator state, these countries can focus on economic regulations to encourage innovation, ensuring the transfer of resources, as well as policies to develop and improve the technological infrastructure on which innovation is based.

Meanwhile, for Madagascar, Mozambique, Liberia and Mali, Action 2 "Supports for Technological Infrastructure" was assigned by the algorithm. In this regard, these countries can focus more on regulations and practices to accelerate technological development by upgrading their ICT use, access and infrastructure in order to move their GFI closer to the terminator state.

Similarly, according to *Table 24*, for Burkina Faso, Sierra Leone, Congo (DRC) and Sudan in State 4, Action 11 "Supports for Financial Inclusion" was determined by the algorithm. In this regard, these countries may need to develop practices that enhance financial inclusion in order to bring them closer to the GFI terminator state. Moreover, according to *Table 24*, for Burundi and Niger in State 2, action 12 "Supports for Social, Political and Economic Environments" was identified by the algorithm. In this sense, these countries could emphasize policies to improve the social, political and economic environment in order to converge GFI closer to the terminal state.

Similarly, based on the GFI calculated by the EW method, *Table 25* below presents the recommended first action for Lower-Middle income countries.

Table 25

Suggested Actions for the Lower-Middle Income Countries Determined as to the EW-based GFI

COUNTRY	GFI	STATE	ACTION	DEFINITION OF ACTION
Indonesia	49.36	13	5	Support for Financial Innovation
Vietnam	45.44	12	4	Support for Financial Development
India	45.36	12	4	Support for Financial Development
Philippines	45.21	12	4	Support for Financial Development
Mongolia	44.67	11	1	Support for Inclusive Financial Market
Iran	44.49	11	1	Support for Inclusive Financial Market
Morocco	43.98	11	1	Support for Inclusive Financial Market
Ukraine	43.72	11	1	Support for Inclusive Financıal Market
Kenya	42.22	11	1	Support for Inclusive Financial Market
El Salvador	41.8	10	1	Support for Inclusive Financial Market
Tunisia	41.49	10	1	Support for Inclusive Financial Market
Lebanon	39.95	10	1	Support for Inclusive Financial Market
Sri Lanka	39.75	10	1	Support for Inclusive Financial Market
Ghana	39.42	10	1	Support for Inclusive Financial Market
Cambodia	38.2	9	4	Support for Financial Development
Egypt	38.18	9	4	Support for Financial Development
Bangladesh	37.7	9	4	Support for Financial Development
Nepal	37.68	9	4	Support for Financial Development
Honduras	37.61	9	4	Support for Financial Development
Nicaragua	37.23	9	4	Support for Financial Development
Venezuela	35.59	8	4	Support for Financial Development
Pakistan	35.35	8	4	Support for Financial Development
Nigeria	34.96	8	4	Support for Financial Development
Tanzania	34.92	8	4	Support for Financial Development
Senegal	34.89	8	4	Support for Financial Development
Laos	34.84	8	4	Support for Financial Development
Côte d'Ivoire	33.96	8	4	Support for Financial Development
Algeria	33.3	8	4	Support for Financial Development
Uzbekistan	33.22	8	4	Support for Financial Development
Cameroon	33.18	8	4	Support for Financial Development
Benin	29.65	6	2	Support for Technological Infrastructure
Myanmar	29.22	6	2	Support for Technological Infrastructure
Zimbabwe	28.42	6	2	Support for Technological Infrastructure
Angola	26.48	5	4	Support for Financial Development
Papua New Guinea	23.51	4	11	Support for Financial Inclusion

Source: Results obtained by the Author

According to *Table 25*, for countries in the upper-lower income group, actions can be recommended for the enhancement of financial development and technological infrastructure in general.

For Algeria, Angola, Bangladesh, Cambodia, Cameroon, Côte d'Ivoire, Egypt, Honduras, India, Laos, Nepal, Nicaragua, Nigeria, Pakistan, Senegal, Philippines, Tanzania, Uzbekistan, Venezuela, Uzbekistan, Venezuela and Vietnam, action 4 "Supports for Financial Development" was assigned by the algorithm. In this perspective, these countries may need to focus on improving the economic infrastructure to increase

financial development and increasing financial efficiency in order to converge their GFI index values to the terminator state.

Similarly, for El Salvador, Ghana, Iran, Kenya, Lebanon, Lebanon, Mongolia, Morocco, Tunisia, Tunisia and Ukraine, Action 1 "Supports for Inclusive Financial Market" was identified by the algorithm. To move closer to the GFI terminator state, they should focus on the adoption, acceptance and deployment of technology-driven financial instruments that will enable financial participants to manage liquidity, manage risk and invest.

For the countries in State 6, Benin, Myanmar and Zimbabwe, the algorithm recommends action 2 "Supports for Technological Infrastructure". These countries could focus more on regulations and practices to accelerate technological development by improving ICT use, access and infrastructure in order to bring GFI icloser to the terminal state.

In addition, for Indonesia in State 3, action 5 "Support for Financial Innovation" was determined by the algorithm, while for Papua New Guinea in State 4, action number 11 "Supports for Financial Inclusion" was chosen as the most appropriate policy.

Based on the GFI with the EW method, *Table 26* below presents the recommended first action for high-middle income countries.

Table 26

Suggested Actions for the Upper-Middle Income Countries Determined as to the EW-based GFI

COUNTRY	GFI	STATE	ACTION	DEFINITION OF ACTION
China	59.14	16	5	Support for Financial Innovation
Malaysia	58.03	16	5	Support for Financial Innovation
Bulgaria	52.26	14	4	Support for Financial Development
Thailand	52.14	14	4	Support for Financial Development
Russia	50.07	13	5	Support for Financial Innovation
South Africa	49.79	13	5	Support for Financial Innovation
Turkey	49.26	13	5	Support for Financial Innovation
Jordan	48.96	13	5	Support for Financial Innovation
Azerbaijan	47.85	12	4	Support for Financial Development
Costa Rica	47.18	12	4	Support for Financial Development
Peru	46.83	12	4	Support for Financial Development
Brazil	45.94	12	4	Support for Financial Development
Mexico	45.88	12	4	Support for Financial Development
Kazakhstan	45.66	12	4	Support for Financial Development
Jamaica	44.50	11	1	Support for Inclusive Financial Market
Colombia	44.22	11	1	Support for Inclusive Financial Market
Guatemala	44.14	11	1	Support for Inclusive Financial Market
Paraguay	42.93	11	1	Support for Inclusive Financial Market
Dominican Republic	42.58	11	1	Support for Inclusive Financial Market
Botswana	42.22	11	1	Support for Inclusive Financial Market
Argentina	41.82	10	1	Support for Inclusive Financial Market
Cuba	40.18	10	1	Support for Inclusive Financial Market
Ecuador	39.85	10	1	Support for Inclusive Financial Market
Namibia	38.75	9	4	Support for Financial Development
Gabon	29.43	6	2	Support for Technological Infrastructure

Source: Results obtained by the Author

According to *Table 26*, action 4 "Supports for Financial development" for Bulgaria, Thailand, Azerbaijan, Costa Rica, Peru, Brazil, Mexico, Kazakhstan, Namibia, which are in the upper-middle income group, was chosen by the algorithm. In this sense, these countries may need to focus on improving the economic infrastructure to increase financial development and enhancing financial efficiency in order to bring their GFI index values closer to the terminator state.

For Russia, South Africa, Turkey and Jordan, which are in the 13th State, along with China and Malasia, the two countries at the top of the country group in terms of GFI, the algorithm recommends action number 5, "Support for Financial Innovation". In this respect, in order to move their GFI closer to the terminator state, these countries can focus on economic regulations to encourage innovation, ensuring the allocation of resources, as well as policies to create and improve the technological infrastructure on which innovation is based.

However, for Jamaica, Argentina, Botswana, Cuba, Dominican Republic, Ecuador, Guatemala, Paraguay, Argentina, Botswana, Cuba, Dominican Republic, Guatemala,

Ecuador, Guatemala and Paraguay, Action 1 "Supports for Inclusive Financial Market" was determined as the most favorable policy. To converge GFI closer to the terminator state, these countries should focus on the adoption, acceptance and diffusion of technology-driven financial instruments that enable financial participants to manage liquidity, mitigate risk and invest.

Finally, Action 2 "Supports for Technological Infrastructure" is proposed for Gabon could focus more on regulations and practices to accelerate technological development by improving ICT use, access and infrastructure in order to bring GFI closer to the cut-off state.

Based on the GFI calculated with the EW method, *Table 27* below shows the suggested first action for high income countries.

Table 27

Suggested Actions for the High Income Countries Determined as to the EW-based GFI

COUNTRY	GFI	STATE	ACTION	DEFINITION OF ACTION
United States	71.6	20	14	Support for Financial Efficiency
Switzerland	69.6	20	14	Support for Financial Efficiency
Singapore	67.1	19	11	Support for Financial Efficiency
Japan	66.3	19	11	Support for Financial Efficiency
Germany	65.4	18	11	Support for Financial Efficiency
Hong Kong	65.2	18	11	Support for Financial Efficiency
Sweden	65.2	18	11	Support for Financial Efficiency
New Zealand	63.8	18	11	Support for Financial Efficiency
Netherlands	63.3	18	11	Support for Financial Efficiency
Denmark	63.3	18	11	Support for Financial Efficiency
Canada	63.2	18	11	Support for Financial Efficiency
Finland	63	18	11	Support for Financial Efficiency
United Kingdom	62.7	17	10	Reducing the Supporting Policies to Increase Financial Efficiency
Australia	62.3	17	10	Reducing the Supporting Policies to Increase Financial Efficiency
Qatar	62.2	17	10	Reducing the Supporting Policies to Increase Financial Efficiency
Belgium	62.1	17	10	Reducing the Supporting Policies to Increase Financial Efficiency
Austria	61.5	17	10	Reducing the Supporting Policies to Increase Financial Efficiency
Israel	60	17	10	Reducing the Supporting Policies to Increase Financial Efficiency
South Korea	60	16	5	Support for Financial Innovation
UAE	59.8	16	5	Support for Financial Innovation
France	59.1	16	5	Support for Financial Innovation
Spain	58.4	16	5	Support for Financial Innovation
Portugal	56.5	15	2	Support for Technological Infrastructure
Czech Republic	55.6	15	2	Support for Technological Infrastructure
Chile	55	15	2	Support for Technological Infrastructure
Ireland	54.3	15	2	Support for Technological Infrastructure
Estonia	54.3	15	2	Support for Technological Infrastructure
Slovakia	54	14	4	Support for Financial Development
Lithuania	53.8	14	4	Support for Financial Development
Kuwait	53.1	14	4	Support for Financial Development
Poland	52.8	14	4	Support for Financial Development
Bahrain	52.6	14	4	Support for Financial Development
Saudi Arabia	51.8	14	4	Support for Financial Development
Hungary	51.8	14	4	Support for Financial Development
Italy	51.6	14	4	Support for Financial Development
Oman	51.2	14	4	Support for Financial Development
Panama	50.2	13	5	Support for Financial Innovation
Taiwan	50	13	5	Support for Financial Innovation
Latvia	49.4	13	5	Support for Financial Innovation
Uruguay	49.2	13	5	Support for Financial Innovation
Trinidad &Tobago	47.5	12	4	Support for Financial Development
Croatia	47.1	12	4	Support for Financial Development
Romania	46	12	4	Support for Financial Development
Greece	44.7	11	1	Supports for Inclusive Financial market

Source: Results obtained by the Author

Based on *Table 27*, Action 13 "Supports for Financial Efficiency" is selected for United States and Switzerland, which are the two countries ranked at the top of the country group in terms of GFI. Nevertheless, for Singapore, Japan, Germany, Hong Kong, Sweden, New Zealand, Netherland, Denmark, Canada, Denmark, Canada and Finland in State 19, Action 13 "Supports for Financial Efficiency" has been again identified. These countries may need to develop practices that promote financial efficinecy in order to move GFI closer to the terminator state.

Furthermore, Action 10 "Reducing the Supporting Policies to Increase Financial Efficiency" is recommended for the United Kingdom, Australia, Qatar, Belgium, Austria and Israel as countries in State 17. In order to converge GFI closer to the terminator state, they could prioritize ensuring that resources allocated to improving financial efficiency are effectively allocated to different applications and arrangements that enable the widespread use, acceptance and development of financial technology.

For South Korea, United Arab Emirates, France, Spain, Spain, Panama, Panama, Taiwan, Latvia and Uruguay, which are at the same income level, action 5 "Support for Financial Innovation" was determined as the most appropriate policy path. In order to move closer to the GFI terminator state, these countries could focus on policies to ensure the economic regulation and allocation of resources to promote innovation, as well as the creation and development of the technological infrastructure on which innovation is based.

For Portugal, Czech Republic, Chile, Ireland and Estonia, action 2 "Supports for Technological Infrastructure" is proposed by the algorithm. For Portugal, Czech Republic, Chile, Ireland and Estonia, action 2 "Supports for Technological Infrastructure" is proposed by the algorithm. In addition, action 4 "Supports for Financial Development" was determined for Slovakia, Lithuania, Kuwait, Poland, Bahrain, Saudi Arabia, Hungary, Italy, Oman, Trinidad & Tobago, Croatia and Romania in State 14. In this regard, these countries may need to focus on improving the economic infrastructure to increase financial development and increasing financial efficiency in order to bring their GFI closer to the terminator state.

Last but not least, for Greece in State 11, the 1st action "Supports for Inclusive Financial Market" was identified. To converge the GFI to a terminal state, Greece could focus on the adoption, acceptance and deployment of technology-driven financial instruments that would allow financial participants to manage liquidity, manage risk and invest.

Earlier, it was mentioned that the recommended actions for the GFI to converge to the terminal state, calculated based on the EW and BAP, were put forward for four different income levels for which the index value was calculated In this respect, after the actions based on the GFI calculated with the EW method, the actions are determined with the BAP were analyzed for four different income groups (low, lower-middle, upper-middle and high).

In this sense, *Table 28* below shows the first action taken for BAP, which is one of the two different methods by which indeces are calculated as a result of the action value function.

Table 28

Actions for States based on BAP

State	Action Index
1	12
2	3
3	4
4	4
5	5
6	5
7	4
8	4
9	4
10	4
11	5
12	2
13	4
14	1
15	4
16	13
17	4
18	5
19	5
20	5
21	4
22	13
23	15
24	3

Source: Results obtained by the Author

Based on the GFI calculated with the BAP method, *Table 29* below presents the recommended actions for low-income countries.

Table 29

Suggested Actions for the Low Income Countries Determined as to the BAP-based GFI

COUNTRY	GFI	STATE	ACTION	DEFINITION OF ACTION
Uganda	37.64	9	4	Supports for Financial Development
Rwanda	36.19	9	4	Supports for Financial Development
Ethiopia	34.66	8	4	Supports for Financial Development
Zambia	33.34	8	4	Supports for Financial Development
Madagascar	30.89	7	4	Supports for Financial Development
Mozambique	30.57	7	4	Supports for Financial Development
Mali	29.88	6	5	Supports for Innovation
Liberia	29.03	6	5	Supports for Innovation
Guinea	28.32	6	5	Supports for Innovation
Malawi	24.65	5	5	Supports for Innovation
Burkina Faso	23.52	4	4	Supports for Financial Development
Sierra Leone	21.97	4	4	Supports for Financial Development
Congo (DRC)	21.78	4	4	Supports for Financial Development
Niger	19	3	4	Supports for Financial Development
Burundi	18.18	1	12	Supports for Social, Political and Economic Environments
Sudan	15.38	1	12	Supports for Social, Political and Economic Environments

Source: Results obtained by the Author

According to *Table 29*, action 4 "Supports for Financial Development" for Rwanda, Uganda, Ethiopia, Zambia, Madagascar, Mozambique, Burkina Faso, Sierra Leone, Congo and Niger, which are in the low income group, was determined by the algorithm. In this regard, these countries may need to focus on improving the economic infrastructure to increase financial development and increasing financial efficiency in order to converge their GFI index values to the terminator state.

For Mali, Liberia, Guinea, Guinea and Malawi, which are at the same income level, action number 5, "Support for Financial Innovation", was assigned as the most eligible policy. In order to get the GFI closer to the terminal state for these countries, they could focus on policies to ensure the economic regulation and allocation of resources to promote innovation, as well as the creation and development of the technological infrastructure on which innovation is based.

In addition, for Liberia and Mali and Guinea, action 2 "Supports for Technological Infrastructure" was determined. These countries can focus more on regulations and practices to accelerate technological development by improving ICT use, access and infrastructure in order to bring GFI closer to the terminal state.

Moreover, according to *Table 29*, for Burundi and Sudan, which are in State 2, action number 12 "Supports for Social, Political and Economic Environments" was determined by the algorithm. In this sense, these countries could emphasize policies to improve the

social, political and economic environment in order to bring GFI closer to the terminal state.

Similarly, based on the GFI calculated by the BAP method, *Table 30* below presents the recommended first action for lower-middle income countries.

Table 30

Suggested Actions for the Lower-Middle Income Countries Determined as to the BAP-based GFI

COUNTRY	FINTECH INDEX	STATE	ACTION	DEFINITION OF ACTION
Indonesia	51.03	14	1	Supports for inclusive Financial market
Vietnam	47.69	12	2	Supports for Technological Infrastructure
India	47.03	12	2	Supports for Technological Infrastructure
Philippines	46.76	12	2	Supports for Technological Infrastructure
Morocco	45.53	12	2	Supports for Technological Infrastructure
Iran	45.22	12	2	Supports for Technological Infrastructure
Ukraine	44.82	11	5	Supports for Innovation
Mongolia	44.7	11	5	Supports for Innovation
Kenya	44.49	11	5	Supports for Innovation
Tunisia	43.01	11	5	Supports for Innovation
El Salvador	42.55	11	5	Supports for Innovation
Ghana	40.76	10	4	Supports for Financial Development
Lebanon	40.42	10	4	Supports for Financial Development
Egypt	40.15	10	4	Supports for Financial Development
Cambodia	39.75	10	4	Supports for Financial Development
Bangladesh	39.35	10	4	Supports for Financial Development
Sri Lanka	39.33	10	4	Supports for Financial Development
Nicaragua	39.18	10	4	Supports for Financial Development
Honduras	38.87	9	4	Supports for Financial Development
Nepal	38.03	9	4	Supports for Financial Development
Tanzania	37.94	9	4	Supports for Financial Development
Pakistan	36.97	9	4	Supports for Financial Development
Nigeria	36.54	9	4	Supports for Financial Development
Senegal	36.17	9	4	Supports for Financial Development
Laos	36.04	9	4	Supports for Financial Development
Cameroon	34.86	8	4	Supports for Financial Development
Côte d'Ivoire	33.71	8	4	Supports for Financial Development
Algeria	33.61	8	4	Supports for Financial Development
Venezuela	32.47	7	4	Supports for Financial Development
Uzbekistan	31.99	7	4	Supports for Financial Development
Benin	31.08	7	4	Supports for Financial Development
Myanmar	30.21	7	4	Supports for Financial Development
Zimbabwe	27.48	6	5	Supports for Innovation
Angola	27.04	6	5	Supports for Innovation
Papua New Guinea	24.81	5	5	Supports for Innovation

Source: Results obtained by the Author

For Indonesia, which ranked first based on *Table 30*, the number 1 action "Supports for Inclusive Financial Market" was determined as the most appropriate policy. To bring GFI index values closer to the terminator state, these countries should focus on the adoption,

acceptance and diffusion of technology-driven financial instruments that will allow financial participants to manage liquidity, control risk and invest.

Similarly, for Ukraine, Mogolia, Kenya, Tunisia, Tunisia, El Salvadore, Zimbabwe, Angola, Papua New Guniea, Action 1 "Supports for Inclusive Financial Market" was identified by the algorithm. In this respect, in order to move GFI closer to the terminator state, they should focus on the adoption, acceptance and diffusion of technology-driven financial instruments that will enable financial participants to manage liquidity and hedge risk.

In addition, Action 2 "Supports for Technological Infrastructure" is proposed for the countries in State 12, namely Vietnam, India, Philippines, Morocco and Iran. In this respect, these countries can focus more on regulations and practices to accelerate technological development by improving ICT use, access and infrastructure in order to bring GFI closer to the terminator state.

For Zimbabwe and Angola, on the other hand, Action 5, "Support for Financial Innovation", was identified by the algorithm. In order to bring GFI closer to the terminator state, these countries could focus on policies to ensure economic regulation and resource allocation to promote innovation, as well as the creation and development of the technological infrastructure on which innovation is based.

As another country group; Ghana, Lebanon, Egypt, Cambodia, Bangladesh, Sri Lanka, Nicaragua, Honduras, Nepal, Tanzania, Pakistan, Nigeria, Senegal, Laos, Cameroon, Côte d'Ivoire, Algeria, Venezuela, Uzbekistan, Benin, Myanmar were assigned to Action 4 "Supports for Financial Development". In order to get the GFI closer to the terminator state, these countries may need to focus on improving the economic infrastructure to increase financial development and on practices to increase financial efficiency. Based on the GFI calculated with the BAP method, *Table 31* below shows the recommended first action for upper-middle income countries.

Table 31

Suggested Actions for the Upper-Middle Income Countries Determined as to the BAP-based GFI

COUNTRY	GFI	STATE	ACTION	DEFINITION OF ACTION
Malaysia	59.98	16	13	Supports for Financial Efficiency
China	59.54	16	13	Supports for Financial Efficiency
Bulgaria	53.44	14	1	Supports for inclusive Financial Market
Thailand	52.75	14	1	Supports for inclusive Financial Market
South Africa	51.17	14	1	Supports for inclusive Financial Market
Russia	50.52	13	4	Supports for Financial Development
Turkey	50.44	13	4	Supports for Financial Development
Jordan	49.63	13	4	Supports for Financial Development
Azerbaijan	48.83	13	4	Supports for Financial Development
Costa Rica	47.86	12	2	Supports for Technological Infrastructure
Peru	47.83	12	2	Supports for Technological Infrastructure
Kazakhstan	47.76	12	2	Supports for Technological Infrastructure
Mexico	47.32	12	2	Supports for Technological Infrastructure
Brazil	46.47	12	2	Supports for Technological Infrastructure
Guatemala	46.30	12	2	Supports for Technological Infrastructure
Colombia	46.16	12	2	Supports for Technological Infrastructure
Jamaica	45.92	12	2	Supports for Technological Infrastructure
Paraguay	44.68	11	5	Supports for Innovation
Dominican Republic	43.59	11	5	Supports for Innovation
Botswana	43.34	11	5	Supports for Innovation
Argentina	41.76	10	4	Supports for Financial Development
Ecuador	41.42	10	4	Supports for Financial Development
Namibia	41.17	10	4	Supports for Financial Development
Cuba	40.46	10	4	Supports for Financial Development
Gabon	28.89	6	5	Supports for Innovation

Source: Results obtained by the Author

According to *Table 31*, action number 13, "Supports for Financial Efficiency", is recommended for China and Malasia, two countries with index values at the top of the country group. In this respect, in order to move these countries closer to the GFI terminator state, it may be suggested that these countries implement policies that will ensure the spread of financial instruments to the grassroots of the society and increase the use, adoption and acceptability of technology-based financial products by emphasizing the increase of regulations and incentives. Along with the individual use of financial instruments, it may be advisable for SMEs in these countries to increase their efficiency in the economy by using financial products and services based on financial technology.

Similarly, for Bulgaria, Thailand, South Africa, Action 1 "Supports for Inclusive Financial Market" was identified by the algorithm. In this respect, in order to move GFI index values closer to the terminator state, they should focus on the adoption, acceptance and diffusion of technology-driven financial instruments that will enable financial participants to manage liquidity, mitigate risk

Action 4 "Supports for Financial Development" for Russia, Turkey, Jordan, Azerbaijan, Argentina, Ecuador, Namibia and Cuba was selected as proper policy. These countries may need to focus on improving the economic infrastructure to increase financial development and financial efficiency in order to bring the GFI closer to the terminator state.

Furthermore, for Costa Rica, Peru, Kazakhstan, Mexico, Brazil, Brazil, Guatemala, Colombia and Jamaica, action number 2 "Supports for Technological Infrastructure" was identified as best policy and these countries can focus more on regulations and practices to accelerate technological development by improving ICT use, access and infrastructure in order to bring their GFI closer to the terminal state.

For Paraguay, Czehia, Botswana, Gabon, the algorithm proposed action 5 "Support for Financial Innovation". In this respect, in order to converge their GFI to the terminator state, these countries can focus on economic regulations to encourage innovation, ensuring the allocation of resources, as well as policies to create and improve the technological infrastructure on which innovation is based.

Based on the GFI calculated with the BAP method, *Table 32* below shows the proposed first action for high income countries.

Table 32

Suggested Actions for the High Income Countries Determined as to the BAP-based GFI

COUNTRY	GFI	STATE	ACTION	DEFINITION OF ACTION
Switzerland	71.50	20	5	Supports for Innovation
United States	71.43	20	5	Supports for Innovation
Singapore	69.16	20	5	Supports for Innovation
Germany	67.73	19	5	Supports for Innovation
Japan	67.63	19	5	Supports for Innovation
Hong Kong	67.19	19	5	Supports for Innovation
Sweden	66.97	19	5	Supports for Innovation
Finland	66.01	19	5	Supports for Innovation
Denmark	65.58	18	5	Supports for Innovation
New Zealand	65.51	18	5	Supports for Innovation
Netherlands	65.29	18	5	Supports for Innovation
Canada	64.58	18	5	Supports for innovation
United Kingdom	64.50	18	5	Supports for Innovation
Belgium	63.77	18	5	Supports for Innovation
Australia	63.28	18	5	Supports for Innovation
Qatar	63.06	18	5	Supports for Innovation
Austria	62.94	17	4	Supports for Financial Development
UAE	61.96	17	4	Supports for Financial Development
Israel	60.54	17	4	Supports for Financial Development
South Korea	60.42	17	4	Supports for Financial Development
France	60.04	17	4	Supports for Financial Development
Spain	59.51	16	13	Supports for Financial Efficiency
Portugal	57.39	16	13	Supports for Financial Efficiency
Ireland	56.70	15	4	Supports for Financial Development
Czech Republic	56.65	15	4	Supports for Financial Development
Estonia	56.52	15	4	Supports for Financial Development
Chile	56.20	15	4	Supports for Financial Development
Slovakia	55.52	15	4	Supports for Financial Development
Lithuania	55.05	15	4	Supports for Financial Development
Bahrain	54.81	15	4	Supports for Financial Development
Poland	54.07	15	4	Supports for Financial Development
Hungary	54.06	15	4	Supports for Financial Development
Kuwait	53.98	14	1	Supports for inclusive Financial market
Saudi Arabia	53.81	14	1	Supports for inclusive Financial market
Italy	52.78	14	1	Supports for inclusive Financial market
Oman	52.26	14	1	Supports for inclusive Financial market
Latvia	51.32	14	1	Supports for inclusive Financial market
Taiwan	51.06	14	1	Supports for inclusive Financial market
Panama	50.50	13	4	Supports for Financial Development
Uruguay	50.41	13	4	Supports for Financial Development
Croatia	48.89	13	4	Supports for Financial Development
Trinidad & Tobago	48.61	13	4	Supports for Financial Development
Romania	46.60	12	2	Supports for Technological Infrastructure
Greece	45.83	12	2	Supports for Technological Infrastructure

Source: Results obtained by the Author

According to *Table 32*, the United States, Switzerland, Singapore, Germany, Japan, Hong Kong, Hong Kong, Sweden, Finland, Denmark, New Zealand, the Netherlands, Canada, the United Kingdom, Belgium, Australia, Qatar, which are in the high-income group, proposed action 5, "Financial Innovation Support". In order to converge the GFI for these countries to the terminator state, they can focus on policies to ensure the economic

regulation and allocation of resources to promote innovation, as well as the creation and development of the technological infrastructure on which innovation is based.

Austria, United Arab Emirates, Israel, South Korea, France, Ireland, Czech Republic, Estonia, Chile, Slovakia, Lithuania, Bahrain, Poland, Hungary, Panama, Uruguay, Croatia and Trinidad & Tobago action 4 “Supports for Financial Development” as suitable policy. In this sense, these countries may need to focus on improving the economic infrastructure to increase financial development and increasing financial efficiency in order to bring their GFI closer to the terminator state.

In addition, for Spain and Portugal, Action 13 "Supports for Financial Efficiency" was proposed. In this scope, in order to get the GFI of these countries closer to the terminator state, it may be recommended that these countries implement policies that will ensure the spread of financial instruments to the grassroots of the society and increase the use, adoption and acceptability of technology-based financial products by increasing regulations and incentives. Along with the individual use of financial instruments, it may be advisable for SMEs in these countries to increase their efficiency in the economy by using financial products and services based on financial technology.

In addition, for Kuwait, Saudi Arabia, Italy, Oman, Latvia and Taiwan, action 1 "Supports for Inclusive Financial Market" was identified and in order to converge GFI index closer to the terminator state, they should focus on adoption, acceptance and widespread adoption of technology-driven financial instruments that will enable financial participants to manage liquidity.

For Romania and Greece, the two lowest countries in the index value group, action 2 "Supports for Technological Infrastructure" was determined as the proper policy and these countries can focus more on regulations and practices to accelerate technological development by improving ICT use, access and infrastructure in order to bring GFI closer to the terminal state.

The findings above set out the first recommended actions for countries to move to a higher state. With RL, a strategy path can be determined regarding the strategies that a country should follow at each stage in order to reach the end state. Nevertheless, it is also possible for countries to choose the optimal strategy that suits them at every stage. In this respect, RL also offers an optimal strategy recommendation. *Appendix 6* presents the graphs expressing the strategy paths that lead Rwanda, Indonesia, China and Switzerland, which

are in the lower, lower- middle, upper-middle and high income groups respectively and ranked first in terms of GFI scores,to the end state through RL. Turkey, which is in the upper middle income group, is also included.

CONCLUSIONS & RECOMMENDATIONS

The convergence of finance and technology has been seriously affecting the financial industry and changing the way it works since the 1990s, as exemplified by ATM machines, online bank money transfer systems, digital currencies, crowdfunding instruments.

In this respect, the 2008 crisis as a global shock, has been an important factor in the handling of Fintech as a different paradigm and its more widespread and powerful agenda. Finally, after the devastating impact of the Covid-19 pandemic, as a different global shock, on the economy, trade, and finance, Fintech is evolving into a new paradigm (Sugandi, 2021). Due to its financial, economic, social and tehcnological impacts, it is important to analyze Fintech's evolution so that policy makers, Fintech innovators, and users can analyze Fintech's effects and future development stages. At the same time, they can benefit from this inevitable progress by revealing the pros and cons of the system, whose advancement is irreversible, over time.

In this regard, the main research question of the study is that “Is it possible to construct a composite indicator to help governments or policy makers to understand where they stand with regard to improving the financial technology?”. The main research question is accompanied by the following supporting research questions.

- What is the theoretical framework of Fintech and its development in terms of economic and financial theories and how they can be explained?
- What are the definitions of Fintech in the literature and what is the theoretical base of them?
- What are the determinants of Fintech in the literature?
- What are the current Fintech developments of the countries? and how does it differ according to the income groups?
- What are the recommended policies for countries to improve their Fintech developments?
- Is there a difference in the suggested policies for countries according to income levels?

The findings obtained under these research questions are summarized below.

Findings

What is the theoretical framework of Fintech and its development in terms of economic and financial theories and how they can be explained?

Thematic evalution analysis was used to reveal the theoretical framework on which Fintech is based. The thematic evaluation analysis shows the evolution of the themes addressed by Fintech research between 1982 and 2022. In the specified period, "financial innovation" emerged as the only theme. According to this finding, it can be said that the theoretical framework on which Fintech is based in the literature is primarily addressed by innovation theories and financial innovation theories.

Considering the 2008 global financial crisis and the impact of the Covid 19 pandemic on the development of financial technology, 2008 and 2019 are taken as breakpoints in the analysis. After the 2008 global financial crisis, it has been revealed that Fintech studies have been focused on the themes of mobile banking, online banking, economic growth and financial technology. Therefore, the effects of Fintech on financial intermediation transactions have paved the way for Fintech to be addressed as part of financial intermediation theories.

With the impact of the pandemic between 2019 and 2022, restrictions imposed on economic and social life have increased individuals' tendency and use of financial technology-oriented products. Thus, themes on the adoption and impacts of fintech have come to the forefront in the studies conducted between the years in question. During this period, the themes of studies on mobile banking evolved into financial inclusion, and the themes of studies on financial technology evolved into trust and the Technology Acceptance Model (TAM) in relation to blockchain, P2P lending and adoption of financial technologies.

As a result of the thematic evaluation analysis, the development of Fintech is mainly explained by innovation theories, financial intermediation theories, TAM model and financial inclusion theories.

What are the definitions of Fintech in the literature and what is the theoretical base of them?

Considering the studies put forward, in general, Fintech definitions can be grouped around three different classifications. The first of these defines FinTech as companies, mostly start-ups, that create technologies used in finance (Laidroo and Avarmaa, 2019;

Haddad and Hornuf, 2019). Another one describes FinTech as a combination of different business models that utilize financial innovation and technology (Lee and Shin, 2018; Liu et al., 2020). The last one defines FinTech as financial technology, innovation and digital technologies that enable the creation of financial products, business models and processes.

In theoretical terms, some definitions make a clear distinction between innovation as a sustainable process and disruption (Sironi, 2016). In these definitions, innovation refers to the improvement of the existing system, while disruption refers to the introduction of new rules within the system (Christensen, 2006). Disruption-based definitions do not include innovations based on existing technologies, such as mobile payments (Bank of International Settlements, 2018; Christensen, 2006; Gomber et al., 2017).

What are the determinants of Fintech in the literature?

In the literature, the emergence and determinants of Fintech are categorized in terms of supply and demand (Shidler, 2017). On the supply side, factors such as technology, macroeconomic conditions and financial market conditions that encourage and influence the providers of products and services to the financial markets to offer innovative financial products and services to the markets come to the fore (Ettlie et al., 2014; Haddad & Hornuf, 2019; Pollari, 2016; Schindler, 2017. On the demand side, demographic factors that ensure the widespread use and adoption of products and services offered by financial service providers are taken into account (Pollari, 2016; Puschmann, 2017).

The Fintech determinants obtained through this theoretical approach are presented in detail in *Table 6.*

What are the current Fintech developments of the countries? and how does it differ according to the income groups?

According to the results, based on all three methods (EW, BAP and PCA), Rwanda, Uganda, Zambia, Ethiopia, Madagascar, Mozambique, Liberia, Mali, Guinea and Malawi are among the low-income countries that rank high in their income groups in terms of GFI score.

Most low-income countries have limited financial infrastructure (Otioma et al., 2019). The technological sophistication of traditional financial institutions and capital markets is low and the accessibility of products and services to the rural poor is very limited (Asongu et al., 2018). The fact that there are fewer structural and regulatory barriers to

overcome in these country groups can be seen as factors that support the development of Fintech.

In addition, in low-income countries, the "Cash is King" principle is generally applicable, where the poor population's access to banking services is very limited and cash is used for most of their transactions (Joseph, 2016). Moreover, access to credit, insurance or savings products, which are more readily available to middle- and high-income groups, is very limited in low-income countries. The majority of the population lives in small settlements in rural areas (Senyo et al., 2022). Traditional financial institutions and organizations have not been motivated to develop the branch infrastructure needed to increase access to financial products for this population. In addition, entrepreneurship is important both in terms of fostering innovation and promoting economic growth and development, but the training and job opportunities are limited (Otioma et al., 2019). Unfortunately, without financial infrastructure, it is difficult for the poor and those with limited access to financial services and products to start businesses and stand on their own feet. Technology, in this sense, is an element that compensates for the shortcomings of the financial infrastructure (Asongu et al., 2018). In these countries, the main enabler of financial inclusion by accelerating access to financial products for the poor is not a FinTech innovation, but a mobile phone (Joseph, 2016). In the last 15 years, mobile phone penetration in low-income countries, particularly in Africa, has grown from zero to 900 million subscribers. However, the critical point here is that approximately 500 million of these subscribers do not have regular access to electricity (Joseph, 2016). The emergence of applications such as PayJoy and Branch as a fintech company that provides financing for mobilephone purchases in emerging markets also supports this situation (Otioma et al., 2019).

FinTech in Rwanda, which ranks at the top of the index score in the country group, is a growing sector with various initiatives aimed at increasing financial inclusion and improving access to financial services. The Rwandan government has implemented policies to promote the development of the FinTech industry, including establishing a regulatory sandbox and promoting innovation (Otioma et al., 2019). Nevertheless, one of the main application in the FinTech industry in Rwanda that has been highly successful in providing financial services that promote financial inclusion is the mobile banking platform MTN Mobile Money. other notable companies include eSACCO, a digital savings and credit cooperative platform, and KCB Bank Rwanda, which has launched

digital banking services including mobile banking and online payments (Kanobe et al., 2017; Tobbin & Kuwornu, 2011).

Similar to Rwanda, digital applications such as MTN Mobile Money, Airtel Money, Tala, Ayera, WorldRemit in Uganda, Carbon, Zoona, Thrive Microfinance, Piggybank.co.zm, BongoHive in Zambia are among the important examples due to their features that increase financial inclusion (Kanobe et al., 2017).

In general terms, the functions of Fintech for low-income country groups can be listed as increased financial inclusion, improved access to credit, increased financial literacy, more convenients and efficienct financial services and creation of new jobs. Furthermore, "Support for Financial Development", "Support for Financial Innovation", "Technological Infrastructure" and "Financial Inclusion" have been proposed for countries in the lower income category in order to accelerate the Fintech development of countries in this income group.

Accordig to results for the Lower-Middle Income group, Indonesia, Vietnam, India, Ukraine, Morocco, Mongolia, Kenya, Tunisia, Lebanon and El Salvador are leading countries according to the index score.

Besides being the first country to establish a 3G network in North Africa, Morocco aims to position itself as a strategic center in the Middle East and North Africa by becoming one of the best performing countries in the region in the field of ICT (Emara & Mohieldin, 2021). After the establishment of the 3G network, the share of the ICT sector in GDP has also increased. In this regard, it is not surprising that it ranks first among the countries in the group in terms of ICT infrastructure (Naz et al., 2022). According to the World Telecommunication Organization (2021), Iran is among the top three countries with the highest growth rate on information technologies in the world in the three evaluation periods. This can also be supported by the fact that the share of the ICT sector in GDP increased from 2.7% in 2018 to 4.6% in 2021. Iran's young, tech-savvy population also plays a role in this progress.

Iman (2018) examined the positive relationship between TCASH, Indonesa's mobile money application, and financial inclusion. Moreover, the study by Nimbrayan et al. (2018) reveals the positive impact of increased financial inclusion on economic growth through the use of Fintech in India. These two countries are followed by the Philipines, Kenya, Morocco and Vietnam. The positive contribution of the widespread use of M-

Pesa in Kenya to Financial Inclusion has been supported by other studies. Oborn et al. (2019) found that M-Pesa, a mobile money, reduces household poverty by increasing financial inclusion in Kenya. With the spread and adoption of M-Pesa in Kenya, financial inclusion increased from 26.4% in 2006 to 40.5% in 2009 (Ozili, 2020). Moreover, Hove and Dubus (2019) find that increased use of Fintech in Kenya reduces income inequality by increasing financial inclusion. Vietnam, on the other hand, is the country with the highest number of academic studies on Fintech, especially on blockchain, in its income group, along with India, as shown in the bibliometric analysis section (Chapter 1) of the study.

The fact that Fintech is based on innovation and technology makes the number of scientific studies and the number of effective research in the field an important indicator in terms of indicating the interest and importance that countries give to Fintech. In this regard, as a result of the bibliometric analysis in the first part of the study, Ukraine, Vietnam, Indonesia and India are among the top 20 countries with the most cited scientific publications on Fintech *Figure 8*. Furthermore, India and Indonesia are among the top 10 countries with the highest number of publications in the field after the 2008 global crisis *Figure 3.* The fact that these countries also stand out in academic publications on Fintech can be considered to support the results of the thesis. The common study areas of these countries are blockchain and cryptocurrency.

For countries in the lower middle income group, Support for "Financial Innovation", "Financial Development" and "Inclusive Financial Markets" are prominent policy recommendations to support the development of Fintech. Consistent with the result, Cantu and Chui (2020) argue that the development and existence of different financial markets for this group of countries plays an important role in the development of Fintech. In addition, Allen (2021), in his study on lower middle income and high income countries, stated that financial development is an important driving factor for countries in the lower middle income group for development of Fintech.

Arner et al.(2015) reveal that the development process of Fintech from past to present, the stage we live in today and described as Fintech 3.5, has taken place under the leadership of developing Asian countries. According to Arner et al.(2015), the emerging characteristics of Asian countries since 2008, such as a strengthening middle class, a large young population, increasing demand and competition for financial technology products, have made these countries increasingly prominent in the development of Fintech. As a

result of the bibliometric analysis on Fintech in Chapter 1, the fact that Asian countries are becoming more prominent in this field together with European Union (EU) countries and the USA can be considered as supporting the Fintech 3.5 phase that Fintech is currently in. In this respect, it is not surprising that countries such as China, Malaysia and Thailand stand out in the upper-middle income group. The presence of a young population with knowledge about and access to mobile technology, a growing middle class, the inability of traditional financial institutions to meet the needs of consumers as a result of their failure to operate effectively in the market, inadequate physical infrastructure in the banking sector, the market opportunity created by consumers who do not have access to financial services (1.2 billion people without a bank account), as well as the young population in India and China who are educated in information technologies and are qualified to provide human capital, one of the most important factors for the development of the sector (Arner, Barberis, et al., 2017b; Gupta & Xia, 2018), countries such as China, Malaysia and Thailand can be counted among the reasons why they stand out in the upper middle income country group.

For lower middle amd upper middle countries, the development of Fintech is driven by customer demands that cannot be met by the products and services of traditional financial institutions and organizations (Baiju & Radhakumari, 2017). Frost (2020) argues that the weaknesses of banks as a traditional financial institution in essential services such as payment and money transfer, and unmet customer demand in these segments, are driving demand and adoption of Fintech products and services in India, Southeast Asia and Latin America. Unmet demand of customers is therefore considered to be the key enabler accelerating the development of Fintech in many underdeveloped and developing countries. In addition, Hau et al. (2019) states that the most important factor affecting the development of Fintech in China is the inclusion of borrowers who cannot benefit from the credit facilities of traditional banks and who are excluded from the system into the financial system through Fintech loans. In other words, it is the customer demand that cannot be met by traditional banking activities. Jagtiani and Lemieux (2018) reveal that the development of Fintech and Fintech credit is taking place in products and services where traditional banks are limited.

Moreover, in parallel with the GFI scores, Huang et al. (2020) also revealed that according to the results of the Asean Fintech Adoption Index, Indonesia, Malaysia, Thailand,

Philippines and Vietnam are the leading countries in terms of Fintech adoption after Singapore, which is in the high-income group.

In addition, according to WB (2020), Fintech in Europe and Central Asia: Maximizing Benefits and Managing Risks, Turkey and Russia are the leading countries compared to the South Caucasus, Western Balkans and Central Asian countries. The barriers to Fintech development in these countries include lack of VC investments, access to finance for entrepreneurial activities, lack of government and corporate support and enabling regulations for fintech innovation, small domestic markets and well-developed, skilled workers. These results also support the "Support for Financial Innovation", "Support for Financial Development" and "Support for Inclusive Financial Market" recommendations for the upper middle income group in the policy patch trajectory chapter of the thesis.

When the results of this thesis are considered from the perspective of high-income countries, these countries are at the forefront of fintech innovation with well-established technology infrastructure, large capital and highly skilled human resources. These endowments enable fintech companies in these countries to rapidly develop and scale their products and services, supporting increased competition and innovation in the financial sector.

Furthermore, unlike in high-income countries, the main function of fintech in low- and middle-income countries is to increase financial inclusion and increase the population with limited access to financial products and services, while in high-income countries, the main issue with fintech is related to the regulatory environment for fintech, such as the need to balance innovation with consumer protection and financial stability. In addition, there is often a high level of competition in the fintech market, which can lead to high barriers to entry for new entrants. Overall, the growth of fintech in high-income countries is likely to continue as technology continues to advance and more people adopt digital financial services.

In addition, according to the results of the analysis, Asian countries such as Singapore, Japan and Hong Kong come to the fore in the category of high-income countries.

These countries' pro-business environment, supportive regulatory framework, high living standards and quality of life, and a population interested in technology and willing to adopt new practices make them attractive to fintech firms and talent (Arner et al., 2015). These countries' fintech applications covers a wide range of areas, including digital

payments, wealth management, insurance, and lending . In addition, as supported by the Tree Field Plot analysis in the bibliometric analysis part of the thesis *Figure 8*, Asian countries in the high income group are dominant in fintech applications such as Blockchain and crypto money.

Among these countries, Singapore is a leading country in terms of financial inclusion and policies and regulations, which are among the most important areas affecting the development of Fintech in high income group, with the effect of its young population with high technology adoption. In addition, it has emerged as one of the world's prominent fintech hubs with a thriving ecosystem of start-ups, established financial institutions and government support. The government in Singapore has implemented policies and incentives to encourage the development of fintech in the country, The Monetary Authority of Singapore (MAS) is actively promoting the development of the FinTech industry through initiatives such as the FinTech Regulatory Sandbox and the Financial Sector Technology and Innovation (FSTI) scheme. The city-state is home to numerous successful fintech startups, such as Grab, SEA, and Lazada, as well as established global fintech firms, such as Ant Group and Gojek.

Furthermore, according to the results of the Asean Fintech Adoption index (Huang et al., 2020), which is a regional index specific to ASEAN countries, which deals with Fintech in terms of adoption, Singapore is the country at the top of the index in terms of Fintech adoption in the region.

Similarly, the Hong Kong Monetary Authority (HKMA) is actively promoting the development of the FinTech industry through initiatives such as the Open API framework and the FinTech Supervisory Sandbox. The government has also established a partnership network with leading global FinTech hubs to promote cooperation and knowledge exchange. In recent years, Hong Kong has emerged as a hub for FinTech innovation in Asia, attracting a growing number of FinTech companies and investors.

Another country that stands out among high-income countries is the United States. In the US, the center of the 2008 global financial crisis, the development of Fintech accelerated in parallel with the consequences and solutions of the financial crisis. After the turmoil, 8.7 million people were unemployed. The loss of jobs of finance-trained experts and the inability of traditional financial institutions to fund individuals with low credibility and SMEs in need of capital has increased the acceleration of Fintech's development in the USA (Arner et al., 2016). Nonetheless, according to *Figure 2*, the US is the second

country after China with the highest number of academic and scientific studies on Fintech. In addition, Frost (2020)argues that where financial services are relatively expensive, the development of fintech, the widespread use and adoption of applications are higher than in other countries. In this sense, Philippon (2016) attributes the high potential, progress and efficiency of Fintech in the US to the relatively high unit cost of finance.

Furthermore, as can be seen in *Figure 3*, Asian countries' interest in Fintech and their efforts in the field gained momentum in the aftermath of the 2008 global crisis as the critical impact of Fintech on economic growth and financial inclusion became apparent. Unlike Asian countries, the US and the UK have been two countries that have been conducting academic studies on Fintech and have made progress since that time since 1982. These implications support the USA's being at the top of the GFI score ranking.

Claessens et al. (2018) show that the use of Fintech loans is parallel to the income level of countries and is more common in countries with higher income levels and less stringent banking regulations. In Germany, De Roure et al. (2016) claims that Fintech credits are effective in meeting the needs of customers with low credibility, where the traditional system is insufficient. In these countries, at the same time, the development of Fintech reveals that the adoption of products, services, processes and applications is also faster. In this respect, the development of fintech products and applications like P2P lending is becoming more common in China, USA and European countries such as UK, Germany, Italy, Spain, Switzerland. Moreover, as a result of this thesis, as can be seen in *Figure 8*, P2P Lending is a topic that is frequently addressed in academic studies, especially in China, India and high-income countries such as USA, UK, Spain, Italy, Germany, Switzerland, Australia and Korea.

What are the recommended policies for countries to improve their Fintech developments?

Is there a difference in the suggested policies for countries according to income levels?

Considering the policy recommendations put forward with the help of RL in the policy path trajectory section of the thesis, "Supports for Financial Efficiency" for Germany, Japan, Hong Kong, Sweeden, Finland, Denmark, New Zealand, Netherlands, Canada, which are in the category of high-income countries, is presented as a policy suggestion to accelerate the development of Fintech.

When the details of the "Financial Efficiency Index" are analyzed in developed countries, it is observed that individuals have more access to financial products and services than

SMEs and entrepreneurs. Therefore, in order to increase the level of Fintech development, these high-income countries should increase SME financing and VC investments and support financial technology-based products, services, applications and processes that will facilitate businesses' access to finance.

In support of these conclusions, according to McKinsey&Company's Europe's Fintech Opportunity Report (2022) , worsening macroeconomic indicators in Europe and globally and difficult access to finance for SMEs and entrepreneurs are barriers to the effective use and development of Fintech in high-income European countries.

Similarly, Cornelli et al.(2021) state that VC funding is among the key factors needed in the development of Fintech, especially in EU countries, with the financing they provide for the initial establishment stages of Fintech start-ups. In addition, Doidge et al. (2013) argue that access to finance and capital raising activities in high-income countries are particularly important for fast-growing sectors such as Fintech. Furthermore, Pollari & Ruddenklau (2021) emphasized the importance of VC investments for the development of Fintech in European Union countries in the high income category according to the KPMG Pulse of Fintech (2021) report. In another study, VC investments were pointed out as one of the most important factors in the progress of Fintech in Japan, according to the Osaka Global Finance One-step Support Center (2022)report.

On the other hand, other high-income countries such as Qatar, Belgium, UK, Austria, Israei, Australia are among the countries with the highest indicators of financial inclusion and access to finance for entrepreneurial activity. For this reason, these countries may direct their resources to less costly policies instead of prioritizing policies that support Financial Efficiency for their Fintech developments.

Main Research Question; Is it possible to construct a composite indicator to help governments or policy makers to understand where they stand with regard to improving the financial technology?"

Considering the determinants and development of Fintech as demand and supply side makes it difficult to make Fintech measurable from these two different perspectives. This challenge can be overcome by constructing a single composite indicator (Lee et al. 2021). Under the theoretical perspective, the main objective of the dissertation is to eliminate the difficulty of measuring Fintech with a composite indicator to be constructed. Therefore, a "Global FinTech Index" consisting of sub-indices as "Fintech Readiness Index",

“Fintech Infrastructure Index” and “Fintech Efficiecy Index” was constructed for 120 countries for 2021 using equal weight, expert opinion and PCA methods. As part of guiding policymakers and providing policy recommendations, which is one of the main objectives of developing composite indicators, the "World Bank Country Classification by Income Group" classification was used for the interpretation of the indicator.

Theoretical Implications

This dissertation provides important theoretical implicaitons in terms of its subject, method and results.

The first composite indicator that deals with Fintech as technological and digital-based innovations

First of all, there are indexes in the literature that address different aspects of Fintech. Among these indices, the Global Fintech Adoption Index 2019 (Ernest & Young, 2019) and the Fintech Adoption Index for Association of Southeast Asian Nations (ASEAN) Countries (AFAI) address Fintech in terms of adoption and acceptability, while the AFAI is an index constructed exclusively for the countries of the ASEAN. Nonetheless, Fintech Index 2016 (Hieminga & Lande, 2016), Index Performance Scores 2017 (Deloitte, 2017), Global Fintech Ranking (Ankenbrand & Bieri, 2018), Global Fintech Index 2020 (Findexable Limited, 2019), Islamic Fintech Competitiveness Index 2021 (Glavina et al., 2021), all consider Fintech by defining it as a start-up, and the vast majority of these indices are city-based rather than country-based. However, unlike other indices, this study is the first composite indicator that deals with Fintech as technological and digital-based innovations that cause change in the field of finance, addressing many different dimensions and revealing the Fintech development levels of countries in this scope.

Revealing the theoretical foundations of Fintech and the theoretical classification of existing definitions

Moreover, the thesis examines Fintech within the framework of economics and finance theories and reveals the theoretical background of it. The theoretical pillars of Fintech are discussed in detail based on the bibliometric analysis of the leading academic studies, and the Theories of Innovation, Financial Intermediation Theory, Technology Acceptance Model and Financial Inclusion are presented in detail. To the best of our knowledge, this is the first study in the literature to explain the theoretical basis of Fintech systematically and based on an analysis. Consequently, different Fintech definitions in the literature have

been classified in terms of handling and explaining Fintech. One of the distinctive features of this dissertation is the presentation of different definitions of Fintech and the categorization of these definitions based on their common aspects. There is no definition classification supported by theory and based on the common aspects of Fintech definitions and the way they are handled.

Introducing a new definition of Fintech

In addition to the definitions in the literature, a new Fintech definition has been introduced, which also forms the basis of the Global Fintech Index. Accordingly, as the starting point of the Global Fintech index, "Fintech" is technological, digital-based financial innovations and applications that support the sustainability of traditional financial institutions/organizations, improve their products and services, also cause a disruptive impact and radical changes with the new challenging products and services in financial markets and industry. The dissertation defines Fintech as technological and digital-based innovations and reveals the Fintech developments of countries under this definition.

Practical Implications

Providing country-specific optimal strategy recommendations that will bring the Fintech level of the relevant country to the highest level

The most important functions of composite indices are to provide guidance to policymakers and to enable them to make policy recommendations that will lead to improvements in the area measured (Organisation for Economic Co-operation and Development (OECD), 2008). In order to improve the Fintech development of countries according to the results of the Global Fintech Index, action (strategy) series specific to each level of development have been proposed to bring them to the most advanced Fintech level. In addition, as part of guiding policy makers and providing policy recommendations, which is one of the main objectives of the construction of composite indicators, the "World Bank Country Classification by Income Group" classification was used in the interpretation of the index scores, unlike other studies, and the optimal strategy differences were revealed in terms of income groups.

Methodologically, using Reinforcement Learning to suggest optimal strategies to increase the Fintech development of countries through actions

Studies methodologically relying on the contructing the index, policy suggestions are interpreted based on the index scores and rankings of the countries, and an optimal strategy cannot be proposed to the countries prospectively. Because the indices reveal the current situation of the countries for the measured phenomenon and cannot reveal a projection for the future. In the dissertation, unlike other studies, the strategy recommendations that will enable countries to reach the highest level of Fintech development are based on the optimal strategy recommendation offered by RL based on index scores. To the best of our knowledge, this is the first study in which RL is used for optimal strategy recommendation.

Develop a new dashboard to present and visualize results

The last and most critical stage of the studies on constructing an index is the visualization and presentation of the results. In general, the presentation and visualization of results is challenging as it combines many different variables for a large number of countries and cities etc. In this dissertation, in order to overcome this difficulty, a dahboard has been designed that includes the sub-index results, GFI scores and rankings of the countries, calculated by three different methods for four different income groups, and optimal strategy recommendations based on GFI. By this way, users can easily compare and interpret the results and recommended strategies of different countries and different income groups. The images of the designed dashboard are given in *Appendix 7*.

Assumptions

The main assumption of this dissertation is that the difficulty of measuring the development of Fintech from two different perspectives, a demand-driven perspective and a supply-driven perspective, can be overcome by developing a single composite indicator (Lee et al., 2021).

Nevertheless, the basic step of composite indicators is to define the concept to be measured. There are different approaches to the definition of Fintech in the literature. In this dissertation, Fintech is defined as technological, digital-based financial innovations and applications that support the sustainability of traditional financial institutions/organizations, improve their products and services, also cause a disruptive impact and radical changes with the new challenging products and services in financial markets and industry. This study assumes that the composite indicator is constructed within this definition.

Another assumption is the honesty of the participants who were interviewed and completed the expert survey in the weighting part of the study, which was conducted based on expert opinion. It is assumed that both interviewers and survey participants are honest and willingly participate in the data collection process.

Limitations and Future Studies

The construction of composite indicators includes the selection of indicators, compensation of missing values, choice of aggregation model, weights of indicators, etc., which require subjective judgment. Most of the disadvantages of composite indicators stem from the subjectivity of some of the stages in their construction. While it may seem idealistic to assume that this debate will be resolved (Nardo et al., 2005), combined indicators still attract the attention of policymakers and the public. The subjectivity of the construction of composite indicators is often criticized, as well as the possibility of manipulating the result if the procedures followed are not clearly and reasonably justified for all (Grupp & Mogee, 2004; Grupp & Schubert, 2010). In an attempt to find a solution to this problem, the OECD (2008) describes a ten-step process, a 'checklist', to establish common guidelines as a basis for the development of composite indicators and to increase the transparency and robustness of the process. Within the scope of this constraint, this dissertation benefited from the OECD's (2008) guidelines and adopted the OECD's methodological steps in constructing the GFI.

Risk, security and trust are critical issues that are frequently addressed in the study of financial technology. In this dissertation, variables related to risk and security such as "e-Commerce security", "Trust in online privacy", "Trust in government websites and applications", "Trust in non-government websites and applications" are evaluated as a sub-group under "Financial Efficiency" as a topic addressed in the Fintech literature. However, as a result of PCA and CA, "e-commerce safety" was excluded from the analysis due to factor loadings, "Trust in online privacy" and "Trust in government websites and apps" could not be included in any component due to cross loading. Therefore, "Risk and Security" was not included in the model as a separate heading. In future studies, a different model can be constructed that addresses these critical variables and topics.

In the expert opinion used in the weighting of the combined indicators, it was aimed to reach experts from different countries and ensure their participation in the survey. However, while experts from Europe, the Middle East and the United States of America

participated in the survey, experts from Asian countries such as India, China and Singapore could not be included. This study can be expanded by taking the opinions of experts from these countries.

In this dissertation, the "Global Fintech Index", which defines Fintech as technology-based innovations that enable disruptive change or improvement of existing products, services and processes in the financial sector, was created based on three different weighting methods: equal weighting, principle component analysis and budget allocation process.

For future studies, ML can be used as a new weighting and composite indicator construction method (Jiménez-Fernández et al., 2022; Tsaples et al., 2022)

As the starting point of the Fintech index, “Fintech” is defined technological and digital-based financial innovations and applications that support the sustainability of traditional financial institutions and organizations and improve their products and services, and also cause a disruptive impact and radical changes in financial markets and industry with the new challenging products and services. The fact that an index expressing the fintech levels of countries in the sense of this definition has not been constructed before and therefore cannot be used as an output has been the most important obstacle to the use of ML as a weighting method in this study.

The index values will pave the way for the calculation of GFI with methods such as ML and fuzzy logic. In particular, the use of index values based on expert opinion in a composite indicator study based on ML can simplify the tedious aspects of the process such as the renewal of expert opinions. Furthermore, as suggested by Jimenez-Fernandez et al.(2022), unsupervised ML can be used as a new weighting and composite indicator construction method in a process where GFI scores cannot be used as output.

REFERENCES

Accenture. (2016). *Fintech-did someone cancel the revolution?* Retrived January 17, 2020 from https://www.accenture.com/t20170720t034938z__w__/us-en/_acnmedia/pdf-57/accenture-fintech-did-someone-cancel-the-revolution.pdf

Adaba, G. B., & Ayoung, D. A. (2017). The development of a mobile money service: an exploratory actor-network study. *Information Technology for Development*, *23*(4), 668–686. https://doi.org/10.1080/02681102.2017.1357525

Aghion & Howitt, P. (1992). A Model of Growth Through Creative Destruction. *The Econometric Society Stable*, *60*(2), 323–351. https://doi.org/https://doi.org/10.2307/2951599

Ahluwalia, S., Mahto, R. V., & Guerrero, M. (2020). Blockchain technology and startup financing: A transaction cost economics perspective. *Technological Forecasting and Social Change*, *151*. https://doi.org/10.1016/j.techfore.2019.119854

Akerlof, G. A. (1978). The Microeconomic Theory Foundations of a Flow of Funds of the Demand for Money. *Journal of Economic Theory*, *18*, 190–215.

Albo, Y., Lanir, J., & Rafaeli, S. (2019). A Conceptual Framework for Visualizing Composite Indicators. *Social Indicators Research*, *141*(1), 1–30. https://doi.org/10.1007/s11205-017-1804-0

Allen, F. (2021). Globalization of Finance and Fintech in the MENA Region. *Economic Research Forum Working Papers*, *1489*. https://erf.org.eg/app/uploads/2021/09/1634550652_436_521705_1489.pdf

Allen, F., Demirguc-kunt, A., Klapper, L., Soledad, M., Peria, M., & Allen, F. (2015). The Foundations of Financial Inclusion: Understanding Ownership and Use of Formal Accounts. *Journal of Financial Intermediation*, *2016*. https://doi.org/10.1016/j.jfi.2015.12.003

Allen, F., & Gale, D. (1994). Allen and Gale. 1994. Liquidity Preference, Market Participation and Asset.pdf. *The American Economic Review*, *84*(4), 933–955.

Allen, F., & Santomero, A. M. (1998). The theory of financial intermediation. *Journal of Banking & Finance 21*, *21*(2), 1461–1. https://doi.org/10.1007/BF01388162

Alliance for Fiscal Inclusion. (2010). Innovative Financial Inclusion. In *G20 Financial Inclusion Experts Group—ATISG Report*. http://www.gpfi.org/sites/default/files/documents/Principles and Report on Innovative Financial Inclusion_0.pdf

Alt, R., Beck, R., & Smits, M. T. (2018). FinTech and the transformation of the financial industry. *Electronic Markets*, *28*(3), 235–243. https://doi.org/10.1007/s12525-018-0310-9

Alterkawi, M. A., & Bittar, T. (2019). The Impact of FinTech Companies on Financial Institutions in Sweden: A Qualitative study on Impacts and Remedies. *Umea School*

of Business, 1–80.

Anagnostopoulos, I. (2018). Fintech and regtech: Impact on regulators and banks. *Journal of Economics and Business*, *100*(June 2017), 7–25. https://doi.org/10.1016/j.jeconbus.2018.07.003

Andrianaivo, M., & Kpodar, K. (2014). ICT , Financial Inclusion , and Growth : Evidence from African Countries. *IMF Worling Paper*, *11*(73). https://doi.org/10.5089/9781455227068.001

Androulaki, E., Karame, G. O., Roeschlin, M., Scherer, T., & Capkun, S. (2013). Evaluating user privacy in Bitcoin. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, *LNCS*, 34–51. https://doi.org/10.1007/978-3-642-39884-1_4

Ankenbrand, T., & Bieri, D. (2018). Assessment of cryptocurrencies as an asset class by their characteristics. *Investment Management and Financial Innovations*, *15*(3), 169–181. https://doi.org/10.21511/imfi.15(3).2018.14

Anyfantaki, S. (2016). The Evolution of Financial Technology (Fintech). *Bank of Greece Economic Bulletin*, *44(3*), https://ssrn.com/abstract=4171513

Arief, R. A., Cangara, A. R., Badu, M. N., Baharuddin, A., & Apriliani, A. (2020). The impact of the European Union (EU) renewable energy directive policy on the management of Indonesian palm oil industry. *IOP Conference Series: Earth and Environmental Science*, *575*(1). https://doi.org/10.1088/1755-1315/575/1/012230

Arner, D. W., Barberis, J., & Buckley, R. P. (2016). 150 years of Fintech : An evolutionary analysis. *Jassa The Finsia Journal of Applied Finance*, *3*, 22.

Arner, D. W., Barberis, J., & Buckley, R. P. (2017a). FinTech, regTech, and the reconceptualization of financial regulation. *Northwestern Journal of International Law and Business*, *37*(3), 373–415.

Arner, D. W., Barberis, J. N., & Buckley, R. P. (2015). The Evolution of Fintech: A New Post-Crisis Paradigm? *SSRN Electronic Journal*, *January*. https://doi.org/10.2139/ssrn.2676553

Arner, D. W., Barberis, J. N., & Buckley, R. P. (2017b). The Emergence of Regtech 2.0: From Know Your Customer to Know Your Data. *SSRN Electronic Journal*, 0–19. https://doi.org/10.2139/ssrn.3044280

Arner, D. W., Barberis, J. N., Walker, J., Buckley, R. P., & Zetzsche, D. A. (2020). Digital Finance & Crisis. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3558889

Arner, D. W., Zetzsche, D. A., Buckley, R. P., & Barberis, J. N. (2017). FinTech and RegTech Financial Stability. *Georgetown Journal of International Affairs*, *18*(3), 47–58.

Arthur, K. N. A. (2017). Financial innovation and its governance: Cases of two major innovations in the financial sector. *Financial Innovation*, *3*(1).

https://doi.org/10.1186/s40854-017-0060-2

Asongu, S. A., Nwachukwu, J. C., & Orim, S. M. I. (2018). Mobile phones, institutional quality and entrepreneurship in Sub-Saharan Africa. *Technological Forecasting and Social Change*, *131*(August 2017), 183–203. https://doi.org/10.1016/j.techfore.2017.08.007

Asongu, S. A., & Odhiambo, N. M. (2021). Inequality, finance and renewable energy consumption in Sub-Saharan Africa. *Renewable Energy*, *165*, 678–688. https://doi.org/10.1016/j.renene.2020.11.062

Awotunde, J. B., Chakraborty, C., & Adeniyi, A. E. (2021). Intrusion Detection in Industrial Internet of Things Network-Based on Deep Learning Model with Rule-Based Feature Selection. *Wireless Communications and Mobile Computing*, *2021*. https://doi.org/10.1155/2021/7154587

Aziz, S., & Dowling, M. (2018). *Machine Learning and AI for Risk Management*. Springer International Publishing. https://doi.org/10.1007/978-3-030-02330-0

Baiju, M. S., & Radhakumari, P. C. (2017). Fintech Revolution - A Step towards Digitization of Payments : A Theoretical Framework. *International Journal of Advance Research and Development.*, *1*(2), 1–9.

Bandura, R. (2011). *Composite Indicators and Rankings: Inventory 2011*.

Banerjee, A. V. ., & Newman, A. F. (1993). Occupational Choice and the Process of Development. *Journal of Political Economy*, *101*(2), 274–298.

Bank of International Settlements. (2018). Implications of fintech developments for banks and bank supervisors. In *Sound Practises* (Issue February).

Barber, S., Boyen, X., Shi, E., & Uzun, E. (2012). Bitter to better - How to make bitcoin a better currency. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, *7397 LNCS*, 399–414. https://doi.org/10.1007/978-3-642-32946-3_29

Barone, D., Jiang, L., Amyot, D., & Mylopoulos, J. (2011). Composite Indicators for Business Intelligence. *International Conference on Conceptual Modeling, LNCS 6998*, 448–458.

Barras, R. (1989). Interactive innovation in financial and business services : The vanguard of the service revolution. *Research Policy*, *19*(3), 215–237.

Basole, R. C., & Patel, S. S. (2018). Transformation Through Unbundling: Visualizing the. *Global FinTech Ecosystem. Service Science*, *10*(4), 379–396. http://pubsonline.informs.org.

Bátiz-lazo, B., & Woldesenbet, K. (2006). The dynamics of product and process innovations in UK banking. *International Journal of Financial Services Management*, *1*(4), 400–421. https://doi.org/10.1504/ijfsm.2006.010120

Batunanggar, S. (2019). Fintech Development and Asian Development Bank Institute.

ADBI Working Paper Series .1014(1014), 1–12. www.adbi.org

Baumol, W. J. (2002). Entrepreneurship, innovation and growth: the david-goliath symbiosIS. *Journal of Entrepreneurial Finance*, *7*(2), 1–10.

Baur, D. G., Hong, K. H., & Lee, A. D. (2018). Bitcoin: Medium of exchange or speculative assets? *Journal of International Financial Markets, Institutions and Money*, *54*(December), 177–189. https://doi.org/10.1016/j.intfin.2017.12.004

Beck et al. (1999). A New Database on Financial Development and Structure. In *Spectroscopy* (Vol. 519, Issue July). The World Bank. https://doi.org/10.1596/1813-9450-2146

Beck, T., Demirgüç-kunt, A., & Ross, L. (2007). Finance , inequality and the poor. *Journal of Economic Growth*, *12*(March), 27–49. https://doi.org/10.1007/s10887-007-9010-6

Becker, W., Saisana, M., Paruolo, P., & Vandecasteele, I. (2017). Weights and importance in composite indicators: Closing the gap. *Ecological Indicators*, *80*(March), 12–22. https://doi.org/10.1016/j.ecolind.2017.03.056

Belanche, D., Cenjor, I., & Pérez-Rueda, A. (2019). Instagram Stories versus Facebook Wall: an advertising effectiveness analysis. *Spanish Journal of Marketing - ESIC*, *23*(1), 69–94. https://doi.org/10.1108/SJME-09-2018-0042

Belleflamm, P., Lambert, T., & Schwienbacher, A. (2010). Crowdfunding: An Industrial Organization Perspective. *The Health Service Journal*, *114*(5892), 36.

Berg, G., Guadamillas, M., Natarajan, H., & Sarkar, A. (2020). Fintech in Europe and Central Asia. *Fintech in Europe and Central Asia*, *4*. https://doi.org/10.1596/33591

Berger, A. N. (2002). The Economic Effects of Technological Progress: Evidence from the Banking Industry. *Finance and Economics Discussion Series*, *2002*(50), 1–42. https://doi.org/10.17016/feds.2002.50

Berger, E., & Nakata, C. (2013). Implementing technologies for financial service innovations in base of the pyramid markets. *Journal of Product Innovation Management*, *30*(6), 1199–1211. https://doi.org/10.1111/jpim.12054

Bessant, J., & Tidd, J. (2015). *Managing Innovation* (Issue December).

Bethlendi, A., & Szocs, A. (2022). How the Fintech ecosystem changes with the entry of Big Tech companies. *Investment Management and Financial Innovations*, *19*(3), 38–48. https://doi.org/10.21511/imfi.19(3).2022.04

Bettinger, A. (1972). Fintech : A series of 40 time shared models used at manufacturers Hanover Trust Company. *Informs Stable*. *2*(4), 62–63.

Blach, J. (2011). Financial innovations and their role in the modern financial system-identification and systematization of the problem, e-Finanse: Financial Internet. *University of Information Technology and Management, Rzeszów, Vol. 7*(3), 13–26.

Błach, J. (2011). Financial innovations and their role in the modern financial system-identification and systematization of the problem. *E-Finanse*, *7*(3), 13–26.

Blakstad, S., & Allen, R. (2018). Leapfrogging Banks in Emerging Markets. In *FinTech Revolution*. 121-136. https://doi.org/10.1007/978-3-319-76014-8_7

Blaseg, D. (2015). Friend or Foe ? Crowdfunding versus Credit when Banks are Stressed Daniel Blaseg. *IWH Discussion Papers*, *8*. https://www.econstor.eu/bitstream/10419/117342/1/834451689.pdf

Bonneau, J., Miller, A., Clark, J., Narayanan, A., Kroll, J. A., & Felten, E. W. (2015). Research perspectives and challenges for bitcoin and cryptocurrencies. *Proceedings - IEEE Symposium on Security and Privacy*, 104–121. https://doi.org/10.1109/SP.2015.14

Bons, R. W. H., Alt, R., Lee, H. G., & Weber, B. (2012). Banking in the Internet and mobile era. *Electronic Markets*, *22*(4), 197–202. https://doi.org/10.1007/s12525-012-0110-6

Boot, A., Hoffmann, P., Laeven, L., & Ratnovski, L. (2021). Fintech : what ' s old , what ' s new ? *Journal of Financial Stability*, *53*. https://doi.org/10.1016/j.jfs.2020.100836

Booysen, F. (2002). An overview and evaluation of composite indices of development. *Social Indicators Research 59:*, *59*, 115–151.

Boreiko, D., & Massarotti, F. (2020). How Risk Profiles of Investors Affect Robo-Advised Portfolios. *Frontiers in Artificial Intelligence*, *3*(10), 1–9. https://doi.org/10.3389/frai.2020.00060

Boz, E., & Mendoza, E. G. (2014). Financial innovation , the discovery of risk , and the U . S . credit crisis . *Journal of Monetary Economics*, *62*, 1–22. https://doi.org/10.1016/j.jmoneco.2013.07.001

Braga, J. P., Pereira, I., & Reis, T. B. (2014). Composite Indicator of Financial Stress for Portugal. In *Banco De Portugal Eurosystem*.

Braggion, F., Manconi, A., & Zhu, H. (2017). Is FinTech a Threat to Financial Stability? Evidence from Peer-to-Peer Lending in China. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2957411

Brandl, B., & Hornuf, L. (2020). Where Did FinTechs Come From, and Where Do They Go? The Transformation of the Financial Industry in Germany After Digitalization. *Frontiers in Artificial Intelligence*, *3(3)*, 1–12. https://doi.org/10.3389/frai.2020.00008

Brave, S., & Butters, R. A. (2011). Monitoring financial stability : A financial conditions index approach. *Economic Perspectives*, *35(1)*, 22–43.

Brealey, R., & Stephen, S. (1977). Term Structure with Uncertain Inflation. *The Journal of Finance*, *32*(2), 277–289.

Breidbach, C., Keating, B., & Lim, C. (2020). Fintech : research directions to explore the

digital transformation of financial service systems. *Journal of Service Theory and Practice*, *30*(1), 79–102. https://doi.org/10.1108/JSTP-08-2018-0185

Brennan, N. M., Subramaniam, N., & van Staden, C. J. (2019). Corporate governance implications of disruptive technology: An overview. *British Accounting Review*, *51*(6). https://doi.org/10.1016/j.bar.2019.100860

Brown, E., & Piroska, D. (2022). Governing Fintech and Fintech as Governance: The Regulatory Sandbox, Riskwashing, and Disruptive Social Classification. *New Political Economy*, *27*(1), 19–32. https://doi.org/10.1080/13563467.2021.1910645

Brunnermeier, M. K., Eisenbach, T. M., & Sannikov, Y. (2012). Macroeconomics with Financial Frictions: A Survey. *NBER Working Paper Series Macroeconomics*, *18102*.

Buchak, G., Matvos, G., Piskorski, T., & Seru, A. (2018). Fintech, regulatory arbitrage, and the rise of shadow banks. *Journal of Financial Economics*, *130*(3), 453–483. https://doi.org/10.1016/j.jfineco.2018.03.011

Buchanan, B. G. (2019). Artificial intelligence in finance. *The Alan Turing Institute*. https://doi.org/10.5281/zenoda.2626454

Bucherie, A., Hultquist, C., Adamo, S., Neely, C., Ayala, F., Bazo, J., & Kruczkiewicz, A. (2022). A comparison of social vulnerability indices specific to flooding in Ecuador: principal component analysis (PCA) and expert knowledge. *International Journal of Disaster Risk Reduction*, *73*. https://doi.org/10.1016/j.ijdrr.2022.102897

Buckley, R. P., Arner, D. W., Zetzsche, D. A., & Weber, R. H. (2020). The road to RegTech: the (astonishing) example of the European Union. *Journal of Banking Regulation*, *21*(1), 26–36. https://doi.org/10.1057/s41261-019-00104-1

Burns, S. (2018). M-Pesa and the 'Market-Led' Approach to Financial Inclusion. *Economic Affairs*, *38*(3), 406–421. https://doi.org/10.1111/ecaf.12321

Buterin, V. (2014). A next-generation smart contract and decentralized application platform. *Etherum*, *January*, 1–36. http://buyxpr.com/build/pdfs/EthereumWhitePaper.pdf

Cai, C. W. (2018). Disruption of financial intermediation by FinTech: a review on crowdfunding and blockchain. *Accounting and Finance*, *58*(4), 965–992. https://doi.org/10.1111/acfi.12405

Cámara, N., & David, T. (2015). Factors that matter for financial inclusion: Evidence from Peru. *Aestimatio*, *9*(2015), 8–29. https://doi.org/10.5605/ieb.10.1

Cantú, C., & Chui, M. (2020). Financial market development and financial stability Carlos. *Bank for International Settlements Papers*, *113*. https://www.bis.org/publ/bppdf/bispap113_b_rh.pdf

Cao, L., Yuan, G., Leung, T., & Zhang, W. (2020). Special issue on AI and FinTech: The challenge ahead. *IEEE Intelligent Systems*, *35*(2), 3–6. https://doi.org/10.1109/MIS.2020.2983494

Cao, S., Lyu, H., & Xu, X. (2020). Technological Forecasting & Social Change InsurTech development : Evidence from Chinese media reports. *Technological Forecasting & Social Change*, *161*(August), 120277. https://doi.org/10.1016/j.techfore.2020.120277

Cappiello, A. (2018). Technology and Insurance. In *Technology and The Insurance Industry* (pp. 7–28).

Carney, M. (2017). The Promise of FinTech – Something New Under the Sun. *Deutsche Bundesbank G20 Conference*, *January*, 1–14. https://www.bankofengland.co.uk/speech/2017/the-promise-of-fintech-something-new-under-the-sun

Chakraborty, C., & Joseph, A. (2017). Machine Learning at Central Banks. *Bank of England Working Paper*, *674*.

Charoenwong, B., Kowaleski, Z., Kwan, A., & Sutherland, A. (2021). RegTech. *MIT Sloan Research Paper*, *6563*(22).

Chen, L. (2016). From Fintech to Finlife: the case of Fintech Development in China. *China Economic Journal*, *9*(3), 225–239. https://doi.org/10.1080/17538963.2016.1215057

Chen, M. A., Wu, Q., & Yang, B. (2019). How Valuable Is FinTech Innovation? *Review of Financial Studies*, *32*(5), 2062–2106. https://doi.org/10.1093/rfs/hhy130

Chen, Y., & Bellavitis, C. (2020). Blockchain disruption and decentralized finance: The rise of decentralized business models. *Journal of Business Venturing Insights*, *13*(June 2020). https://doi.org/10.1016/j.jbvi.2019.e00151

Chen, Z., & Jin, M. (2017). Financial Inclusion in China: Use of Credit. *Journal of Family and Economic Issues*, *38*(4), 528–540. https://doi.org/10.1007/s10834-017-9531-x

Cherif, M., & Gazdar, K. (2011). What Drives Venture Capital Investments in Europe ? New Results from a Panel Data Analysis. *Journal of Applied Business and Economics*, *12*(3), 122–139.

Chiu, Y., & Iris, H. (2016). Fintech and Disruptive Business Models in. *Journal of Technology Law & Policy*, *21*, 55–112. http://ssrn.com/abstract=2559504.

Chowdhury, S., Govindaraj, R., Nath, S. S., & Solomon, K. (2019). Analysis of the IoT sensors and networks with big data and sharing the data through cloud platform. *International Journal of Innovative Technology and Exploring Engineering*, *8*(4S2), 405–408.

Christensen, C. M. (2006). The ongoing process of building a theory of disruption. *Journal of Product Innovation Management*, *23*(1), 39–55. https://doi.org/10.1111/j.1540-5885.2005.00180.x

Christensen, C. M., & Bower, J. L. (1996). Customer Power , Strategic Investment , and the Failure of Leading Firms. *Strategic Management Journal*, *17*(3), 197–218.

Chuang, L.-M., Liu, C.-C., & Kao, H.-K. (2016). International Journal of Management and

Administrative Sciences (IJMAS) The Adoption of Fintech Service: TAM perspective. *International Journal of Management and Administrative Sciences (IJMAS*, *3*(07), 1–15. www.ijmas.orgwww.ijmas.org

Chuen, D. L. K., & Teo, E. G. S. (2015). Emergence of Fintech and the Lasic Principles. *SSRN Electronic Journal*, *April*. https://doi.org/10.2139/ssrn.2668049

Cizel, J., Frost, J., Houben, A., & Wierts, P. (2019). Effective Macroprudential Policy: Cross-Sector Substitution from Price and Quantity Measures. *Journal of Money, Credit and Banking*, *51*(5), 1209–1235. https://doi.org/10.1111/jmcb.12630

Claessens, S., Frost, J., Turner, G., & Zhu, F. (2018a). Fintech credit markets around the world : size , drivers. *BIS Quarterly Review*, *September*, 29–49.

Claessens, S., Frost, J., Turner, G., & Zhu, F. (2018b). Fintech credit markets around the world: size, drivers and policy issues. *BIS Quarterly Review*, *September*, 29–49.

Coakley, J., & Huang, W. (2020). P2P lending and outside entrepreneurial finance. *European Journal of Finance*, *0*(0), 1–18. https://doi.org/10.1080/1351847X.2020.1842223

Cocca, T. D. (2016). Potential and Limitations of Virtual Advice in Wealth Management. *The Capco Institute Journal of Financial Transformation*, *December*.

Cojoianu, T. F., Clark, G. L., Hoepner, A. G. F., Pažitka, V., & Wójcik, D. (2021). Fin vs. tech: are trust and knowledge creation key ingredients in fintech start-up emergence and financing? *Small Business Economics*, *57*(4), 1715–1731. https://doi.org/10.1007/s11187-020-00367-3

Comin, D., & Hobijn, B. (2010). Technology Diffusion and Postwar Growth Technology Di ¤ usion and Postwar Growth. *Harvard Business School BGIE Unit*, *11–027*. Available at SSRN: https://ssrn.com/abstract=1676306 or http://dx.doi.org/10.2139/ssrn.1676306

Commission, E. (2018). FinTech Action plan: For a more competitive and innovative European financial. *Communıcatıon From The Commıssıon to The European Parliament, The Council, The European Central bank* https://ec.europa.eu/info/sites/info/files/180308-action-plan-fintech_en.pdf

Cong, L. W., & He, Z. (2019). Blockchain Disruption and Smart Contracts. *Review of Financial Studies*, *32*(5), 1754–1797. https://doi.org/10.1093/rfs/hhz007

Corbet, S., Meegan, A., Larkin, C., Lucey, B., & Yarovaya, L. (2018). Exploring the dynamic relationships between cryptocurrencies and other financial assets. *Economics Letters*, *165*, 28–34. https://doi.org/10.1016/j.econlet.2018.01.004

Cornelli, G., Doerr, S., Franco, L., & Frost, J. (2021). Funding for fintechs: patterns and drivers. *BIS Quarterly Review*, *September*, 31–43.

Cornelli, G., Frost, J., Gambacorta, L., Rau, R., Wardrop, R., & Ziegler, T. (2020). Fintech and Big Tech Credit: A New Database. *Bank for International Settlements*, *887*, 1–35.

Crosby, M., Nachiappan, Pattanayak, P., Verma, S., & Kalyanaraman, V. (2016). BlockChain Technology: Beyond Bitcoin. *Applied Innovation Review*, *27*(2), 222–228. https://doi.org/10.15358/0935-0381-2015-4-5-222

Cumming, D. J., & Schwienbacher, A. (2018). Fintech venture capital. *Corporate Governance: An International Review*, *26*(5), 374–389. https://doi.org/10.1111/corg.12256

Currie, W. L., & Seltsikas, P. (2001). Delivering Business Critical Information Systems Though Application Service Providers: the Need for a Market Segmentation Strategy. *International Journal of Innovation Management*, *05*(03), 323–349. https://doi.org/10.1142/s1363919601000403

Dabic, M., Cvijanović, V., & González-Loureiro, M. (2013). Keynesian, post-Keynesian versus Schumpeterian, neo-Schumpeterian: An integrated approach to the innovation theory. *Management Decision*, *42*(8), 1195–1217. https://doi.org/10.1108/K-04-2013-0069

Dachyar, M., Zagloel, T. Y. M., & Saragih, L. R. (2019). Knowledge growth and development: internet of things (IoT) research, 2006–2018. *Heliyon*, *5*(8), e02264. https://doi.org/10.1016/j.heliyon.2019.e02264

Danneels, E. (2004). Disruptive technology reconsidered: A critique and research agenda. *Journal of Product Innovation Management*, *21*(4), 246–258. https://doi.org/10.1111/j.0737-6782.2004.00076.x

Dapp, T. F. (2014). Fintech – The digital (r)evolution in the financial sector. *DB Research , Frankfurt am Main*, 39. www.dbresearch.com

Darko, A., Chan, A. P. C., Ameyaw, E. E., Owusu, E. K., Pärn, E., & Edwards, D. J. (2019). Review of application of analytic hierarchy process (AHP) in construction. *International Journal of Construction Management*, *19*(5), 436–452. https://doi.org/10.1080/15623599.2018.1452098

Das, S. R. (2019). The future of fintech. *Financial Management*, *48*(4), 981–1007. https://doi.org/10.1111/fima.12297

Dastile, X., Celik, T., & Potsane, M. (2020). Statistical and machine learning models in credit scoring : A systematic literature survey. *Applied Soft Computing Journal*, *91*, 106263. https://doi.org/10.1016/j.asoc.2020.106263

Davis, F. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly: Management Information Systems*, *13*(3), 319–339. https://doi.org/10.2307/249008

Davis, K., Maddock, R., & Foo, M. (2017). Catching up with indonesia's fintech industry. *Law and Financial Markets Review*, *11*(1), 33–40. https://doi.org/10.1080/17521440.2017.1336398

de Roure, C., Pelizzon, L., & Tasca, P. (2016). How Does P2P Lending Fit into the Consumer Credit Market? *SSRN Electronic Journal*, *30*. https://doi.org/10.2139/ssrn.2848043

de Sherbinin, A., & Bardy, G. (2015). Social vulnerability to floods in two coastal megacities: New York City and Mumbai. *Vienna Yearbook of Population Research*, *13*(1), 131–166. https://doi.org/10.1553/populationyearbook2015s131

Decancq, K., & Lugo, M. A. (2012). Weights in Multidimensional Indices of Wellbeing: An Overview. *Econometric Reviews*, *32*(1), 7–34. https://doi.org/10.1080/07474938.2012.690641

Deloitte. (2017). Connecting Global FinTech: Interim Hub Review. *Deliotte and Global Fintech Hubs Federation*.

Demir, A., Pesqué-Cela, V., Altunbas, Y., & Murinde, V. (2022). Fintech, financial inclusion and income inequality: a quantile regression approach. *European Journal of Finance*, *28*(1), 86–107. https://doi.org/10.1080/1351847X.2020.1772335

Demirguc-Kunt, A., Klapper, L., Singer, D., Ansar, S., & Hess, J. (2018). The Global Findex Database 2017: Measuring Financial Inclusion and the Fintech Revolution. In *The Global Findex Database 2017: Measuring Financial Inclusion and the Fintech Revolution*. https://doi.org/10.1596/978-1-4648-1259-0

Dev, M. S. (2006). Financial Inclusion: Issues and Challenges. *Economic and Political Weekl*, *41*(41), 4310–4313.

Dharmadasa, P. D. C. S. (2021). "Fintech Services" and the Future of Financial Intermediation: A Review. *Sri Lanka Journal of Economic Research*, *8*(2), 21. https://doi.org/10.4038/sljer.v8i2.135

Diamond, D. W. (1984). Financial intermediation and delegated monitoring. *Review of Economic Studies*, *51*(3), 393–414. https://doi.org/10.2307/2297430

Diemers, D., Lamaa, A., Salamat, J., & Steffens, T. (2015). Developing a FinTech ecosystem in the GCC: let's get ready for take off. *Strategy&*, 16.

Ding, N., Gu, L., & Peng, Y. (2022). Fintech , financial constraints and innovation : Evidence from China. *Journal of Corporate Finance*, *73*(3), 102194. https://doi.org/10.1016/j.jcorpfin.2022.102194

Doidge, C., Karolyi, G. A., & Stulz, R. M. (2013). The U.S. left behind? Financial globalization and the rise of IPOs outside the U.S. *Journal of Financial Economics*, *110*(3), 546–573. https://doi.org/10.1016/j.jfineco.2013.08.008

Dolega-Dolegowski, D., Proniewska, K., Dolega-Dolegowska, M., Pregowska, A., Hajto-Bryk, J., Trojak, M., Chmiel, J., Walecki, P., & Fudalej, P. S. (2022). Application of holography and augmented reality based technology to visualize the internal structure of the dental root – a proof of concept. *Head and Face Medicine*, *18*(1), 4–9. https://doi.org/10.1186/s13005-022-00307-4

Domowitz, I. (2002). Liquidity, transaction costs, and reintermediation in electronic markets. *Journal of Financial Services Research*, *22*(1–2), 141–157. https://doi.org/10.1023/A:1016077023185

Dosi, G. (1988). *The Nature of the Innovation Process* (G. Dosi, C. Freeman, R. Nelson, G.

Silverberg, & L. Soete (eds.)). Pinter Publishers.

Duran, R., & Griffin, P. (2021). *Institutional Knowledge at Singapore Management University Smart contracts : Will Fintech be the catalyst for the next global financial crisis ? Smart contracts : A catalyst of the next global financial crisis ?* 104–122.

Dushnitsky, G., Guerini, M., Piva, E., & Rossi-Lamastra, C. (2016). Crowd funding in Europe: Determinants of platform creation across countries. *California Management Review*, *58*(2), 44–71. https://doi.org/10.1525/cmr.2016.58.2.44

Dyson, B., & Hodgson, G. (2016). DIGITAL CASH: Why Central Banks Should Start Issuing Electronic Money. *Positive Money*, 1–36. https://positivemoney.org/wp-content/uploads/2016/01/Digital_Cash_WebPrintReady_20160113.pdf

Edler, J., & Fagerberg, J. (2017). Innovation policy: What, why, and how. *Oxford Review of Economic Policy*, *33*(1), 2–23. https://doi.org/10.1093/oxrep/grx001

Elia, G., Stefanelli, V., & Ferilli, G. B. (2022). Investigating the role of Fintech in the banking industry: what do we know? *European Journal of Innovation Management*, *12*(2). https://doi.org/10.1108/EJIM-12-2021-0608

Eling, M., & Lehmann, M. (2017). The Impact of Digitalization on the Insurance Value Chain and the Insurability of Risks. *The Geneva Papers on Risk and Insurance - Issues and Practice*. https://doi.org/10.1057/s41288-017-0073-0

Emara, N., & Mohieldin, M. (2021). *Beyond the Digital Dividends: Fintech and Extreme Poverty in the Middle East and Africa*. *23*(2).

Ernest & Young. (2019). *Global FinTech Adoption Index 2019*, Retrieved September 16, 2021 from https://fintechauscensus.ey.com/2019/Documents/ey-global-fintech-adoption-index-2019.pdf. 1–44.

Esposti, S. D. (2014). When big data meets dataveillance: The hidden side of analytics. *Surveillance and Society*, *12*(2), 209–225. https://doi.org/10.24908/ss.v12i2.5113

Ettlie, J. E., Reza, E. M., & Ettlie, J. E. (2014). Organizational integration and process innovaton. *The Academy of Management Journal*, *35*(4), 795–827. https://doi.org/10.2307/256316

Fama, E. (2012). Agency problems and the theory of the firm. *The Economic Nature of the Firm: A Reader, Third Edition*, *88*(21), 270–282. https://doi.org/10.1017/CBO9780511817410.022

Félix, E. G. S., Pires, C. P., & Gulamhussen, M. A. (2013). The Determinants of Venture Capital in Europe - Evidence Across Countries. *Journal of Financial Services Research*, *44*(3), 259–279. https://doi.org/10.1007/s10693-012-0146-y

Feng, F., Zhang, L., Du, Y., & Wang, W. (2015). Visualization and quantitative study in bibliographic databases : A case in the field of university – industry cooperation. *Journal of Informetrics*, *9*(1), 118–134. https://doi.org/10.1016/j.joi.2014.11.009

Financial Stability Board. (2017). Financial Stability Implications from Fintech:

Supervisory and Regulatory Issues that Merit Authorities' Attention. *Financial Stability Board*, *June*, 1–61. www.fsb.org/emailalert

Finnerty, J. D. (1992). An overview of corporate securities innovation. Journal of Applied Corporate Finance, 4(4). https://doi.org/10.1111/j.1745-6622.1992.tb00215.x

Foley, S., Karlsen, J. R., & Putnins, T. J. (2019). Sex, Drugs, and Bitcoin: How Much Illegal Activity Is Financed through Cryptocurrencies? *Review of Financial Studies*, *32*(5), 1798–1853. https://doi.org/10.1093/rfs/hhz015

Frame, S. W., Wall, L. D., & White, L. (2019). Technological Change and Financial Innovation in Banking: Some Implications for Fintech. In *Federal Reserve Bank of Atlanta, Working Papers* 3(19). https://doi.org/10.29338/wp2018-11

Frame, S. W., & White, L. J. (2005). Empirical Studies of Financial Innovation: Lots of Talk, Little Action? In *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.325800

Freudenberg, M. (2003). Composite indicators of country performance: a critical assessment. *OECD Science, Technology and Industry Working Papers*, *16*, 35. Retrived September 15, 2020 from http://www.oecdilibrary.org/docserver/download/5lgsjhvj7lbt.pdf?expires=1436619503&id=id&accname=guest&checksum=DA782FFA25365A66A8238E1D5106BE79

Frost, J. (2020). The economic forces driving fintech adoption across countries. *The Technological Revolution in Financial Services: How Banks, FinTechs, and Customers Win Together*, *838*, 70–89. https://doi.org/10.2139/ssrn.3515326

Gabor, D., & Brooks, S. (2017). The digital revolution in financial inclusion: international development in the fintech era. *New Political Economy*, *22*(4), 423–436. https://doi.org/10.1080/13563467.2017.1259298

Gai, K., Qiu, M., & Sun, X. (2018). A survey on FinTech. *Journal of Network and Computer Applications*, *103*(2), 262–273. https://doi.org/10.1016/j.jnca.2017.10.011

Galor, O., & Zeira, J. (2013). Income Distribution and Macroeconomics. *The Review of Economic Studies*, *60*(1), 35–52. Retrived January 25, 2021 from https://www.econstor.eu/handle/10419/102616

Gambacorta, L., & Mistrulli, P. E. (2004). Does bank capital affect lending behavior? *Journal of Financial Intermediation*, *13*(4), 436–457. https://doi.org/10.1016/j.jfi.2004.06.001

Gandal, N., Shur-Ofry, M., Crystal, M., & Shilony, R. (2021). Out of sight: patents that have never been cited. *Scientometrics*, *126*(4), 2903–2929. https://doi.org/10.1007/s11192-020-03849-z

Garcia, R., & Roger, C. (2002). A critical look at technological innovation typology and innovativeness terminology: a literature review. *Journal of Product Innovation Management*, 19(2), 110–132. doi:10.1111/1540-5885.1920110

Gepp, A., Linnenluecke, M. K., O'Neill, T. J., & Smith, T. (2018). Big data techniques in auditing research and practice: Current trends and future opportunities. *Journal of Accounting Literature*, *40*(5), 102–115. https://doi.org/10.1016/j.acclit.2017.05.003

Gershenson, D., Herrera, L., Lambert, F., Ramos, G., Rousset, M., Torres, J., Werner, A., Lahreche, A., Beaton, K., Khera, P., Martínez Pería, S., & Ogawa, S. (2021). Fintech and Financial Inclusion in Latin America and the Caribbean. *IMF Working Paper*, *21*(221). Retrived November 12, 2022 from https://www.econstor.eu/handle/10419/102616

Ghosh, S., & Vinod, D. (2016). Furthering the Financial Inclusion Agenda in India : How Important Is Gender? *Economic and Political Weekly*, *51*(12), 126–132.

Giglio, F. (2021). Fintech: A Literature Review. *International Business Research*, *15*(1), 80. https://doi.org/10.5539/ibr.v15n1p80

Gimpel, H., Rau, D., & Röglinger, M. (2018). Understanding FinTech start-ups – a taxonomy of consumer-oriented service offerings. *Electronic Markets*, *28*(3), 245–264. https://doi.org/10.1007/s12525-017-0275-0

Gisselquist, R. M. (2014). Developing and evaluating governance indexes: 10 questions. *Policy Studies*, *35*(5), 513–531. https://doi.org/10.1080/01442872.2014.946484

Glavina, S., Aidrus, I., & Trusova, A. (2021). Assessment of the Competitiveness of Islamic Fintech Implementation : A Composite Indicator for Cross-Country Analysis. *Journal of Risk and Financial Management*, *14*(12).

Global, O., & Support, F. O. (2022). *Fıntech and investments in Osaka , JAPAN*. Retrieved January 20, 2023 from https://www.pref.osaka.lg.jp/attach/39795/00420642/Fintech2022.pdf

Gomber, P., Kauffman, R. J., Parker, C., & Weber, B. W. (2018). On the Fintech Revolution: Interpreting the Forces of Innovation, Disruption, and Transformation in Financial Services. *Journal of Management Information Systems*, *35*(1), 220–265. https://doi.org/10.1080/07421222.2018.1440766

Gomber, P., Koch, J. A., & Siering, M. (2017). Digital Finance and FinTech: current research and future research directions. *Journal of Business Economics*, *87*(5), 537–580. https://doi.org/10.1007/s11573-017-0852-x

González-Alcaide, G., Calafat, A., Becoña, E., Thijs, B., & Glänzel, W. (2016). Co-citation analysis of articles published in substance abuse journals: Intellectual structure and research fields (2001–2012). *Journal of Studies on Alcohol and Drugs*, *77*(5), 710–722. https://doi.org/10.15288/jsad.2016.77.710

Gosavi, A. (2018). Can Mobile Money Help Firms Mitigate the Problem of Access to Finance in Eastern sub-Saharan Africa? *Journal of African Business*, *19*(3), 343–360. https://doi.org/10.1080/15228916.2017.1396791

Grassi, L., & Lanfranchi, D. (2022). RegTech in public and private sectors: the nexus between data, technology and regulation. In *Journal of Industrial and Business Economics* (Vol. 49, Issue 3). Springer International Publishing.

https://doi.org/10.1007/s40812-022-00226-0

Greco, M., Grimaldi, M., & Cricelli, L. (2016). An analysis of the open innovation effect on firm performance. *European Management Journal*, *34*(5), 501–516. https://doi.org/10.1016/j.emj.2016.02.008

Greco, S., Ishizaka, A., Tasiou, M., & Torrisi, G. (2019). On the Methodological Framework of Composite Indices: A Review of the Issues of Weighting, Aggregation, and Robustness. *Social Indicators Research*, *141*(1), 61–94. https://doi.org/10.1007/s11205-017-1832-9

Groh, A. P., & Wallmeroth, J. (2016). Determinants of venture capital investments in emerging markets. *Emerging Markets Review*, *29*, 104–132. https://doi.org/10.1016/j.ememar.2016.08.020

Grupp, H., & Mogee, M. E. (2004). Indicators for national science and technology policy: How robust are composite indicators? *Research Policy*, *33*(9), 1373–1384. https://doi.org/10.1016/j.respol.2004.09.007

Grupp, H., & Schubert, T. (2010). Review and new evidence on composite innovation indicators for evaluating national performance. *Research Policy*, *39*(1), 67–78. https://doi.org/10.1016/j.respol.2009.10.002

Guidotti, P. E. . (2017). Currency Substitution and Financial Innovation. *Journal of Money,* Credit and Banking, 25(1), 109–124.

Guiso, L., Sapienza, P., & Zingales, L. (2004). The role of social capital in financial development. *American Economic Review, 94(3), 526-556* https://doi.org/10.2139/ssrn.209610

Guo, F., Wang, J., Cheng, Z., Li, Y., Wang, F., & Wei, A. (2019). The Peking University Digital Financial Inclusion Index of China (2011-2018). *Institute of Digital Finance, Peking University*, 1–70. Retrieved January 20, 2021 from http://idf.pku.edu.cn

Gupta, A., & Xia, C. (2018). A paradigm shift in banking: Unfolding asia's fintech adventures. In *International Symposia in Economic Theory and Econometrics, 25(3)* https://doi.org/10.1108/S1571-038620180000025010

Haas, P., Blohm, I., Peters, C., & Leimeister, J. M. (2015). Modularization of crowdfunding services - Designing disruptive innovations in the banking industry. *2015 International Conference on Information Systems: Exploring the Information Frontier, ICIS 2015*, 1–12.

Haddad, C., & Hornuf, L. (2019). The emergence of the global fintech market: economic and technological determinants. *Small Business Economics*, *53*(1), 81–105. https://doi.org/10.1007/s11187-018-9991-x

Hasman, A., Samartín, M., & van Bommel, J. (2014). Financial intermediation in an overlapping generations model with transaction costs. *Journal of Economic Dynamics and Control*, *45*, 111–125. https://doi.org/10.1016/j.jedc.2014.05.012

Hau, H., Huang, Y., Shan, H., & Sheng, Z. (2019). How FinTech Enters China's Credit

Market. *AEA Papers and Proceedings*, *109*, 60–64. https://doi.org/10.1257/pandp.20191012

Hauser, J., Tellis, G. J., & Griffin, A. (2006). Research on Innovation : A Review and Agenda for Marketing Science. *Marketing Science*, *25*(6), 687–717. https://doi.org/10.1287/mksc.1050.0144

He, D., Leckow, R., Haksar, V., Mancini-Griffoli, T., Jenkinson, N., Kashima, M., Khiaonarong, T., Rochon, C., & Tourpe, H. (2017). Fintech and Financial Services: Initial Considerations. *International Monetary Fund*, 49. https://www.imf.org/~/media/Files/Publications/SDN/2017/sdn1705.ashx

Helbing, D. (2019). *Towards Digital Enlightenment*.

Hellwig, D. P., & Huchzermeier, A. (2019). An Industry Study of Blockchain Technology ' s Impact on Trade Finance. *SSRN Electronic Journal*, 1–9.

Henderson, R., & Clark, K. (1990). Architectural Innovation : The Reconfiguration of Existing Product Technologies and the Failure of Established Firms. *Administrative Science Quarterly*, *35*(1). https://doi.org/10.2307/2393549

Herck Giaquinto, L., & Bortoluzzo, A. B. (2020). Angel investors, seed-stage investors and founders influence on FinTech funding: an emerging market context. *Macroeconomics and Finance in Emerging Market Economies*, *13*(3), 276–294. https://doi.org/10.1080/17520843.2020.1737169

Hermes, N. (2014). Does microfinance affect income inequality ? Does microfinance affect income inequality ? *Applied Economics*, *46*(9), 1021–1034. https://doi.org/10.1080/00036846.2013.864039

Hester, D. D. . (1969). Financial Disintermediation and Policy. *Journal of Money , Credit and Banking*, *1*(3), 600–617.

Hieminga, G., & Lande, F. (2016). The FinTech Index. *ING Economics Department*, *November*.

Higginson, M., Nadeau, M.-C., & Rajgopal, K. (2019). *Blockchain ' s Occam problem*.

Hill, J. A..(2021). Covid-19 , Banks and Fintechs. *Consumer Finance Law Quarterly Report 346*. Retrieved March 01, 2021 from https://ssrn.com/abstract=3777562 or http://dx.doi.org/10.2139/ssrn.3777562

Holmstrom, B., & Tirole, J. (1997). Financial Intermediation, Loanable Funds, and the Real Sector. *The Quarterly Journal of Economic*, *112*(3), 663–691.

Honohan, P. (2017). Management and Resolution of Banking Crises : Lessons from Recent European Experience. *Peterson Institute for International Economics*, *17*(1), 1–11.

Houston, J. F., Lin, C., Lin, P., & Ma, Y. (2010). Creditor rights, information sharing, and bank risk taking. *Journal of Financial Economics*, *96*(3), 485–512. https://doi.org/10.1016/j.jfineco.2010.02.008

Hu, Z., Ding, S., Li, S., Chen, L., & Yang, S. (2019). Adoption intention of fintech services for bank users: An empirical examination with an extended technology acceptance model. *Symmetry*, *11*(3). https://doi.org/10.3390/sym11030340

Huang, J., Chai, J., & Cho, S. (2020). Deep learning in finance and banking: A literature review and classification. *Frontiers of Business Research in China*, *14*(1). https://doi.org/10.1186/s11782-020-00082-6

Huang, J., Xia, J., Yu, Y., & Zhang, N. (2018). Composite eco-efficiency indicators for China based on data envelopment analysis. *Ecological Indicators*, *85*(4), 674–697. https://doi.org/10.1016/j.ecolind.2017.10.040

Huebner, J., Vuckovac, D., Fleisch, E., & Ilic, A. (2019). Fintechs and the new wave of financial intermediaries. *Proceedings of the 23rd Pacific Asia Conference on Information Systems: Secure ICT Platform for the 4th Industrial Revolution, PACIS 2019*.

Ikpaahindi, L. (1985). *An Overview of bibliometrics: Its Measurements, Laws and Their Applications*.

Iman, N. (2018). Is mobile payment still relevant in the fintech era? *Electronic Commerce Research and Applications*, *30*(5), 72–82.https://doi.org/10.1016/j.elerap.2018.05.009

International Monetary Fund, & World Bank. (2019). Fintech: the Experience So Far. *IMF Policy Paper*, *7*, 1–77. Retrieved April 15, 2021 from https://www.imf.org/~/media/Files/Publications/PP/2019/PPEA2019024.ashx

International Organization of Securities Commisssions (IOSCO). (2017). Research Report on Financial Technologies (Fintech). *International Organization of Securities Commissions*, *2*, 1–75. Retrieved May 15, 2020 from https://www.iosco.org/library/pubdocs/pdf/IOSCOPD554.pdf

Isaia, E., & Oggero, N. (2022). The potential use of robo-advisors among the young generation : Evidence from Italy. *Finance Research Letters*, *48*, 1. https://doi.org/10.1016/j.frl.2022.103046

Iyer, S. (2016). The new economics of religion. *Journal of Economic Literature*, *54*(2), 395–411. https://doi.org/10.1257/jel.54.2.395

Jack, W., & Suri, T. (2011). Mobile Money: The Economics of M-Pesa. *NBER Working Paper Series*, 1–30.

Jagtiani, J., & John, K. (2018). Fintech: The Impact on Consumers and Regulatory Responses. *Journal of Economics and Business*, *100*(10), 1–6. https://doi.org/10.1016/j.jeconbus.2018.11.002

Jagtiani, J., & Lemieux, C. (2018). do fintech lenders penetrate areas that are underserved by traditional do fintech lenders penetrate areas that are underserved by traditional banks ? *Journal of Economics and Business*, *100*(2), 3–4. https://doi.org/10.1016/j.jeconbus.2018.03.001

Jamison, J., Karlan, D., & Zinman, J. (2014). Financial Education and Access to Savings Accounts: Complements or Substitutes? Evidence from Ugandan Youth Clubs. In *National Bureau Of Economic Research: Vol. May*. http://www.nber.org/papers/w20135

Jiménez-Fernández, E., Sánchez, A., & Sánchez Pérez, E. A. (2022). Unsupervised machine learning approach for building composite indicators with fuzzy metrics. *Expert Systems with Applications*, *200*(4), 116927. https://doi.org/10.1016/j.eswa.2022.116927

Joseph, S. (2016). FinTech: The Not So Little Engine That Can. *The FinTech Book*, 66–68. https://doi.org/10.1002/9781119218906.ch17

Jun, J., & Yeo, E. (2016). Entry of FinTech Firms and Competition in the Retail Payments Market. *Asia-Pacific Journal of Financial Studies*, *45*(2), 159–184. https://doi.org/10.1111/ajfs.12126

Jünger, M., & Mietzner, M. (2020). Banking goes digital: The adoption of FinTech services by German households. *Finance Research Letters*, *34*(8), 101260. https://doi.org/10.1016/j.frl.2019.08.008

Junior, C., & Cherobim, A. P. M. S. (2019). Academic production and technological emergence in finance. *Innovation & Management Review*, *17*(2), 115–131. https://doi.org/10.1108/INMR-01-2019-0005

Kahn, K. B. (2018). Understanding innovation. *Business Horizons*, *61*(3), 453–460. https://doi.org/10.1016/j.bushor.2018.01.011

Kalra, D. (2019). Overriding fintech. *Proceeding of 2019 International Conference on Digitization: Landscaping Artificial Intelligence, ICD 2019*, *10(19)* 254–259. https://doi.org/10.1109/ICD47981.2019.9105915

Kang, J. (2018). Mobile payment in Fintech environment: trends, security challenges, and services. *Human-Centric Computing and Information Sciences*, *8*(1). https://doi.org/10.1186/s13673-018-0155-4

Kanga, D., Oughton, C., Harris, L., & Murinde, V. (2022). The diffusion of fintech, financial inclusion and income per capita. *European Journal of Finance*, *28*(1), 108–136. https://doi.org/10.1080/1351847X.2021.1945646

Kanobe, F., Alexander, P. M., & Bwalya, K. J. (2017). Policies, regulations and procedures and their effects on mobile money systems in Uganda. *Electronic Journal of Information Systems in Developing Countries*, *83*(1). https://doi.org/10.1002/j.1681-4835.2017.tb00615.x

Kauffman, R. J., Liu, J., & Ma, D. (2015). Technology investment decision-making under uncertainty. *Information Technology and Management*, *16*(2), 153–172. https://doi.org/10.1007/s10799-014-0212-2

Kauffman, R. J., & Ma, D. (2015). Special issue: Contemporary research on payments and cards in the global fintech revolution. *Electronic Commerce Research and Applications*, *14*(5), 261–264. https://doi.org/10.1016/j.elerap.2015.09.005

Khanboubi, F., Boulmakoul, A., & Tabaa, M. (2019). Impact of digital trends using IoT on banking processes. *Procedia Computer Science*, *151*(5), 77–84. https://doi.org/10.1016/j.procs.2019.04.014

Khraisha, T., & Arthur, K. (2018). Can we have a general theory of financial innovation processes? A conceptual review. *Financial Innovation*, *4*(1). https://doi.org/10.1186/s40854-018-0088-y

Kim, Y., Park, Y.-J., Choi, J., & Yeon, J. (2015). *An Empirical Study on the Adoption of "Fintech" Service: Focused on Mobile Payment Services*. *April*, 136–140. https://doi.org/10.14257/astl.2015.114.26

Knell, M., & Stix, H. (2015). Trust in Banks during Normal and Crisis Times-Evidence from Survey Data. *Economica*, *82*, 995–1020. https://doi.org/10.1111/ecca.12162

Kordela, D. (2018). Robo-Advisors in Asset Management-The Experience from Germany. *European Journal of Service Management*, *28*(1), 151–157. https://doi.org/10.18276/ejsm.2018.28/1-19

Lacasse, R. M., Lambert, B. A., Osmani, E., Couture, C., Roy, N., Sylvain, J., & Nadeau, F. (2016). A digital tsunami: FinTech and Crowdfunding. *International Scientific Conference on Digital Intelligence*, 1–5.

Laeven, L., Levine, R., & Michalopoulos, S. (2015). Financial innovation and endogenous growth. *Journal of Financial Intermediation*, *24*(1), 1–24. https://doi.org/10.1016/j.jfi.2014.04.001

Laidroo, L., & Avarmaa, M. (2020). The role of location in FinTech formation. *Entrepreneurship and Regional Development*, *32*(7–8), 555–572. https://doi.org/10.1080/08985626.2019.1675777

Langley, P. (2016). Crowdfunding in the United Kingdom: A cultural economy. *Economic Geography*, *92*(3), 301–321. https://doi.org/10.1080/00130095.2015.1133233

Langley, P., & Leyshon, A. (2021). The Platform Political Economy of FinTech: Reintermediation, Consolidation and Capitalisation. *New Political Economy*, *26*(3), 376–388. https://doi.org/10.1080/13563467.2020.1766432

Larson, W. D., & Sinclair, T. M. (2021). Nowcasting unemployment insurance claims in the time of. *International Journal of Forecasting*, *38*(2), 635–647. https://doi.org/10.1016/j.ijforecast.2021.01.001

Lee, C.-C., Li, X., Yu, C.-H., & Zhao, J. (2021). Does fintech innovation improve bank efficiency? Evidence from China's banking industry. *International Review of Economics and Finance*, *74*(3), 468–483. https://doi.org/10.1016/j.iref.2021.03.009

Lee, I., & Shin, Y. J. (2018). Fintech: Ecosystem, business models, investment decisions, and challenges. *Business Horizons*, *61*(1), 35–46. https://doi.org/10.1016/j.bushor.2017.09.003

Leong, K., & Sung, A. (2018). Fintech: What is it and how to use technologies to create business value in fintech way ? *International Journal of Innovation, Management*

and Technology, *9*(2). https://doi.org/10.18178/ijimt.2018.9.2.791

Lerner, J., & Tufano, P. (2011). The consequences of financial innovation: A counterfactual research agenda. *Annual Review of Financial Economics*, *3*, 41–85. https://doi.org/10.1146/annurev.financial.050808.114326

Levine, R. (1997). Financial development and economic growth: views and agenda. *Journal of Economic Literature*, *35*(2), 688–726.

Li, X., Lv, Z., Wang, S., Wei, Z., & Wu, L. (2019). A reinforcement learning model based on temporal difference algorithm. *IEEE Access*, *7*, 121922–121930. https://doi.org/10.1109/ACCESS.2019.2938240

Liao, H., Tang, M., Li, Z., & Lev, B. (2019). Bibliometric analysis for highly cited papers in operations research and management science from 2008 to 2017 based on Essential Science Indicators. *Omega (United Kingdom)*, *88*, 223–236. https://doi.org/10.1016/j.omega.2018.11.005

Liberati, M. R., Sowa, S. P., May, C. A., & Doran, P. J. (2020). Making measures count: structured indicator selection to improve program success. *Environmental and Sustainability Indicators*, *8*(October), 100077. https://doi.org/10.1016/j.indic.2020.100077

Lin, M., & Viswanathan, S. (2013). Home Bias in Online Investments: An Empirical Study of an Online Crowd Funding Market. *SSRN Electronic Journal*, *2013*. https://doi.org/10.2139/ssrn.2219546

Liu, J. (2021). On the convergence of reinforcement learning with Monte Carlo Exploring Starts. *Automatica*, *129*. https://doi.org/10.1016/j.automatica.2021.109693

Liu, J., Li, X., & Wang, S. (2020). What have we learnt from 10 years of fintech research? a scientometric analysis. *Technological Forecasting and Social Change*, *155*(November 2019), 120022. https://doi.org/10.1016/j.techfore.2020.120022

Lu, L. (2018). Promoting SME finance in the context of the fintech revolution: a case study of the uk's practice and regulation. *Banking and Finance Law Review*, *33*(3), 317–343.

Luo, S., Sun, Y., Yang, F., & Zhou, G. (2022). Does fintech innovation promote enterprise transformation? Evidence from China. *Technology in Society*, *68*, 101821. https://doi.org/10.1016/j.techsoc.2021.101821

Lv, S., Du, Y., & Liu, Y. (2022). How do fintechs impact banks' profitability?—an empirical study based on banks in China. *FinTech*, *1*(2), 155–163. https://doi.org/10.3390/fintech1020012

Maadooliat, M., Huang, J. Z., & Hu, J. (2015). Integrating data transformation in principal components analysis. *Journal of Computational and Graphical Statistics*, *24*(1), 84–103. https://doi.org/10.1080/10618600.2014.891461

Magnuson, W. (2018). *Texas A & M Law Scholarship Regulating Fintech Regulating Fintech*. *1167*.

Maier, E. (2016). Supply and demand on crowdlending platforms: connecting small and medium-sized enterprise borrowers and consumer investors. *Journal of Retailing and Consumer Services*, *33*, 143–153. https://doi.org/10.1016/j.jretconser.2016.08.004

Maiti, M., & Ghosh, U. (2021). Next generation internet of things in fintech ecosystem. *IEEE Internet of Things Journal*, *March 2021*. https://doi.org/10.1109/JIOT.2021.3063494

Makina, D. (2019). The potential of fintech in enabling financial inclusion. In *Extending Financial Inclusion in Africa*. Elsevier Inc. https://doi.org/10.1016/B978-0-12-814164-9.00014-1

Marston, S., Li, Z., Bandyopadhyay, S., Zhang, J., & Ghalsasi, A. (2011). Cloud computing – the business perspective. *Decision Support Systems*, *21*(1), 176–189. https://doi.org/10.2139/ssrn.1413545

Martin, A., & Parigi, B. M. (2013). Bank capital regulation and structured finance. *Journal of Money, Credit and Banking*, *45*(1), 87–119. https://doi.org/10.1111/j.1538-4616.2012.00563.x

McCallum, A. (1995). Instance-based state identification for reinforcement learning. *Advances in Neural Information Processing Systems*, *26*(3), 377–384. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.49.2521&rep=rep1&type=pdf

McCann, P., & Ortega-Argilés, R. (2013). Modern regional innovation policy. *Cambridge Journal of Regions, Economy and Society*, *6*(2), 187–216. https://doi.org/10.1093/cjres/rst007

Mckinsey, T. (2022). *Europe ' s fintech opportunity Europe ' s fintech opportunity*. *October*.

Mehrban, S., Khan, M. A., Nadeem, M. W., Hussain, M., Ahmed, M. M., Hakeem, O., Saqib, S., Kiah, M. L. M., Abbas, F., & Hassan, M. (2020). Towards secure FinTech: A survey, taxonomy, and open research challenges. *IEEE Access*, *8*, 23391–23406. https://doi.org/10.1109/ACCESS.2020.2970430

Meng, S., He, X., & Tian, X. (2021). Microprocessors and microsystems research on fintech development issues based on embedded cloud computing and big data analysis. *Microprocessors and Microsystems*, *83*(January), 103977. https://doi.org/10.1016/j.micpro.2021.103977

Mention, A.-L. (2021). The age of fintech: implications for research, policy and practice. *The Journal of FinTech*, *01*(01), 2050002. https://doi.org/10.1142/s2705109920500029

Mention, A.-L., & Torkkeli, M. (2014). Innovation in financial services: a dual ambiguity. In *Security* 1(1)). Retrieved June 19, 2021 from http://www.dot.state.fl.us/research-center/Completed_Proj/Summary_PTO/FDOT_BC137_38_FF_rpt.pdf

Merton, R. C. (1992). Financial innovation and economic performance. *Journal of Applied Corporate Finance*, *4*(4). https://doi.org/10.1111/j.1745-6622.1992.tb00214.x

Micu, I., & Micu, A. (2016). Financial Technology (Fintech) and its implementation on the romanian non-banking capital market. *SEA - Practical Application of Science*, *XVIII*(1), 47–54.

Miers, I., Garman, C., Green, M., & Rubin, A. D. (2013). Zerocoin: Anonymous distributed e-cash from bitcoin. *Proceedings - IEEE Symposium on Security and Privacy*, 397–411. https://doi.org/10.1109/SP.2013.34

Milian, E. Z., Spinola, M. de M., & Carvalho, M. M. d. (2019). Fintechs: A literature review and research agenda. *Electronic Commerce Research and Applications*, *34*(January). https://doi.org/10.1016/j.elerap.2019.100833

Mishra, P., & Moustafa, A. (2023). Reinforcement learning based monotonic policy for online resource allocation. *Future Generation Computer Systems*, *138*(4), 313–327. https://doi.org/10.1016/j.future.2021.09.023

Mollick, E. (2014). The dynamics of crowdfunding: An exploratory study. *Journal of Business Venturing*, *29*(1), 1–16. https://doi.org/10.1016/j.jbusvent.2013.06.005

Mookerjee, R., & Kalipioni, P. (2010). Availability of financial services and income inequality : The evidence from many countries. *Emerging Markets Review*, *11*(4), 404–408. https://doi.org/10.1016/j.ememar.2010.07.001

Morawczynski, O., & Pickens, M. (2009). Poor People Using Mobile Financial Services: Observations on Customer Usage and Impact from M-PESA. *Cgap*, *August*, 4. http://www.cgap.org/publications/poor-people-using-mobile-financial-services

Moritz, A., Block, J., Lutz, E., Ordanini, A., Miceli, L., Pizzetti, M., & Parasuraman, A. (2015). Qualitative research in financial markets investor communication in equity-based crowdfunding: a qualitative-empirical study. In *Qualitative Research in Financial Markets* 7(3). http://dx.doi.org/10.1108/QRFM-07-2014-

Mortimer, G., Neale, L., Hasan, S. F. E., & Dunphy, B. (2015). Investigating the factors influencing the adoption of m-banking: a cross cultural study. *International Journal of Bank Marketing*, *33*(4), 540–570.

Murinde, V., Rizopoulos, E., & Zachariadis, M. (2022). The impact of the FinTech revolution on the future of banking: Opportunities and risks. *International Review of Financial Analysis*, *81*(7), 102103. https://doi.org/10.1016/j.irfa.2022.102103

Muthukannan, P., Tan, B., Chiang, F. Ter, & Leong, C. (2021). Novel mechanisms of scalability of financial services in an emerging market context: Insights from Indonesian Fintech Ecosystem. *International Journal of Information Management*, *61*(7), 102403. https://doi.org/10.1016/j.ijinfomgt.2021.102403

Muzellec, L., Ronteau, S., & Lambkin, M. (2015). Two-sided Internet platforms: A business model lifecycle perspective. *Industrial Marketing Management*, *45*(1), 139–150. https://doi.org/10.1016/j.indmarman.2015.02.012

Nakamoto, S. (2008). Bitcoin: A Peer-to-Peer electronic cash system. *Transforming Government: People, Process and Policy*, *15*(4), 580–596. https://doi.org/10.1108/TG-06-2020-0114

Narayan, S. W., & Sahminan, S. (2018). Has fintech influenced Indonesia's exchange rate and inflation? *Buletin Ekonomi Moneter Dan Perbankan*, *21*(2), 189–202. https://doi.org/10.21098/bemp.v21i2.966

Nardo, M., Commission, E., Saisana, M., Commission, E., & Saltelli, A. (2005). Handbook on constructing composite indicators. https://doi.org/10.1787/533411815016 Retrieved February 4, 2020 from https://www.oecd.org/sdd/42495745.pdf

Nardo, M., Saisana, M., Saltelli, A., & Tarantola, S. (2005). Tools for composite ındicators building Prepared by. In *Joint Research Centre & European Commission* (Vol. 21682).

Navaretti, G. B. Calzolari, G. Mansilla-Fernandez, J. M. & Pozzolo, A. F. (2018). Fintech and Banking. Friends or Foes? *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3099337

Naz, F., Karim, S., Houcine, A., & Naeem, M. A. (2022). Fintech growth during covıd-19 in MENAregion: current challenges and future prospects. *Electronic Commerce Research*. https://doi.org/10.1007/s10660-022-09583-3

Nejad, M. (2016). Research on financial services innovations: A quantitative review and future research directions. *International Journal of Bank Marketing*, *34*(7), 1042–1068. https://doi.org/10.1108/IJBM-08-2015-0129

Nejad, M. (2022). Research on financial innovations: an interdisciplinary review. In *International Journal of Bank Marketing* (Vol. 40, Issue 3). https://doi.org/10.1108/IJBM-07-2021-0305

Nimbrayan, P. K. (2018). The biggest financial inclusion initiative in the world. *Economic Affairs*, *63*(2). https://doi.org/10.30954/0424-2513.2.2018.38

Nofer, M., Gomber, P., Hinz, O., & Schiereck, D. (2017). Blockchain. *Business and Information Systems Engineering*, *59*(3), 183–187. https://doi.org/10.1007/s12599-017-0467-3

Nofsinger, J. R., & Wang, W. (2011). Determinants of start-up firm external financing worldwide. *Journal of Banking and Finance*, *35*(9), 2282–2294. https://doi.org/10.1016/j.jbankfin.2011.01.024

Norden, L., Silva Buston, C., & Wagner, W. (2014). Financial innovation and bank behavior: Evidence from credit markets. *Journal of Economic Dynamics and Control*, *43*, 130–145. https://doi.org/10.1016/j.jedc.2014.01.015

Oborn, E., Barrett, M., Orlikowski, W., & Kim, A. (2019). Trajectory dynamics in innovation : developing and transforming a mobile money service across time and place. *Organization Science*, *30*(5), 1097–1123.

Odei-Appiah, S., Wiredu, G., & Adjei, J. K. (2022). Fintech use, digital divide and financial inclusion. *Digital Policy, Regulation and Governance* , *24*(5), 435–448. https://doi.org/10.1108/DPRG-09-2021-0111

OECD/Eurostat. (2018). Oslo Manual 2018: Guidelines for Collecting, Reporting and Using

Data on Innovation. In *The Measurement of Scientific; Technological and Innovation Activities*. Retrieved March 5, 2020 from https://www.oecd-ilibrary.org/docserver/9789264304604-en.pdf?expires=1635188344&id=id&accname=guest&checksum=A0EFE082698559115B1F21499AE294A1%0Ahttps://doi.org/10.1787/9789264304604-en

OECD. (2008). *Handbook on Constructing Composite Indicators*. Retrieved March 5, 2020 from https://www.oecd.org/sdd/42495745.pdf

OECD. (2018). Digitalisation and finance. *Financial Markets, Insurance and Private Pensions*, 110. Retrieved Jnuary 17, 2020 from https://www.oecd.org/finance/private-pensions/Financial-markets-insurance-pensions-digitalisation-and-finance.pdf

Oke, A. (2006). Innovation types and innovation management practices in service companies. *International Journal of Operations & Production Management*, *27*(6), 561–587. https://doi.org/10.1108/01443570710750268

Omar, M. A., & Inaba, K. (2020). Does financial inclusion reduce poverty and income inequality in developing countries? A panel data analysis. *Journal of Economic Structures*, *9*(1). https://doi.org/10.1186/s40008-020-00214-4

Otioma, C., Madureira, A. M., & Martinez, J. (2019). Spatial analysis of urban digital divide in Kigali, Rwanda. *GeoJournal*, *84*(3), 719–741. https://doi.org/10.1007/s10708-018-9882-3

Ouma, S. A., Odongo, T. M., & Were, M. (2017). Mobile financial services and financial inclusion: Is it a boon for savings mobilization? *Review of Development Finance*, *7*(1), 29–35. https://doi.org/10.1016/j.rdf.2017.01.001

Ozili, P. K. (2020). Theories of Financial Inclusion. *SSRN Electronic Journal*, *September*. https://doi.org/10.2139/ssrn.3526548

Ozili, P. K. (2021). Financial inclusion research around the world: A review. *Forum for Social Economics*, *50*(4), 457–479. https://doi.org/10.1080/07360932.2020.1715238

Panos, G. A., & Wilson, J. O. S. (2020). Financial literacy and responsible finance in the FinTech era: capabilities and challenges. *European Journal of Finance*, *26*(4–5), 297–301. https://doi.org/10.1080/1351847X.2020.1717569

Park, C., & Mercado, R. v. (2018). Financial Inclusion : New Measurement and Cross-Country Impact Assessment. Retrived 26 January 2020 from https://ssrn.com/abstract=3199427 or http://dx.doi.org/10.2139/ssrn.3199427

Patwardhan, A. (2018). Financial Inclusion in the Digital Age. *Handbook of Blockchain, Digital Finance, and Inclusion, Volume 1: Cryptocurrency, FinTech, InsurTech, and Regulation, 12(3)*, 57–89. https://doi.org/10.1016/B978-0-12-810441-5.00004-X

Perlman, L. (2019). *Fintech and regtech: Data as the new regulatory honeypot*. 1–37. Retrived 07 June 2020 from https://dfsobservatory.com/sites/default/files/Fintech and Regtech - Perlman Final.pdf

Philippon, T. (2016). The FinTech Opportunity. In *Nature Methods* 7(6) https://doi.org/10.3386/w22476

Pissourios, I. A. (2013). An interdisciplinary study on indicators: A comparative review of quality-of-life, macroeconomic, environmental, welfare and sustainability indicators. *Ecological Indicators*, *34*, 420–427. https://doi.org/10.1016/j.ecolind.2013.06.008

Pollari, I. (2016). The Rise & Importance of Fintech. *Jassa The Finsia Journal of Applied Finance*, *3*, 15–21.

Pollari, I., & Ruddenklau, A. (2021). KPMG Pulse of Fintech. *KPMG-Fintech-Report*, 1–85. Retrived 10 June 2020 from https://assets.kpmg/content/dam/kpmg/xx/pdf/2020/02/pulse-of-fintech-h2-2019.pdf%0Afile:///C:/Users/balra/Desktop/Research/FinalReferences/pulse-of-fintech-h1-2020.pdf

Precup, M. (2015). The future of private equity in Europe - the determinants across countries. *Romanian Journal of European Affairs*, *15*(4), 72–92.

Puschmann, T. (2017). Fintech. *Business and Information Systems Engineering*, *59*(1), 69–76. https://doi.org/10.1007/s12599-017-0464-6

PwC. (2019). Global Fintech 2019. *PwC Global Fintech Report*, 1–29. https://www.pwc.com/gx/en/industries/financial-services/assets/pwc-global-fintech-report-2019.pdf

Rajan, R. G., & Zingales, L. (2003). The Great Reversals : The Politics of Financial Development in the 20th Century. *OECD Economics Department Working Papers*, *265*. https://doi.org/10.1787/18151973

Raskin, M., & Yermack, D. (2016). Digital Currencies, Decentralized Ledgers, and The Future of Central Banking. *NBER Working Paper Series*, *22238*.

Rau, P. R. (2018). Law, Trust, and the Development of Crowdfunding. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2989056

Rawat, S., Rawat, A., Kumar, D., & Sabitha, A. S. (2021). Application of machine learning and data visualization techniques for decision support in the insurance sector. *International Journal of Information Management Data Insights*, https://doi.org/10.1016/j.jjimei.2021.100012

Reckien, D., Salvia, M., Heidrich, O., Church, J. M., Pietrapertosa, F., De Gregorio-Hurtado, S., D'Alonzo, V., Foley, A., Simoes, S. G., Krkoška Lorencová, E., Orru, H., Orru, K., Wejs, A., Flacke, J., Olazabal, M., Geneletti, D., Feliu, E., Vasilie, S., Nador, C., Dawson, R. (2018). How are cities planning to respond to climate change? Assessment of local climate plans from 885 cities in the EU-28. *Journal of Cleaner Production*, *191*(August), 207–219. https://doi.org/10.1016/j.jclepro.2018.03.220

Riasanow, T., Flötgen, R. J., Setzke, D. S., Böhm, M., & Krcmar, H. (2018). The generic ecosystem and innovation patterns of the digital transformation in the financial industry. *Proceedings of the 22nd Pacific Asia Conference on Information Systems*

- *Opportunities and Challenges for the Digitized Society: Are We Ready?, PACIS 2018, June*.

Rijanto, A. (2021). Blockchain technology adoption in supply chain finance. *Journal of Theoretical and Applied Electronic Commerce Research*, *16*(7), 3078–3098. https://doi.org/10.3390/jtaer16070168

Risius, M., & Spohrer, K. (2017). A Blockchain Research Framework: What We (don't) Know, Where We Go from Here, and How We Will Get There. *Business and Information Systems Engineering*, *59*(6), 385–409. https://doi.org/10.1007/s12599-017-0506-0

Rossi, M. C. (2014). Is Cloud Computıng A Challenge To The Tradıtıonal Concept Of A. *International Tax Report*, *March*, 1–54. https://doi.org/http://dx.doi.org/10.2139/ssrn.2685649

Sahay, R., Allmen, Ulric Eriksson von Lahreche, A., Khera, P., Ogawa, S., Bazarbash, M., & Beaton, K. (2020). The Promise of Fintech; Financial Inclusion in the Post COVID-19 Era. In *IMF Departmental Papers / Policy Papers from International Monetary Fund* (Issue 20).

Sahay, R., Čihák, M., Diaye, P. N., Barajas, A., Mitra, S., Kyobe, A., & Mooi, Y. N. (2015). Financial Inclusion : Can It Meet Multiple Macroeconomic Goals ? *IMF Staff Discussion Note*, *15*(17).

Saiedi, E., Mohammadi, A., Broström, A., & Shafi, K. (2018). Distrust in Banks and Fintech Participation: The Case of Peer-to-Peer Lending. *Entrepreneurship: Theory and Practice*, *46*(5), 1170–1197. https://doi.org/10.1177/1042258720958020

Saisana, M., & Tarantola, S. (2016). State-of-the-art report on current methodologies and practices for composite indicator development. *European Commission*, 1–72. https://doi.org/10.13140/RG.2.1.1505.1762

Salerno, A. C. F. (2020). Regulating the Fintech Revolution: How Regulators Can Adapt toTwenty-First Century Financial Technology. *New York University AnnualSurvey of American Law*, *75*(2), 365–392.

Saltelli, A. (2007). Composite indicators between analysis and advocacy. *Social Indicators Research*, *81*(1), 65–77. https://doi.org/10.1007/s11205-006-0024-9

Sapienza, P., & Zingales, L. (2012). A Trust Crisis. *International Review of Finance*, *12*(2), 123–131. https://doi.org/10.1111/j.1468-2443.2012.01152.x

Schär, F. (2021). Decentralized finance: on blockchain-and smart contract-based financial markets. *Federal Reserve Bank of St. Louis Review*, *103*(2), 153–174. https://doi.org/10.20955/r.103.153-74

Schindele, A., & Szczesny, A. (2016). The impact of Basel II on the debt costs of German SMEs. *Journal of Business Economics*, *86*(3), 197–227. https://doi.org/10.1007/s11573-015-0775-3

Schindler, J. (2017). FinTech and Financial Innovation: Drivers and Depth. *Finance and*

Economics Discussion Series, *2017*(081). https://doi.org/10.17016/feds.2017.081

Schueffel, P. (2016). Taming the beast: A scientific definition of fintech. *Journal of Innovation Management*, *4*(4), 32–54. https://doi.org/10.24840/2183-0606_004.004_0004

Schueffel, P. (2017). The Concise Fintech Compandium. *School of Management Fribourg*, *8*(10), 148–162.

Scott, S. V, Reenen, J. Van, & Zachariadis, M. (2017). The long-term effect of digital innovation on bank performance : An empirical study of SWIFT adoption in financial services. *Research Policy*, *46*(5), 984–1004. https://doi.org/10.1016/j.respol.2017.03.010

Senyo, P. K., Karanasios, S., Gozman, D., & Baba, M. (2022). FinTech ecosystem practices shaping financial inclusion: the case of mobile money in Ghana. *European Journal of Information Systems*, *31*(1), 112–127. https://doi.org/10.1080/0960085X.2021.1978342

Setiawan, K., & Maulisa, N. (2020). The evolution of fintech: a regulatory approach perspective. *Advances in Economics, Business and Management Research*, 218–225. https://doi.org/10.2991/aebmr.k.200321.029

Sharpe, A. (2004). Literature Review of Frameworks for Macro-indicators. *Development*, *February*, 1–79. Retrived 12 January 2020 from http://www.csls.ca/reports/LitRevMacro-indicators.pdf

Shaydullina, V. K. (2018). Review of institutional and legal issues for the development of the Fintech industry. *European Research Studies Journal*, *21*(2), 171–178.

Shefrin, H., & Statman, M. (2000). Behavioral Portfolio Theory. *The Journal of Financial and Quantitative Analysis*, *35*(2), 173–185. https://doi.org/10.1007/BF01084155

Shiller, R. J. (2013). Capitalism and Financial Innovation. *Financial Analysts Journal*, *69*(1), 21–25.

Shim, Y., & Shin, D. H. (2016). Analyzing China's Fintech Industry from the Perspective of Actor-Network Theory. *Telecommunications Policy*, *40*(2–3), 168–181. https://doi.org/10.1016/j.telpol.2015.11.005

Singh, S., Sahni, M. M., & Kovid, R. K. (2020). What drives FinTech adoption? A multi-method evaluation using an adapted technology acceptance model. *Management Decision*, *58*(8), 1675–1697. https://doi.org/10.1108/MD-09-2019-1318

Singh, V., Chen, S. S., Singhania, M., Nanavati, B., & Gupta, A. (2022). How are reinforcement learning and deep learning algorithms used for big data based decision making in financial industries–A review and research agenda. *International Journal of Information Management Data Insights*, *2*(2), 100094. https://doi.org/10.1016/j.jjimei.2022.100094

Śledzik, K. (2013). Schumpeter's View on Innovation and Entrepreneurship. *SSRN Electronic Journal*, *October*. https://doi.org/10.2139/ssrn.2257783

Small, H. (1973). Co-citation in the Scientific Literature : A New Measure of the Relationship Between Two Documents. *Journal of the American Society for Information Science*, *24*(4), 265–269.

Stiglitz, J. E., & Weiss, A. (1982). Credit Rationing in Markets With Imperfect Information. *The American Economic Review*, *71*(3), 393–410. https://doi.org/10.2139/ssrn.1010965

Stoeckli, E., Dremel, C., & Uebernickel, F. (2018). Exploring characteristics and transformational capabilities of InsurTech innovations to understand insurance value creation in a digital world. *Electronic Markets*.28(3). https://doi.org/10.1007/s12525-018-0304-7

Sugandi, E. A. (2021). The Covid-19 Pandemic and Indonesia's Fintech Markets. *SSRN Electronic Journal*, *1281*. https://doi.org/10.2139/ssrn.3916514

Suryono, R. R., Budi, I., & Purwandari, B. (2020). Challenges and trends of financial technology (Fintech): A systematic literature review. *Information (Switzerland)*, *11*(12), 1–20. https://doi.org/10.3390/info11120590

Suseendran, G., Chandrasekaran, E., Akila, D., & Sasi Kumar, A. (2020). Banking and FinTech (Financial Technology) Embraced with IoT Device. In *Advances in Intelligent Systems and Computing*. 1042(2). 197–211. https://doi.org/10.1007/978-981-32-9949-8_15

Sutton, R. S., & Barto, A. G. (2015). An introduction to reinforcement learning. In *An introduction to reinforcement learning*.15(3). https://doi.org/10.4018/978-1-60960-165-2.ch004

Szita, I. (2012). Reinforcement learning in games. In *Adaptation, Learning, and Optimization* 12(4), 539–577. https://doi.org/10.1007/978-3-642-27645-3_17

Tajudeen, F. P., Nadarajah, D., Jaafar, N. I., & Sulaiman, A. (2022). The impact of digitalisation vision and information technology on organisations' innovation. *European Journal of Innovation Management*, *25*(2), 607–629. https://doi.org/10.1108/EJIM-10-2020-0423

Tang, H. (2019). Peer-to-Peer Lenders versus Banks : Substitutes or Complements ? *The Review of Financial Studies*, *32*(5).

Tarasewicz, N. A., & Jönsson, A. M. (2021). An ecosystem model based composite indicator, representing sustainability aspects for comparison of forest management strategies. *Ecological Indicators*, *133*(10). https://doi.org/10.1016/j.ecolind.2021.108456

Thakor, A. V. (2020). Fintech and banking: What do we know? *Journal of Financial Intermediation*, *41*(7). https://doi.org/10.1016/j.jfi.2019.100833

Thomas, M. L., & Morse, J. N. (2017). FinTech — Origins and Prognosis. *Researchgate*, *7* Retrived 10 January 2020 from https://www.researchgate.net/publication/318792964_FinTech-Origins_and_Prognosis

Tobbin, P., & Kuwornu, J. K. M. (2011). Adoption of mobile money transfer technology: structural equation modeling approach. *European Journal of Business and Management*, *3*(7), 59–78. http://www.iiste.org/Journals/index.php/EJBM/article/view/593

Tripathy, A. K., & Jain, A. (2020). FinTech adoption: strategy for customer retention. *Strategic Direction*, *36*(12), 47–49. https://doi.org/10.1108/SD-10-2019-0188

Tsaples, G., Papathanasiou, J., & Georgiou, A. C. (2022). An Exploratory DEA and Machine Learning Framework for the Evaluation and Analysis of Sustainability Composite Indicators in the EU. *Mathematics*, *10*(13). https://doi.org/10.3390/math10132277

Turegano, D. M., & Herrero, A. G. (2018). Financial inclusion, rather than size, is the key to tackling income inequality. *The Singapore Economic Review*, *1*(8), 1–18. https://doi.org/10.1142/S0217590818410047

Urbanowicz, R. J., & Moore, J. H. (2009). Learning Classifier Systems: A Complete Introduction, Review, and Roadmap. *Journal of Artificial Evolution and Applications*, *2009*, 1–25. https://doi.org/10.1155/2009/736398

Van Hove, L., & Dubus, A. (2019). M-PESA and financial inclusion in Kenya: Of paying comes saving? *Sustainability (Switzerland)*, *11*(3), 1–26. https://doi.org/10.3390/su11030568

Venkatesh, Morris, Davis, & Davis. (2003). User Acceptance of Information Technology: Toward a Unified View. *MIS Quarterly*, *27*(3), 425. https://doi.org/10.2307/30036540

Vergara, C. C., & Agudo, L. F. (2021). Fintech and Sustainability : Do They Affect Each Other ? *Sustainability*, *13*(13).

Wang, S., Yuan, Y., Member, S., Wang, X., Li, J., Qin, R., & Wang, F. (2018). *An Overview of Smart Contract : Architecture , Applications , and Future Trends*. *3*(4), 14–19.

Wasiuzzaman, S., Lee, C. L., Boon, O. H., & Chelvam, H. P. (2021). Examination of the motivations for equity-based crowdfunding in an emerging market. *Journal of Theoretical and Applied Electronic Commerce Research*, *16*(2), 63–79. https://doi.org/10.4067/S0718-18762021000200105

Weeks, M. R. (2015). Is disruption theory wearing new clothes or just naked? Analyzing recent critiques of disruptive innovation theory. *Innovation: Management, Policy and Practice*, *17*(4), 417–428. https://doi.org/10.1080/14479338.2015.1061896

Wei, C.-Y., Dann, C., & Zimmert, J. (2021). *A Model Selection Approach for Corruption Robust Reinforcement Learning*. *167*(20), 1–54. http://arxiv.org/abs/2110.03580

Wiréhn, L., Danielsson, Å., & Neset, T. S. S. (2015). Assessment of composite index methods for agricultural vulnerability to climate change. *Journal of Environmental Management*, *156*, 70–80. https://doi.org/10.1016/j.jenvman.2015.03.020

Wójcik, D. (2021). Financial geography II: The impacts of FinTech – Financial sector and

centres, regulation and stability, inclusion and governance. *Progress in Human Geography*, *45*(4), 878–889. https://doi.org/10.1177/0309132520959825

World Bank. (2022). Finance for an Equıtable Recovery. https://doi.org/10.1596/978-1-4648-1730-4

World Economic Forum. (2017). Beyond Fintech: A Pragmatic Assessment of Disruptive Potential in Financial Services (Issue August). http://www3.weforum.org/docs/Beyond_Fintech_-_A_Pragmatic_Assessment_of_Disruptive_Potential_in_Financial_Services.pdf

Xu, P., Zhang, J., Lu, J., Zhang, H., Gao, T., & Chen, S. (2022). A prior knowledge-embedded reinforcement learning method for real-time active power corrective control in complex power systems. *Frontiers in Energy Research*, *10*(September), 1–15. https://doi.org/10.3389/fenrg.2022.1009545

Yan, T. C., Schulte, P., Lee, D., & Chuen, K. (2018). InsurTech and FinTech : Banking and Insurance Enablement. In *Handbook of Blockchain, Digital Finance, and Inclusion, Volume 1* (1st ed., Vol. 1). Elsevier Inc. https://doi.org/10.1016/B978-0-12-810441-5.00011-7

Yan, W., & Zhou, W. (2022). Is blockchain a cure for peer-to-peer lending? *Annals of Operations Research*, *321*(1), 693–716. https://doi.org/10.1007/s10479-022-05108-1

Yang, F. C., Kao, R. H., Chen, Y. T., Ho, Y. F., Cho, C. C., & Huang, S. W. (2018). A Common Weight Approach to Construct Composite Indicators: The Evaluation of Fourteen Emerging Markets. *Social Indicators Research*, *137*(2), 463–479. https://doi.org/10.1007/s11205-017-1603-7

Yang, X., Zheng, H., & Yi, X. (2020). *Studies on the Effect of Fintech on Chinese Economy and Its Development Path*. *385*(Iceemr), 31–34. https://doi.org/10.2991/assehr.k.191221.008

Yao, M., Di, H., Zheng, X., & Xu, X. (2018). Impact of payment technology innovations on the traditional financial industry: A focus on China. *Technological Forecasting and Social Change*, *135*, 199–207. https://doi.org/10.1016/j.techfore.2017.12.023

Yao, Y., Li, J., & Sun, X. (2021). Measuring the risk of Chinese Fintech industry: evidence from the stock index. *Finance Research Letters*, *39*(October 2019), 101564. https://doi.org/10.1016/j.frl.2020.101564

Yoo, H., Kim, B., Kim, J. W., & Lee, J. H. (2021). Reinforcement learning based optimal control of batch processes using Monte-Carlo deep deterministic policy gradient with phase segmentation. *Computers and Chemical Engineering*, *144*. https://doi.org/10.1016/j.compchemeng.2020.107133

Young, D. S., & Casey, E. A. (2019). An Examination of the Sufficiency of Small Qualitative Samples. *Social Work Research*, *43*(1), 53–58. https://doi.org/10.1093/swr/svy026

Zavolokina, L., Dolata, M., & Schwabe, G. (2016). The FinTech phenomenon: antecedents

of financial innovation perceived by the popular press. *Financial Innovation*, *2*(1). https://doi.org/10.1186/s40854-016-0036-7

Zetzsche, D. A., Arner, D. W., & Buckley, R. P. (2020). Decentralized finance. *Journal of Financial Regulation*, *6*(2), 172–203. https://doi.org/10.1093/jfr/fjaa010

Zhang, X., Yu, Y., & Zhang, N. (2021). *Sustainable supply chain management under big data : a bibliometric analysis*. *Sustainable Supply Chain Management*, *34*(1), 427–445. https://doi.org/10.1108/JEIM-12-2019-0381

Zhang, X., Zhao, T., Wang, L., & Dong, Z. (2022). Does Fintech benefit financial disintermediation? Evidence based on provinces in China from 2013 to 2018. *Journal of Asian Economics*, *82*(July), 101516. https://doi.org/10.1016/j.asieco.2022.101516

Zhang, Y., Jia, H., Diao, Y., Hai, M., & Li, H. (2016). Research on Credit Scoring by Fusing Social Media Information in Online Peer-to-Peer Lending. *Procedia Computer Science*, *91*(Itqm), 168–174. https://doi.org/10.1016/j.procs.2016.07.055

APPENDICES

Appendix 1: *Expert Opinion Survey*

Dear Participant,

This survey, which was created to get expert opinion for a research on Financial Technology, will only be used for scientific purposes. The data obtained will be kept confidential and will not be used for any other purpose.

Thank you for taking the time to take this survey, which lasts approximately 15 minutes, and for sharing your valuable feedback.

Res. Asst. Oylum Şehvez Ergüzel
Asst. Prof. Mustafa Kenan Erkan

Dear Participant,

This study aims to develop the Financial Technology (FinTech) index as a composite indicator that measures the capacity of a country in respect of producing, using and adopting the technologically enabled innovations in financial services.

As a starting point , “FinTech” is defined as technological and digital-based financial innovations and applications that support the sustainability of traditional financial institutions and organizations and improve their products and services, and also cause a disruptive impact and radical changes in financial markets and industry with the new challenging products and services.

In this survey, you should score the main groups and sub groups of the FinTech Index by using a scale between 0-100 with the help of the expertise you have. You can use any number between 0 and 100 to reveal the importance of the indicator. As your score approaches 100, the importance of the indicator will increase, while as it approaches zero, it will decrease.

IMPORTANT: At the end of the scoring, the total the points awarded must be 100.

On a scale of 0-100,

0- indicates that the importance of the indicator is at the lowest level.
100- indicates that the importance of the indicator is at the highest level.

Government has a significant role to play in the development of the FinTech market by creating a FinTech friendly business environment through progressive policies, tax incentives and programmes. FinTech formation is positively associated with the presence of a flexible and transparent regulatory environment and institutions that enhance innovation. Therefore, “Policy and Regulation Readiness” reveals the level of countries on the legal infrastructure and policies that accelerate the development of FinTech.

Please imagine to construct a **"POLICY AND REGULATION READINESS"** indicator for countries, by using the following indicators and give a point for each indicator according to their importance.

• **Regulation:** It assesses the extent to which regulation limits the freedom of exchange in credit, labor, and product markets in a specific country
• **Corruption perception index:** It ranks countries according to their perceived public sector corruption that is evaluated by the experts opinion
• **Support for digital literacy:** It assesses the existence of a strategy that supports digital literacy whereby the government plan or strategy should address courses in Information and Communication Technology (ICT) skills, computer science, programming, or other classes where computers are mandatory in the curriculum

IMPORTANT: At the end of the scoring, the total the points awarded must be 100.

On a scale of 0-100,

0- indicates that the importance of the indicator is at the lowest level.
100- indicates that the importance of the indicator is at the highest level.

Regulation	0
Corruption perception index	0
Support for digital literacy	0
Total	0

Economic readiness indicates the state of the economic environment and key economic indicators that affect the development of FinTech in countries.

Please imagine constructing an **"ECONOMIC READINESS"** indicator for countries, by using the following indicators and give a point for each indicator according to their importance.

• **Sound Money:** It contains components such as money growth, standard deviation of inflation, inflation, and freedom to own foreign currency bank accounts. To earn a higher rating, a country must follow policies and adopt institutions that lead to low rates of inflation and avoid regulations that limit the ability to use alternative currencies.

• **Freedom to Trade Internationally:** It comes from the Fraser Institute database and measures a wide variety of restraints that affect international exchange, including tariffs, quotas, hidden administrative restraints, control on exchange rates, and the movement of capital.

• **GDP per Capita:** GDP per capita provides a basic measure of the value of output per person, which is an indirect indicator of per capita income.

• **Financial Development Index:** It is a relative ranking of countries on the depth, access, and efficiency of their financial institutions and financial markets

IMPORTANT: At the end of the scoring, the total the points awarded must be 100.

On a scale of 0-100,

0- indicates that the importance of the indicator is at the lowest level.
100- indicates that the importance of the indicator is at the highest level.

Sound Money	0
Freedom to Trade Internationally	0
GDP per Capita	0
Financial Development Index	0
Total	0

Technological readiness includes factors that affect the technological infrastructure and supports the potential of countries in FinTech.

Please imagine constructing a **"TECHNOLOGICAL READINESS"** indicator for countries, by using the following indicators and give a point for each indicator according to their importance.

• **R&D expenditures:** It is defined as the total expenditure (current and capital) on R&D carried out by all resident companies, research institutes, university and government laboratories, etc., in a country

• **Number of Startup divided by labor force:** The number of FinTech startups in a given country and year divided by labor force

• **Made or received digital payments in the past year (% age 15+):** The percentage of individuals who report using mobile money, a debit or credit card, or a mobile phone to make a payment from an account, or report using the internet to pay bills or to buy something online, in the past 12 months.

IMPORTANT: At the end of the scoring, the total the points awarded must be 100.

On a scale of 0-100,

0- indicates that the importance of the indicator is at the lowest level.
100- indicates that the importance of the indicator is at the highest level.

R&D expenditures	0
Number of Startup divided by labor force	0
Made or received digital payments in the past year (% age 15+)	0
Total	0

ICT Readiness indicates the quality of the ICT services that accelarate the availability and development of the FinTech products and services.

Please imagine constructing an **"ICT READINESS"** indicator for countries, by using the following indicators and give a point for each indicator according to their importance.

• **Average fixed broadband upload speed:** It is a measure of average fixed-line broadband upload speed. A faster speed is a positive indicator for better performance

• **Average fixed broadband download speed:** It is a measure of average fixed-line broadband download speed. A faster speed is a positive indicator for better performance

• **Average mobile upload speed:** This measures average mobile upload speed. A faster speed is a positive indicator for better performance.

• **Average mobile download speed:** This measures average mobile download speed. A faster speed is a positive indicator for better performance.

• **Secured internet servers:** Secure servers are those servers that use the secure sockets layer protocol to protect communication from unintended recipients. More commonly publicly-trusted TLS/SSL certificates

• **Fixed line broadband subscribers:** Fixed broadband subscriptions refers to fixed subscriptions to high-speed access to the public Internet

IMPORTANT: At the end of the scoring, the total the points awarded must be 100.

On a scale of 0-100,

0- indicates that the importance of the indicator is at the lowest level.
100- indicates that the importance of the indicator is at the highest level.

Average fixed broadband upload speed	0
Average fixed broadband download speed	0
Average mobile upload speed	0
Average mobile download speed	0
Secured Internet servers	0
Fixed line broadband subscribers	0
Total	0

Financial innovation refers to the potential of countries to create new financial services, products and technologies. Financial innovation indicator reveals the current potantial of the countries in terms of domestic market size as demand side and the Automated Teller Machines (ATMs) per 100,000 adults, online banking services and number of commercial bank branches as being among the important actors in the supplier side of the financial innovation through the Fintech development stages.

Please imagine constructing a **"FINANCIAL INNOVATION"** indicator for countries, by using the following indicators and give a point for each indicator according to their importance.

• **ATMs per 100,000 adults:** ATMs are computerized telecommunications devices that provide clients of a financial institution with access to financial transactions in a public place.

• **e-Finance content:** Assesses whether online banking services are offered by the largest retail bank by number of customers (retail and corporate). Online banking services must include, at a minimum, account access to view balances and transactions. In this question, online is synonymous with mobile

• **Domestic market size index:** It is measured by gross domestic product (GDP) based on the purchasing-power-parity (PPP) valuation of country GDP, in current international dollar (billions). FinTech formation intensity is greater in countries with stronger home demand.Strong market demand is a fundamental driver of FinTechs. Successful FinTech hubs have a large local market (UK, US and China) or act as gateways to a larger market (for example, Singapore and Hong Kong).

• **Number of commercial bank branches per 100,000 adults in the population**

IMPORTANT: At the end of the scoring, the total the points awarded must be 100.

On a scale of 0-100,

0- indicates that the importance of the indicator is at the lowest level.
100- indicates that the importance of the indicator is at the highest level.

ATMs per 100,000 adults	0
e-Finance content	0
Domestic market size index	0
Number of commercial bank branches per 100,000 adults in the population	0
Total	0

Social infrastructure refers to factors such as educated people and labour force participation that facilitates the acceptance, adoption and developments of the financial technology.

Please imagine constructing a **"SOCIAL INFRASTRUCTURE"** indicator for countries, by using the following indicators and give a point for each indicator according to their importance.

• **Urban population (% of population):** Urban population refers to people living in urban areas as a percentage of the total population

• **Labour force participation rate:** The labour force participation rates is calculated as the labour force divided by the total working-age population

• **Level of literacy:** Literate population over 15, expressed as a percentage of the total population

• **Education attainment:** Mean years of schooling

• **Government e-inclusion strategy:** Assesses whether the country has any initiatives or plans that address e-inclusion.

IMPORTANT: At the end of the scoring, the total the points awarded must be 100.

On a scale of 0-100,

0- indicates that the importance of the indicator is at the lowest level.
100- indicates that the importance of the indicator is at the highest level.

Urban population (% of population)	0
Labour force participation rate	0
Level of literacy	0
Education attainment	0
Government e-inclusion strategy	0
Total	0

ICT infrastructure represents equipment necessary to implement and operate systems and networks for communications services as well as support applications, digital content, and FinTech applications.

Please imagine constructing an **"ICT INFRASTRUCTURE"** indicator for countries, by using the following indicators and give a point for each indicator according to their importance.

• **Government initiatives to make Wi-Fi available:** Assesses whether the network is free to join or not. “Public” means that the Wi-Fi network and associated hotspot(s) must be accessible in a public park, library, public building, airport, train or ferry terminal.

• **Private sector initiatives to make Wi-Fi available:** Assesses whether the network is free to join or not and whether the public Wi-Fi is available to anyone (general population, tourists, etc.) or just to customers of the largest Internet Service ProviderISP in the country.

• **Network coverage (min. 3G):** Percentage of the population covered by at least a 3G mobile network refers to the percentage of inhabitants that are within range of at least a 3G mobile-cellular signal; irrespective of whether or not they are subscribers.

• **Trust in Non-government websites and apps:** To what extent do you trust the information you receive from the following sources online? - 'Non-government websites / apps that are based in your country.'

• **Urban electricity access:** Access to electricity is calculated as the percentage of population with access to electricity. Electrification data are collected from industry, national surveys and international sources

• **Rural electricity access:** Access to electricity is calculated as the percentage of population with access to electricity. Electrification data are collected from industry, national surveys and international sources

IMPORTANT: At the end of the scoring, the total the points awarded must be 100.

On a scale of 0-100,

0- indicates that the importance of the indicator is at the lowest level.
100- indicates that the importance of the indicator is at the highest level.

Government initiatives to make Wi-Fi available	0
Private sector initiatives to make Wi-Fi available	0
Network coverage (min. 3G)	0
Trust in Non-government websites and apps	0
Urban electricity access	0
Rural electricity access	0
Total	0

Technology is one of the most fundamental components of FinTech. Therefore, its development largely depends on the widespread use of technology by individuals, businesses and governments. In this context, ICT usage and affordability includes technology usage and access costs necessary for the development of fintech.

Please imagine constructing a **"ICT USAGE AND AFFORDABILITY"** indicator for countries, by using the following indicators and give a point for each indicator according to their importance.

• **Mobile telephone subscription per 100 people:** Mobile cellular telephone subscriptions are subscriptions to a public mobile telephone service.

• **Internet users:** Percentage of households with Internet

• **Mobile phone cost:** Monthly cost of a 1 GB postpaid mobile broadband data plan, expressed as a percentage of monthly GNI per capita.

• **Fixed-line monthly broadband cost:** Price of fixed-line monthly broadband to the consumer as a percentage of monthly income

IMPORTANT: At the end of the scoring, the total the points awarded must be 100.

On a scale of 0-100,

0- indicates that the importance of the indicator is at the lowest level.
100- indicates that the importance of the indicator is at the highest level.

Mobile telephone subscription per 100 people	0
Internet users	0
Mobile phone cost	0
Fixed-line monthly broadband cost	0
Total	0

Availability of funding for FinTechs at different stages of maturity and through various funding sources (seed funding, private VC funding, government-backed schemes etc.) is critical for a leading FinTech hub. Access to Finance for Entrepreneurial Activity is the ability of business to access financial services such as payment, deposit , credit. The availability of external financing is positively associated with the number of start-ups, which is an important indicator of entrepreneurship, as well as innovation and financial technology.

Please imagine constructing a **"ACCESS TO FINANCE FOR ENTREPRENEURIAL ACTIVITY"** indicator for countries, by using the following indicators and give a point for each indicator according to their importance.

• **Soundness of banks:** The soundness of a bank indicates the capabilities of its capital adequacy, asset quality, liquidity, and profitability to cope with adverse market conditions

• **Financing of SMEs:** In a country, to what extent can small- and medium-sized enterprises (SMEs) access finance they need for their business operations through the financial sector?

• **Venture Capital investment:** Venture capital is a subset of private equity (i.e. equity capital provided to enterprises not quoted on a stock market) and refers to equity investments made to support the pre-launch, launch and early stage development phases of a business

• **Financial services meeting business needs:** In reporting country, to what extent are financial services meeting for businesses?

IMPORTANT: At the end of the scoring, the total the points awarded must be 100.

On a scale of 0-100,

0- indicates that the importance of the indicator is at the lowest level.
100- indicates that the importance of the indicator is at the highest level.

Soundness of banks	0
Financing of SMEs	0
Venture Capital investment	0
Financial services meeting business needs	0
Total	0

Financial inclusion is efforts to make financial products and services accessible and affordable to all individuals and businesses, regardless of their personal net worth or company size.

Please imagine constructing a **"FINANCIAL INCLUSION"** indicator for countries, by using the following indicators and give a point for each indicator according to their importance.

• **Affordability of financial services:** In reporting country, to what extent are financial services affordable for businesses?

• **Availability of financial services:** In reporting country, to what extent does the financial sector provide a wide range of financial products and services to businesses?

• **Ease of access to loans:** In your country, how easy is it to obtain a bank loan with only a good business plan and no collateral?

• **Number of Crypto owners (% of population):** The number of adults who own and use at least one cryptocurrency. “Owner” means those who hold the currency in their portfolios but don’t necessarily transact with it.

IMPORTANT: At the end of the scoring, the total the points awarded must be 100.

On a scale of 0-100,

0- indicates that the importance of the indicator is at the lowest level.
100- indicates that the importance of the indicator is at the highest level.

Affordability of financial services	0
Availability of financial services	0
Ease of access to loans	0
Number of Crypto owners (% of population)	0
Total	0

Please imagine constructing a **"FINTECH READINESS INDEX "** that expresses the equipments such as policies and regulations, economic, technical and ICT infrastructure that support a country's development in the field of financial technology and innovation, by using the following indicators and give a point for each indicator according to their importance.

• **Policy and Regulation Readiness:** It reveals the level of countries on the legal infrastructure and policies that accelerate the development of FinTech.

• **Economic Readiness:** It indicates the state of the economic environment and key economic indicators such as sound mnoney, freedom to trade internationally, GDP per Capita that affect the development of FinTech in countries.

• **Technological Readiness:** It includes indicators such as R&D expenditures, number of Startup divided by labor force and made or received digital payment expressing the technical infrastructure that supports the potential of countries in FinTech.

• **ICT Readiness:** It indicates the quality of the ICT services that accelarate the availability and development of the FinTech products and services.

IMPORTANT: At the end of the scoring, the total the points awarded must be 100.

On a scale of 0-100,

0- indicates that the importance of the indicator is at the lowest level.
100- indicates that the importance of the indicator is at the highest level.

Policy and Regulation Readiness	0
Economic Readiness	0
Technological Readiness	0
ICT Readiness	0
Total	0

Please imagine constructing a **"FINTECH INFRASTRUCTURE INDEX "** that refers to the factors that focus on countries' access to information and communication technologies, social infrastructure and financial innovative equipment that will facilitate the creation, adoption and access of financial technologies by using the following indicators and give a point for each indicator according to their importance.

• **Financial Innovation:** Financial innovation refers to the potential of countries to create new financial services, products and technologies. Financial innovation indicator reveals the current potantial of the countries in terms of domestic market size as demand side and the ATMs per 100,000 adults, online banking services and number of commercial bank branches as being among the important actors in the supplier side of the financial innovation through the FinTech development stages.

• **Social Infrastructure:** Social infrastructure refers to factors such as educated people and labour force participation that facilitates the acceptance, adoption and developments of the financial technology.

• **ICT Infrastructure:** ICT infrastructure represents equipment necessary to implement and operate systems and networks for communications services as well as support applications, digital content, and FinTech applications.

• **ICT Usage and Affordability:** Technology is one of the most fundamental components of FinTech. Therefore, its development largely depends on the widespread use of technology by individuals, businesses and governments. In this context, ICT usage and affordability includes technology usage and access costs necessary for the development of FinTech.

IMPORTANT: At the end of the scoring, the total the points awarded must be 100.

On a scale of 0-100,

0- indicates that the importance of the indicator is at the lowest level.
100- indicates that the importance of the indicator is at the highest level.

Financial Innovation	0
Social Infrastructure	0
ICT Infrastructure	0
ICT Usage and Affordability	0
Total	0

Fintech increases financial inclusion by facilitating the access of businesses and individuals to financial services and products. Fintech efficiency index reveals the effective access of enterprises and individuals to financial products and services. Under this statement, please imagine constructing a **"FINTECH EFFICIENCY INDEX "** by using the following indicators and give a point for each indicator according to their importance.

• **Access to Finance for Entrepreneurial Activity:** It is the ability of business to obtain financial services such as payment, deposit , credit. The availability of external financing is positively associated with the number of start-ups, which is an important indicator of entrepreneurship, as well as innovation and financial technology.

• **Financial inclusion:** It is efforts to make financial products and services accessible and affordable to all individuals and businesses, regardless of their personal net worth or company size.

IMPORTANT: At the end of the scoring, the total the points awarded must be 100.

On a scale of 0-100,

0- indicates that the importance of the indicator is at the lowest level.
100- indicates that the importance of the indicator is at the highest level.

Access to Finance for Entrepreneurial Activity	0
Financial inclusion	0
Total	0

Please imagine constructing a **"GLOBAL FINTECH INDEX "** as a composite indicator that measures the capacity of a country in respect of producing, using and adopting the technologically enabled innovations in financial services by using the following indices and give a point for eachof them according to their importance.

• **Fintech Readiness Index:** It is an indicator that expresses the endownments such as human capital, policies and regulations, financial conditions, economic and technical infrastructure that support a country's development in the field of financial technology and innovation. Therefore, this composite indicator consists of the subgroups of countries' policy and regulation readiness, economic readiness, technological readiness ve ICT readiness.

• **Fintech Infrastructure Index:** FinTech Infrastructure index examines the quality and breadth of available infrastructure required for access and development of FinTech. Therefore, this composite indicator consists of the subgroups of countries' financial innovation, social infrastructure, ICT infrastructure and ICT usage and affordability.

• **Fintech Efficiency Index:** Availability of funding for FinTechs at different stages of maturity and through various funding sources is critical for a leading FinTech hub.This index consists of the “Access to Finance for Entrepreneurial Activity” and “Financial Inclusion”

IMPORTANT: At the end of the scoring, the total the points awarded must be 100.

On a scale of 0-100,

0- indicates that the importance of the indicator is at the lowest level.
100- indicates that the importance of the indicator is at the highest level.

Fintech Readiness Index	0
Fintech Infrastructure Index	0
Fintech Efficiency Index	0
Total	0

In which sector do you currently work?

- Business, consultancy or management
- Accountancy, banking or finance
- Computing or IT
- Academics
- Other (Please Specify)

What is your position at your work?

- Manager
- Chief executive officier
- Chief financial officier or controller
- Chief technology officier
- Consultant
- Accountant
- Academician
- Other (Please Specify)

Number of years of experience

- From 0 to 5
- From 5 to 10
- From 11 to 15
- From 16 to 20
- More than 20

We thank you for your time spent taking this survey.
Your response has been recorded.

Appendix 2: *Results of the Reliability Analysis*

Reliability Analysis for Policy and Regulation

```
Reliability analysis
Call: alpha(x = data[, c("Regulation", "Corruption perception index",
    "Support for Digital Literacy")])

  raw_alpha std.alpha G6(smc) average_r S/N   ase mean  sd median_r
       0.7      0.75    0.68       0.5 2.9 0.045 0.63 0.2     0.43

    95% confidence boundaries
         lower alpha upper
Feldt     0.59   0.7  0.78
Duhachek  0.61   0.7  0.79


 Reliability if an item is dropped:
                                    raw_alpha std.alpha G6(smc) average_r S/N alpha se var.r med.r
Sound Money-NORMALIZATION                0.82      0.83    0.79      0.62 4.9    0.026 0.018  0.55
Freedom to Trade Internationally         0.79      0.79    0.76      0.56 3.8    0.030 0.036  0.49
GDP per capita                           0.78      0.81    0.76      0.59 4.3    0.035 0.018  0.54
Financial Development Index-NORMALIZATION 0.79     0.80    0.76      0.57 4.0    0.034 0.026  0.55

 Item statistics
                                      n raw.r std.r r.cor r.drop mean   sd
Sound Money-NORMALIZATION           120  0.76  0.80  0.72   0.62 0.83 0.19
Freedom to Trade Internationally    120  0.82  0.85  0.79   0.70 0.68 0.19
GDP per capita                      120  0.85  0.83  0.77   0.72 0.18 0.22
Financial Development Index-NORMALIZATION 120  0.88  0.84  0.79   0.72 0.37 0.28
```

Reliability Analysis for Economic Readiness

```
Reliability analysis
Call: alpha(x = data[, c("Sound Money-NORMALIZATION", "Freedom to Trade Internationally",
    "GDP per capita", "Financial Development Index-NORMALIZATION")])

  raw_alpha std.alpha G6(smc) average_r S/N   ase mean   sd median_r
      0.84      0.85    0.86      0.58 5.6 0.023 0.51 0.18     0.54

    95% confidence boundaries
         lower alpha upper
Feldt     0.79  0.84  0.88
Duhachek  0.79  0.84  0.89


 Reliability if an item is dropped:
                          raw_alpha std.alpha G6(smc) average_r S/N alpha se var.r med.r
Regulation                     0.60      0.60    0.43      0.43 1.5    0.072    NA  0.43
Corruption perception index    0.49      0.57    0.40      0.40 1.3    0.074    NA  0.40
Support for Digital Literacy   0.74      0.79    0.65      0.65 3.8    0.040    NA  0.65

 Item statistics
                            n raw.r std.r r.cor r.drop mean   sd
Regulation                120  0.77  0.84  0.74   0.61 0.65 0.16
Corruption perception index 120  0.84  0.85  0.77   0.60 0.41 0.27
Support for Digital Literacy 120  0.82  0.75  0.51   0.46 0.84 0.31
```

Reliability Analysis for Technological Readiness

```
Reliability analysis
Call: alpha(x = data[, c("R&D expenses", "Made or received digital payments",
    "Number of Startup")], check.keys = TRUE)

  raw_alpha std.alpha G6(smc) average_r S/N   ase mean   sd median_r
      0.79      0.82    0.75       0.6 4.4 0.029 0.28 0.19     0.57

    95% confidence boundaries
         lower alpha upper
Feldt     0.72  0.79  0.85
Duhachek  0.74  0.79  0.85


 Reliability if an item is dropped:
                                raw_alpha std.alpha G6(smc) average_r S/N alpha se var.r med.r
R&D expenses                         0.65      0.71    0.55      0.55 2.5    0.053    NA  0.55
Made or received digital payments    0.72      0.72    0.57      0.57 2.6    0.051    NA  0.57
Number of Startup-                   0.77      0.80    0.67      0.67 4.1    0.037    NA  0.67

 Item statistics
                                  n raw.r std.r r.cor r.drop  mean   sd
R&D expenses                    120  0.86  0.87  0.78   0.71 0.200 0.20
Made or received digital payments 120  0.91  0.87  0.77   0.70 0.542 0.29
Number of Startup-              120  0.78  0.83  0.67   0.61 0.098 0.17
```

Reliability Analysis for ICT Readiness

```
Reliability analysis
Call: alpha(x = data[, c("Average fixed broadband upload speed",
    "Average fixed broadband download speed", "Average mobile upload speed-NORMALIZATION",
    "Average mobile download speed-NORMALIZATION", "Secured Internet servers",
    "Fixed-line broadband subscribers")])

  raw_alpha std.alpha G6(smc) average_r S/N   ase mean   sd median_r
      0.89      0.89    0.93      0.58 8.3 0.014 0.23 0.17     0.58

    95% confidence boundaries
         lower alpha upper
Feldt     0.85  0.89  0.91
Duhachek  0.86  0.89  0.91

 Reliability if an item is dropped:
                                       raw_alpha std.alpha G6(smc) average_r S/N alpha se var.r med.r
Average fixed broadband upload speed        0.87      0.88    0.90      0.59 7.1    0.016 0.025  0.60
Average fixed broadband download speed      0.84      0.85    0.87      0.53 5.6    0.020 0.022  0.50
Average mobile upload speed-NORMALIZATION   0.88      0.89    0.91      0.62 8.1    0.014 0.021  0.60
Average mobile download speed-NORMALIZATION 0.86      0.87    0.88      0.56 6.5    0.017 0.028  0.55
Secured Internet servers                    0.89      0.90    0.94      0.63 8.6    0.015 0.025  0.62
Fixed-line broadband subscribers            0.86      0.86    0.90      0.55 6.2    0.019 0.032  0.51

 Item statistics
                                         n raw.r std.r r.cor r.drop  mean   sd
Average fixed broadband upload speed   120  0.79  0.79  0.78   0.70 0.155 0.18
Average fixed broadband download speed 120  0.92  0.91  0.92   0.87 0.243 0.23
Average mobile upload speed-NORMALIZATION 120  0.72  0.73  0.68   0.61 0.374 0.19
Average mobile download speed-NORMALIZATION 120  0.84  0.84  0.82   0.77 0.253 0.20
Secured Internet servers               120  0.67  0.70  0.60   0.59 0.062 0.14
Fixed-line broadband subscribers       120  0.89  0.87  0.85   0.80 0.321 0.31
```

Reliability Analysis for Financial Innovation

```
Reliability analysis
Call: alpha(x = data[, c("ATMs per 100,000 adults", "Domestic market size index",
    "e-Finance content", "Number of commercial bank branches-NORMALIZATION")])

  raw_alpha std.alpha G6(smc) average_r S/N   ase mean   sd median_r
      0.72      0.72    0.67      0.39 2.6 0.041 0.44 0.15     0.41

    95% confidence boundaries
         lower alpha upper
Feldt     0.63  0.72  0.79
Duhachek  0.64  0.72  0.80
```

```
 Reliability if an item is dropped:
                                          raw_alpha std.alpha G6(smc) average_r S/N alpha se   var.r med.r
ATMs per 100,000 adults                        0.63      0.63    0.54      0.36 1.7    0.057 0.00728  0.34
Domestic market size index                     0.63      0.64    0.55      0.37 1.8    0.057 0.00472  0.40
e-Finance content                              0.66      0.66    0.57      0.40 2.0    0.053 0.00325  0.40
Number of commercial bank branches-NORMALIZATION      0.70      0.70    0.61      0.44 2.4    0.047 0.00048  0.45

 Item statistics
                                            n raw.r std.r r.cor r.drop mean   sd
ATMs per 100,000 adults                   120  0.76  0.77  0.66   0.56 0.20 0.20
Domestic market size index                120  0.76  0.76  0.65   0.55 0.47 0.20
e-Finance content                         120  0.76  0.73  0.60   0.51 0.85 0.23
Number of commercial bank branches-NORMALIZATION 120  0.66  0.69  0.51   0.43 0.21 0.18
```

Reliability Analysis for Social Infrastructure

```
Reliability analysis
Call: alpha(x = data[, c("Urban Population", "Labour force participation rate",
    "Level of literacy", "Education Attainment",
    "Government e-Inclusion Strategy")], check.keys = TRUE)

  raw_alpha std.alpha G6(smc) average_r S/N   ase mean   sd median_r
      0.76      0.71    0.76      0.33 2.5 0.027 0.56 0.15      0.2

    95% confidence boundaries
         lower alpha upper
Feldt     0.68  0.76  0.82
Duhachek  0.71  0.76  0.81
```

```
 Reliability if an item is dropped:
                                raw_alpha std.alpha G6(smc) average_r S/N alpha se var.r med.r
Urban Population                     0.65      0.60    0.67      0.27 1.5    0.041 0.089  0.17
Labour force participation rate-     0.80      0.76    0.79      0.44 3.2    0.022 0.110  0.42
Level of literacy                    0.62      0.58    0.58      0.25 1.4    0.045 0.048  0.20
Education Attainment                 0.58      0.54    0.55      0.23 1.2    0.050 0.047  0.13
Government e-Inclusion Strategy      0.80      0.77    0.80      0.46 3.4    0.026 0.099  0.44

 Item statistics
                                  n raw.r std.r r.cor r.drop mean   sd
Urban Population                120  0.84  0.79  0.74   0.68 0.57 0.26
Labour force participation rate- 120  0.41  0.48  0.25   0.21 0.36 0.16
Level of literacy               120  0.88  0.82  0.86   0.75 0.81 0.25
Education Attainment            120  0.91  0.87  0.92   0.82 0.57 0.25
Government e-Inclusion Strategy 120  0.31  0.45  0.19   0.17 0.51 0.11
```

Reliability Analysis for ICT Infrastructure

```
Reliability analysis
Call: alpha(x = data[, c("Government initiatives to make Wi-Fi available",
    "Private sector initiatives to make Wi-Fi available",
    "Network coverage 3G", "Urban electricity access",
    "Rural electricity access", "Trust in Non-government websites and apps")],
    check.keys = TRUE)

  raw_alpha std.alpha G6(smc) average_r S/N   ase mean   sd median_r
      0.79      0.83    0.85      0.46   5 0.027 0.74 0.21     0.39

    95% confidence boundaries
         lower alpha upper
Feldt     0.73  0.79  0.84
Duhachek  0.74  0.79  0.84
```

```
                                                raw_alpha std.alpha G6(smc) average_r S/N alpha se var.r med.r
Government initiatives to make Wi-Fi available         0.72      0.79    0.81      0.42 3.7    0.038 0.066  0.36
Private sector initiatives to make Wi-Fi available     0.83      0.85    0.87      0.52 5.5    0.020 0.072  0.65
Network coverage 3G                                   0.74      0.78    0.80      0.42 3.6    0.034 0.058  0.36
Urban electricity access                              0.75      0.77    0.79      0.40 3.4    0.033 0.061  0.39
Rural electricity access                              0.69      0.76    0.77      0.38 3.1    0.039 0.051  0.36
Trust in Non-government websites and apps-            0.81      0.87    0.88      0.58 6.9    0.026 0.036  0.65

 Item statistics
                                                  n raw.r std.r r.cor r.drop mean   sd
Government initiatives to make Wi-Fi available  120  0.83  0.81  0.78   0.70 0.80 0.37
Private sector initiatives to make Wi-Fi available 120  0.69  0.58  0.43   0.42 0.59 0.46
Network coverage 3G                             120  0.80  0.82  0.80   0.73 0.86 0.20
Urban electricity access                        120  0.81  0.86  0.87   0.75 0.92 0.17
Rural electricity access                        120  0.88  0.90  0.93   0.79 0.78 0.33
Trust in Non-government websites and apps-      120  0.38  0.46  0.29   0.24 0.49 0.20
```

Reliability Analysis for ICT Usage and Affordability

```
Reliability analysis
Call: alpha(x = data[, c("Mobile subscribers", "Internet users (percent of population)",
    "Mobile phone cost", "Fixed-line monthly broadband cost")],
    check.keys = TRUE)

  raw_alpha std.alpha G6(smc) average_r S/N   ase mean   sd median_r
       0.7       0.72     0.7      0.39 2.5 0.032 0.69 0.14     0.37

    95% confidence boundaries
         lower alpha upper
Feldt     0.60   0.7  0.78
Duhachek  0.63   0.7  0.76


 Reliability if an item is dropped:
                                      raw_alpha std.alpha G6(smc) average_r S/N alpha se var.r med.r
Mobile subscribers                         0.60      0.61    0.59      0.34 1.6    0.042 0.062  0.34
Internet users (percent of population)     0.53      0.53    0.46      0.27 1.1    0.070 0.025  0.32
Mobile phone cost-                         0.60      0.68    0.60      0.41 2.1    0.045 0.019  0.34
Fixed-line monthly broadband cost-         0.72      0.77    0.70      0.52 3.3    0.034 0.011  0.57

 Item statistics
                                        n raw.r std.r r.cor r.drop mean   sd
Mobile subscribers                    120  0.74  0.78  0.67   0.59 0.30 0.15
Internet users (percent of population) 120  0.92  0.85  0.82   0.71 0.57 0.31
Mobile phone cost-                    120  0.74  0.71  0.60   0.55 0.89 0.18
Fixed-line monthly broadband cost-    120  0.48  0.60  0.37   0.32 0.98 0.11
```

Reliability Analysis for Access to Finance for Entrepreneurial Activity

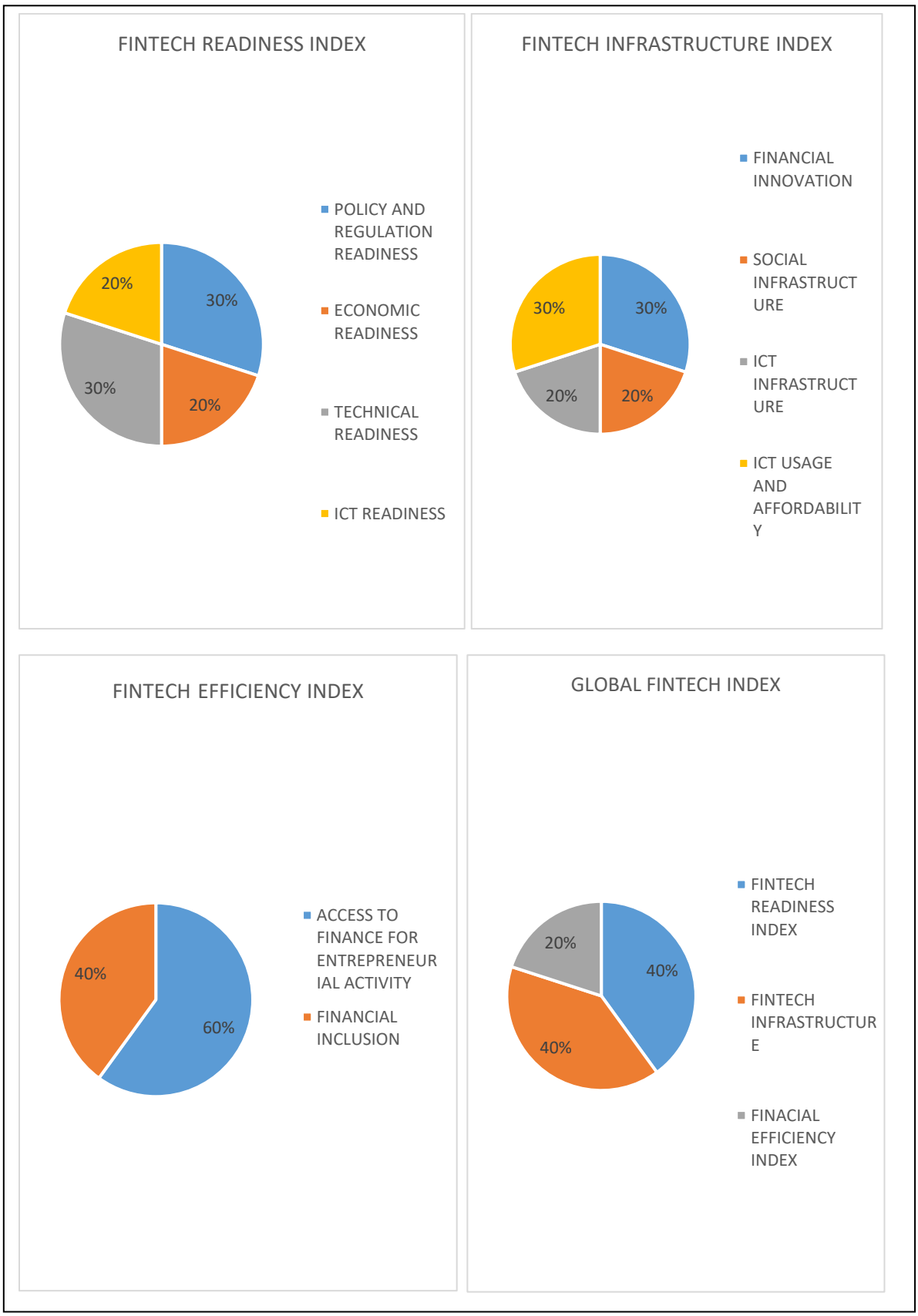
```
Reliability analysis
Call: alpha(x = data[, c("Soundness of banks -NORMALIZATION",
    "Financing of SMEs-NORMALIZATION", "VC investment-NORMALIZATION",
    "Financial services meeting business needs")])

  raw_alpha std.alpha G6(smc) average_r S/N   ase mean   sd median_r
      0.9       0.9    0.89       0.7 9.4 0.014 0.56 0.18     0.69

    95% confidence boundaries
         lower alpha upper
Feldt     0.87   0.9  0.93
Duhachek  0.87   0.9  0.93


 Reliability if an item is dropped:
                                       raw_alpha std.alpha G6(smc) average_r  S/N alpha se  var.r med.r
Soundness of banks -NORMALIZATION           0.91      0.91    0.88      0.78 10.6    0.013 0.0021  0.78
Financing of SMEs-NORMALIZATION             0.84      0.85    0.80      0.65  5.6    0.025 0.0060  0.64
VC investment-NORMALIZATION                 0.86      0.87    0.83      0.69  6.8    0.020 0.0062  0.66
Financial services meeting business needs   0.87      0.87    0.84      0.69  6.5    0.020 0.0159  0.66

 Item statistics
                                        n raw.r std.r r.cor r.drop mean   sd
Soundness of banks -NORMALIZATION     120  0.80  0.82  0.71   0.67 0.67 0.19
Financing of SMEs-NORMALIZATION       120  0.94  0.93  0.91   0.86 0.50 0.24
VC investment-NORMALIZATION           120  0.90  0.89  0.85   0.80 0.42 0.22
Financial services meeting business needs 120  0.88  0.90  0.85   0.81 0.65 0.17
```

```
Reliability analysis
Call: alpha(x = data[, c("Affordability of financial services",
    "Availability of financial services", "Number of Crypto owners",
    "Ease of access to loans")])

  raw_alpha std.alpha G6(smc) average_r S/N  ase mean   sd median_r
      0.83       0.8    0.83       0.5   4 0.02 0.47 0.15     0.49

    95% confidence boundaries
         lower alpha upper
Feldt     0.78  0.83  0.88
Duhachek  0.80  0.83  0.87


 Reliability if an item is dropped:
                                  raw_alpha std.alpha G6(smc) average_r  S/N alpha se  var.r med.r
Affordability of financial services      0.69      0.65    0.68      0.38  1.8    0.0403 0.1301  0.19
Availability of financial services       0.72      0.67    0.74      0.41  2.0    0.0361 0.1642  0.19
Number of Crypto owners                  0.94      0.94    0.91      0.83 15.0    0.0099 0.0015  0.83
Ease of access to loans                  0.69      0.65    0.70      0.38  1.8    0.0403 0.1523  0.16

 Item statistics
                                    n raw.r std.r r.cor r.drop  mean   sd
Affordability of financial services 120  0.94  0.90  0.92   0.86 0.587 0.20
Availability of financial services  120  0.91  0.88  0.86   0.81 0.628 0.19
Number of Crypto owners             120  0.36  0.47  0.19   0.18 0.041 0.12
Ease of access to loans             120  0.93  0.90  0.91   0.85 0.605 0.20
```

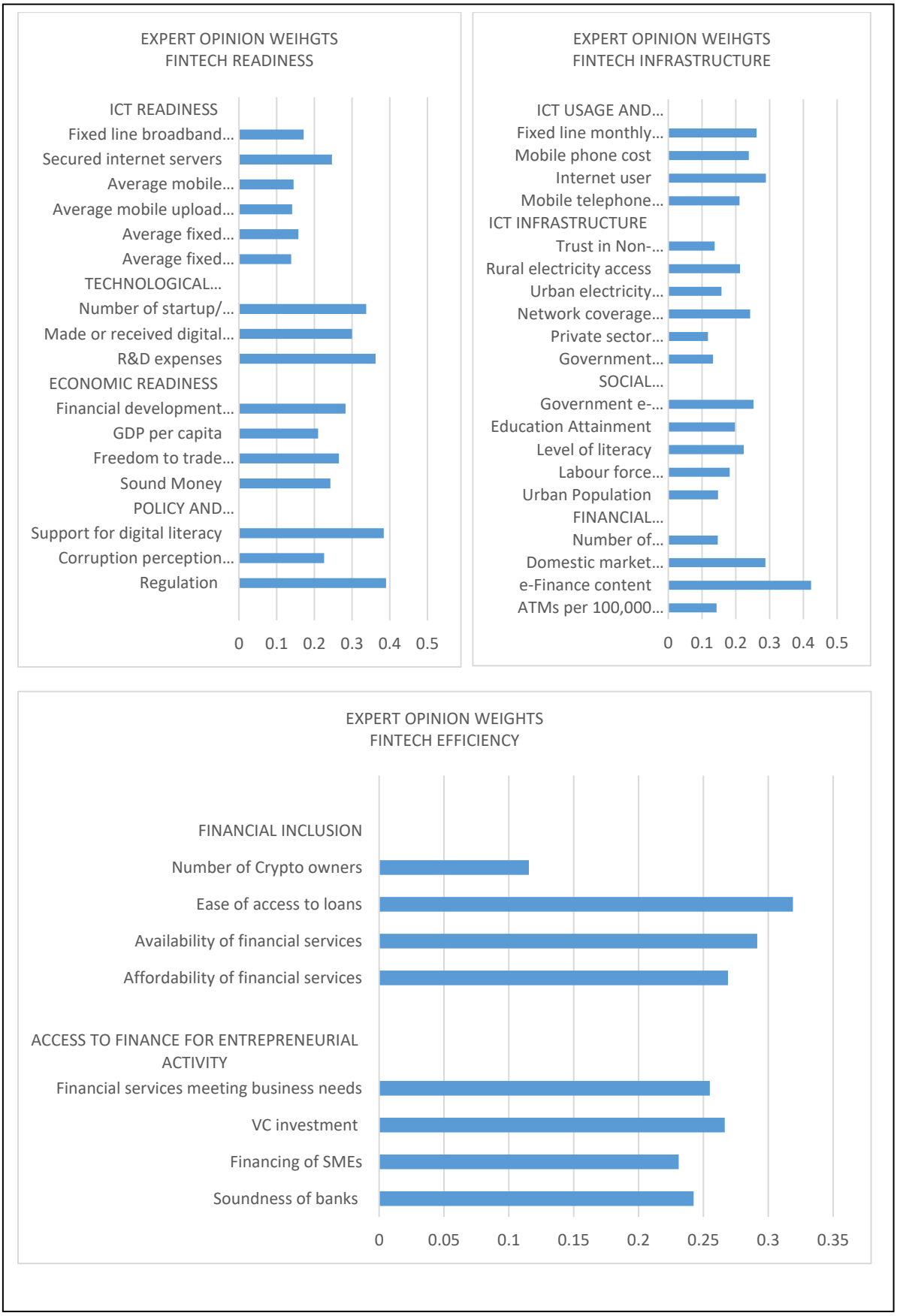
Appendix 3: *Weights Determined by EW*

FINTECH INDEX WEIGHTS-EQUAL WEIGHT METHOD					
	WEIGHT		**WEIGHT**		**WEIGHT**
A. FINTECH READINESS INDEX	**0.33**	**B. FINTECH INFRASTRUCTURE INDEX**	**0.33**	**C. FINACIAL EFFICIENCY INDEX**	**0.33**
A1. POLICY AND REGULATION READINESS	**0.25**	**B1. FINANCIAL INNOVATION**	**0.25**	**C1. ACCESS TO FINANCE FOR ENTREPRENEURIAL ACTIVITY**	**0.5**
Regulation	**0.33**	ATMs per 100,000 adults	**0.25**	Soundness of banks	**-0.25**
Corruption perception index	**0.33**	e-Finance content	**0.25**	Financing of SMEs	**0.25**
Support for digital literacy	**0.33**	Domestic market size index	**0.25**	VC investment	**0.25**
A2. ECONOMIC READINESS	**0.25**	Number of commercial bank branches per 100,000 adults in the population	**0.25**	Financial services meeting business needs	**0.25**
Sound Money	**0.25**	**B2. SOCIAL INFRASTRUCTURE**	**0.25**	**C2. FINANCIAL INCLUSION**	**0.5**
Freedom to trade internationaly	**0.25**	Urban Population	**0.20**	Affordability of financial services	**0.25**
GDP per capita	**0.25**	Labour force participation rate	**0.20**		
Financial development index	**0.25**	Level of literacy	**0.20**	Availability of financial services	**0.25**
A3.TECHNOLOGICAL READINESS	**0.25**	Education Attainment	**0.20**	Ease of access to loans	**0.25**
R&D expenses	**0.33**	Government e-inclusion strategy	**0.20**	Number of Crypto owners	**0.25**
Made or received digital payment	**0.33**	**B3. ICT INFRASTRUCTURE**	**0.25**		
Number of startup/ labor force	**0.33**	Government initiatives to make Wi-Fi available	**0.17**		
A4. ICT READINESS	**0.25**	Private sector initiatives to make Wi-Fi available	**0.17**		
Average fixed broadband upload speed	**0.17**	Network coverage (min. 3G)	**0.17**		
Average fixed broadband download speed	**0.17**	Urban electricity access	**0.17**		
Average mobile upload speed	**0.17**	Rural electricity access	**0.17**		
Average mobile download speed	**0.17**	Trust in Non-government websites and apps	**0.17**		
Secured internet servers	**0.17**	**B4. ICT USAGE AND AFFORDABILITY**	**0.25**		
Fixed line broadband subscribers	**0.17**	Mobile telephone subscription per 100 people	**0.25**		
		Internet user	**0.25**		
		Mobile phone cost	**-0.25**		
		Fixed line monthly broadband costs	**-0.25**		

Appendix 4: *Weights Determined by BAP*



Appendix 4: *Weights Determined by BAP*

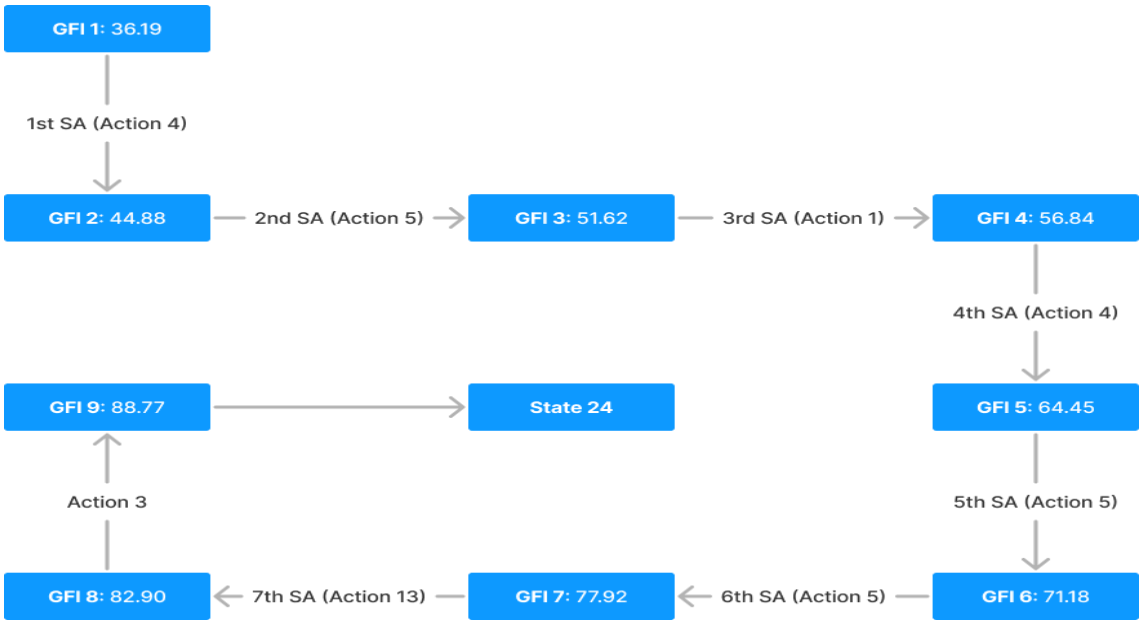


Appendix 5: *Weights Determined by PCA*

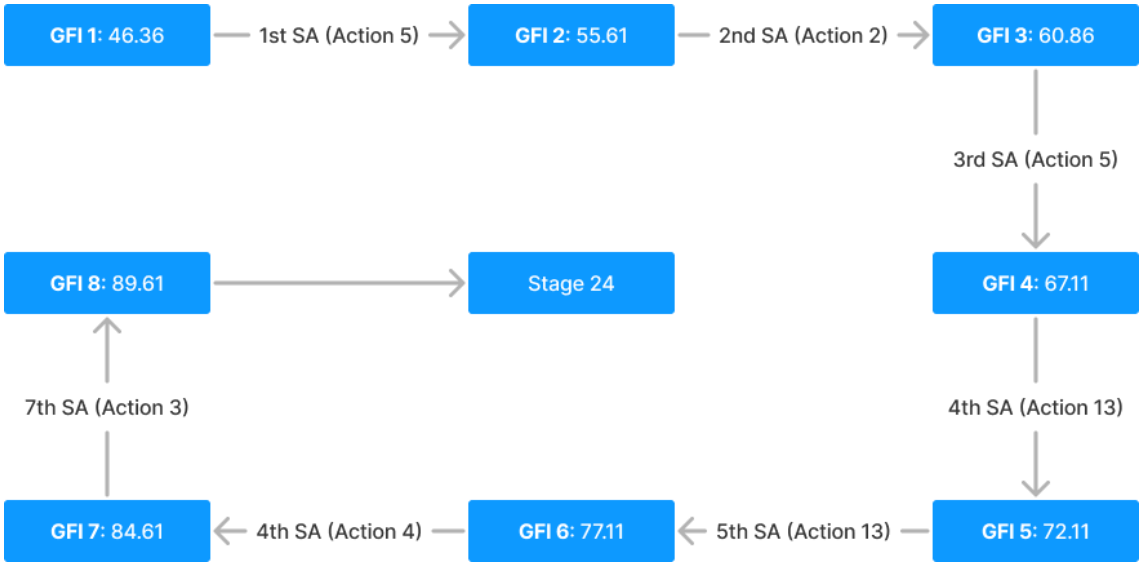
FINTECH INDEX WEIGHTS-EQUAL WEIGHT METHODS					
	WEIGHT		**WEIGHT**		**WEIGHTS**
FINTECH READINESS INDEX	**9.009**	**FINTECH INFRASTRUCTURE INDEX**	**7.53**	**FINACIAL EFFICIENCY INDEX**	**6.4**
Regulation	**0.74**	ATMs per 100,000 adults	**0.41**	Soundness of banks	**-0.31**
Corruption perception index	**0.75**	e-Finance content	**0.29**	Financing of SMEs	**0.39**
Support for digital literacy	**0.32**	Domestic market size index	**0.12**	VC investment	**0.43**
Sound Money	**0.54**	Number of commercial bank branches per 100,000 adults in the population	**0.25**	Financial services meeting business needs	**0.32**
Freedom to trade internationaly	**0.64**	Urban Population	**0.27**	Affordability of financial services	**0.31**
GDP per capita	**0.77**	Labour force participation rate	**0.21**	Affordability of financial services Availability of financial services	
Financial development index	**0.59**	Level of literacy	**0.28**	Affordability of financial services	**0.39**
R&D expenses	**0.59**	Education Attainment	**0.49**	Availability of financial services Ease of access to loans	**0.24**
Made or received digital payment	**0.68**	Government e-inclusion strategy	**0.02**	Number of Crypto owners	**0.12**
Number of startup/ labor force	**-0.67**	Government initiatives to make Wi-Fi available	**0.12**		
Average fixed broadband upload speed	**0.66**	Private sector initiatives to make Wi-Fi available	**0.27**		
Average fixed broadband download speed	**0.75**	Network coverage (min. 3G)	**0.23**		
Average mobile upload speed	**0.44**	Urban electricity access	**0.05**		
Average mobile download speed	**0.59**	Rural electricity access	**0.15**		
Secured internet servers	**0.71**	Trust in Non-government websites and apps	**-0.15**		
Fixed line broadband subscribers	**0.72**	Mobile telephone subscription per 100 people	**0.31**		
		Internet user	**0.45**		
		Mobile phone cost	**-0.18**		
		Fixed line monthly broadband costs	**-0.02**		

Appendix 6: *Strategy Path for Rwanda, Indonesia, China, Switzerland and Turkey*

Strategy Path for Rwanda based on BAP

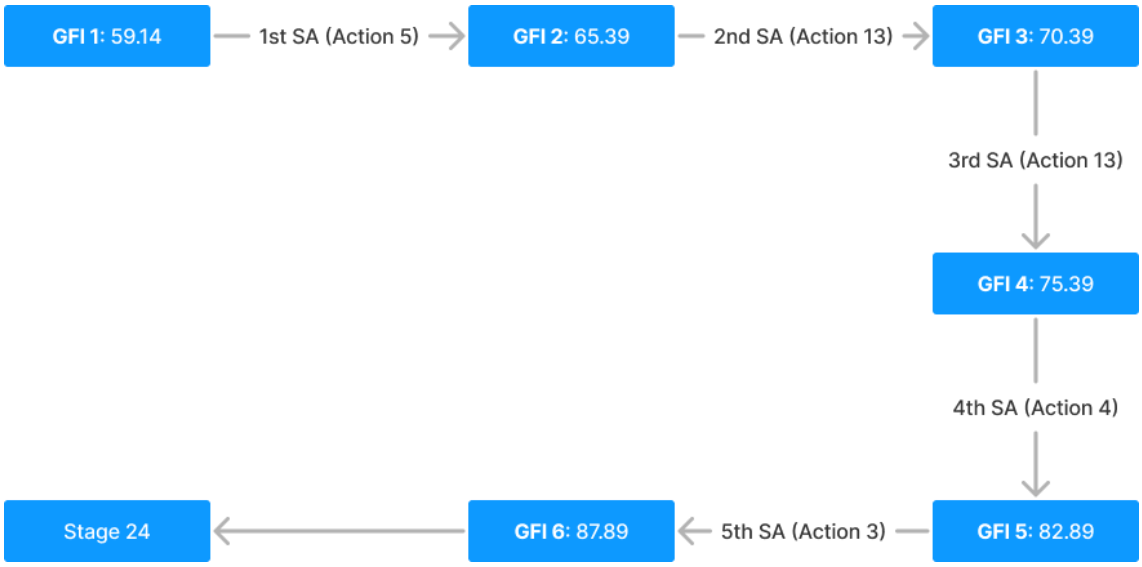


Strategy Path for Indonesia based on EW

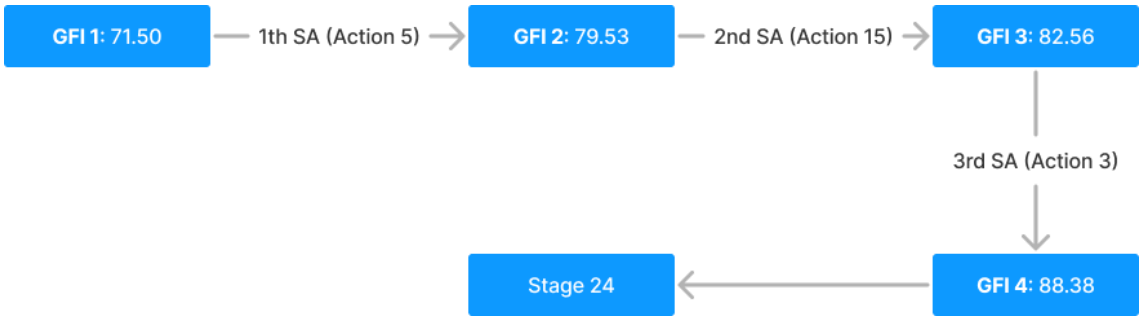


Appendix 6: *Strategy Path for Rwanda, Indonesia, China, Switzerland and Turkey*

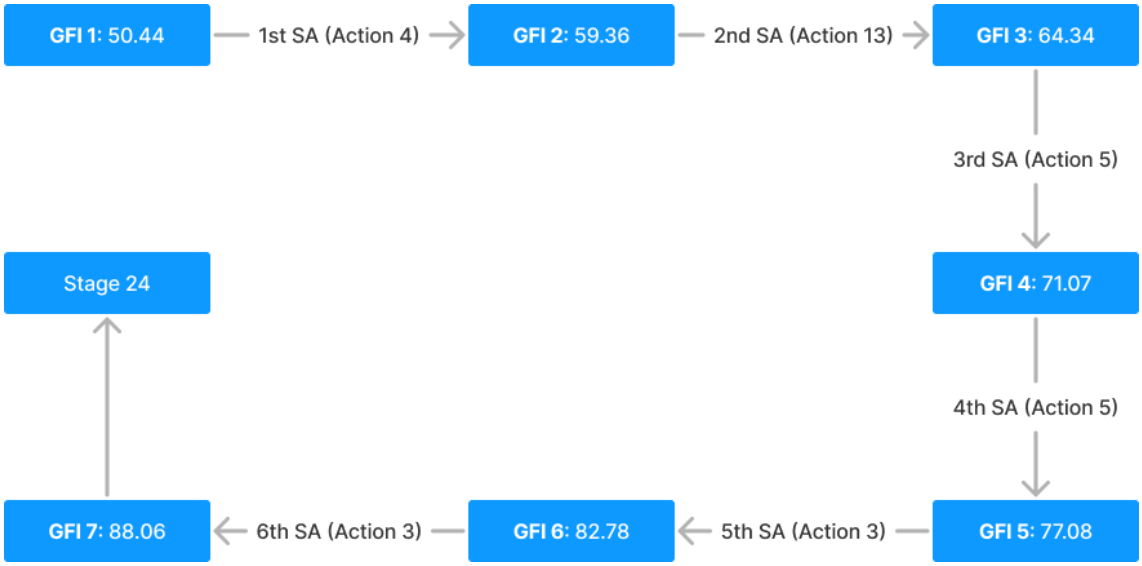
Strategy Path for China based on EW



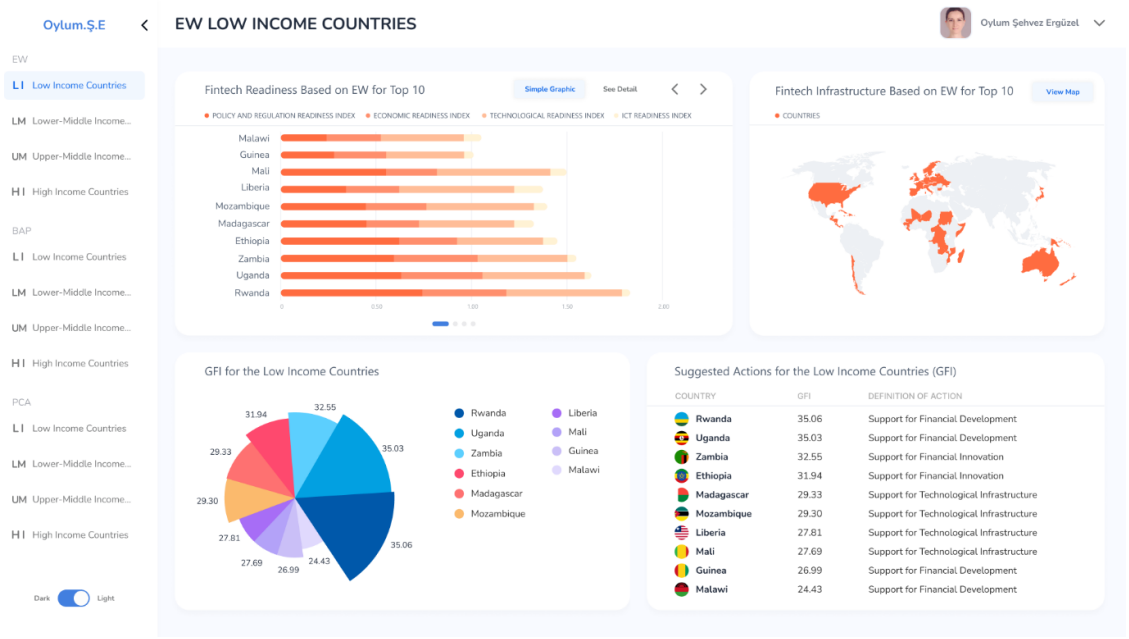
Strategy Path for Switzerland based on BAP

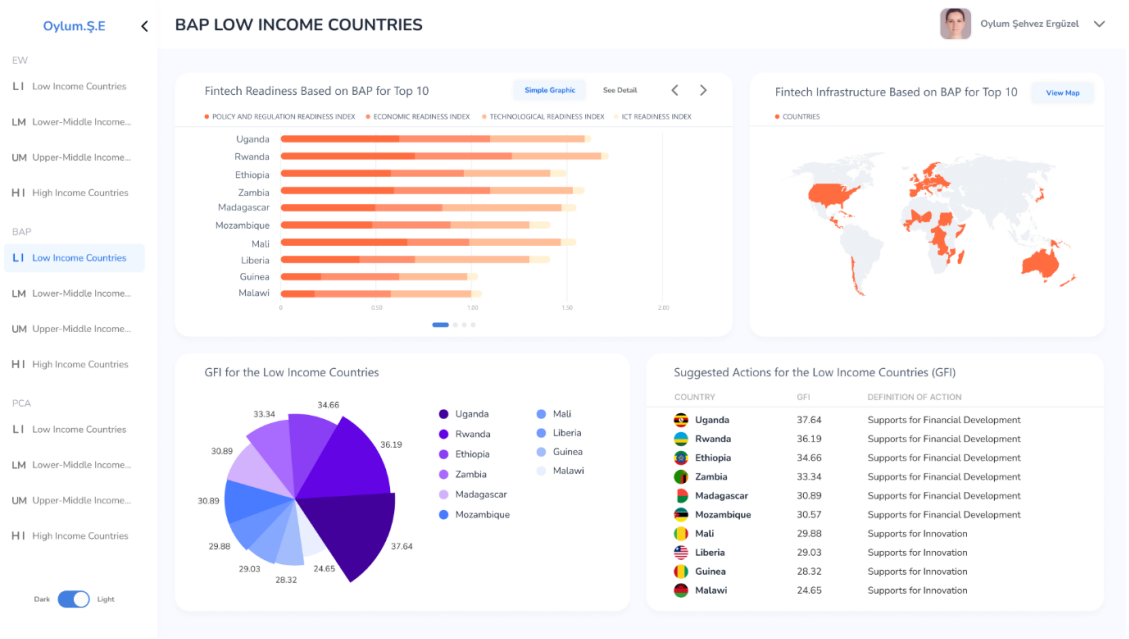


Strategy Path for Turkey based on BAP



Appendix 7: *Designed Dashboard for Visualization and Presentation*






Oylum.Ş.E
PCA LOW INCOME COUNTRIES
Oylum Şehvez Ergüzel
EW
LI Low Income Countries
LM Lower-Middle Income...
UM Upper-Middle Income...
HI High Income Countries
BAP
LI Low Income Countries
LM Lower-Middle Income...
UM Upper-Middle Income...
HI High Income Countries
PCA
LI Low Income Countries
LM Lower-Middle Income...
UM Upper-Middle Income...
HI High Income Countries
Dark
Light
GFI Based on PCA for Top 10
Simple Graphic
See Detail
FINTECH READINESS INDEX
FINTECH INFRASTRUCTURE INDEX
FINTECH EFFICIENCY INDEX
Malawi
Burkina Faso
Mali
Madagascar
Mozambique
Ethiopia
Liberia
Zambia
Uganda
Rwanda
Fintech Infrastructure Based on PCA for Top 10
View Map
COUNTRIES
GFI for the Low Income Countries
25.23
29.55
24.09
31.88
23.60
23.22
31.98
22.97
19.85
20.06
Rwanda
Uganda
Zambia
Liberia
Ethiopia
Mozambique
Madagascar
Mali
Burkina Faso
Malawi
GFI for the Low Income Countries
COUNTRY
GFI
Malawi 19.85
Burkina Faso 20.06
Mali 22.97
Madagascar 23.22
Mozambique 23.60
Ethiopia 24.09
Liberia 25.23
Zambia 29.55
Uganda 31.88
Rwanda 31.98


GFI Based on PCA for Top 10 High Income Countries
Total Country
10
GFI: 86.71
SWEDEN
GFI: 86.12
CANADA
GFI: 93.70
DENMARK
GFI: 94.18
UNITED STATES
GFI: 86.70
NETHERLANDS
GFI: 83.03
GERMANY
GFI: 82.77
JAPAN
GFI: 98.72
SWITZERLAND
GFI: 88.78
HONG KONG
GFI: 97.95
SINGAPORE
Top 10 Country Fintech Index
Country Readiness Infrasturucture Efficiency
Japan 5.62 3.07 1.40
Germany 5.59 3.01 1.57
Canada 5.98 3.13 1.35
Netherlands 6.27 2.83 1.39
Sweden 6.23 2.80 1.49
Hong Kong 6.26 3.06 1.46
Denmark 7.12 2.90 1.21
United States 6.59 3.05 1.86
Singapore 7.30 2.88 1.64
Switzerland 7.29 3.03 1.59

CURRICULUM VITAE

Name-Surname: Oylum Şehvez ERGÜZEL

EDUCATION

Program	Faculty	Year
PhD	Sakarya University/Graduate School of Business / Accounting and Finance	2015-Present
Master of Science	Charles University / Economics and Finance (completed the courses and at the master thesis stage).	2020- Present
Master of Art	Sakarya University/Graduate School of Business/ International Trade and Finance	2015
Bachelor of Art (Double Major)	Yeditepe University/ Faculty of Economy and Administrative Sciences/ Political Science and International Relations (English)	2008
Bachelor of Art (Minor Major)	Yeditepe University/ Faculty of Commercial Sciences / International Finance (English)	2008
Bachelor of Art (Major)	Yeditepe University/ Faculty of Economy and Administrative Sciences/ / Economics (English)	2007
High School	Uşak Anatolian Teacher High School	2000

WORK EXPERINCES

Year	Department	Position
2013-Present	Sakarya University / Sakarya	Research Assistant
2008-2011	AKBANK Head Office / Istanbul Financial Control and International Reporting	Assistant Manager

Language

English

ACADEMIC WORKS

Articles in International Refereed Journals Indexed by SSCI

Seren Özsoy, Oylum Şehvez Ergüzel, Ahmet Yağmur Ersoy, Metin Saygılı. (2022) "The Impact of Digitalization on Export of High Technology Products: A Panel Data Approach", The Journal of International Trade and Economic Development, https://doi-org.ezproxy.is.cuni.cz/10.1080/09638199.2021.1965645, (Q2)

Oylum Şehvez Ergüzel, Hakan Tunahan , Sinan Esen (2016) "Measuring The Globalization of Cities From The New Regionalism Perspective",Springer Plus ,Vol. 5 ,pp. 1536 - ,ISSN: ,DOI: 10.1186/s40064-016-3179-0 ,(Q2)

http://springerplus.springeropen.com/articles/10.1186/s40064-016-3179-0

Articles in International Refereed Journals Indexed by Scopus, ECON-LIT-EBSCO and Others

Büşra Gezikol, Oylum Şehvez Ergüzel, Hakan Tunahan, "A literature Review on the Determinants of Human Development", 2019, Available at SSRN: https://ssrn.com/abstract=3373520 or http://dx.doi.org/10.2139/ssrn.3373520

Oylum Şehvez Ergüzel, Hakan Tunahan, Sinan Esen, "Different Approach to Global Supplier Risk: A Finance Based Model", Alphanumeric Journal, 7, ISSN: 2148-2225, pp.11-24 ,2019 DOI: https://doi.org/10.17093/alphanumeric.513136 http://dergipark.org.tr/tr/pub/alphanumeric/issue/48887/513136

Samet Güner, Oylum Şehvez Ergüzel, Halil İbrahim Cebeci, "Evaluation of Operational Effectiveness of International Airports: A Regional Comparison", Alphanumeric Journal, 7(3), ISSN: 2148-2225, pp.37-44 ,2019, DOI: https://doi.org/10.17093/alphanumeric.499533 http://dergipark.org.tr/tr/pub/alphanumeric/issue/48887/499533

Sinan Esen, Halil Şimdi, Oylum Şehvez Ergüzel "The Effect of International Trading Activities of Firms on Their Financial Structure" ,International Business Research ,Vol. 9 ,pp. - ,ISSN:1913-9012,DOI: http://dx.doi.org/10.5539/ibr.v9n6p1 , ,2016 http://www.ccsenet.org/journal/index.php/ibr/article/view/58304/31169

Feyyaz Zeren, Oylum Şehvez Ergüzel "Testing for Bubbles in the Housing Market: Further Evidence from Turkey", Financial Studies, vol. 19, pp. 40-52, 2015.

Feyyaz Zeren, Oylum Şehvez Ergüzel "Role of Credit Volume on Unemployment Rate: Further Evidence from G-20 Countries", The Empirical Economics Letters, vol. 14, pp. 151-159, 2015.

Feyyaz Zeren, Oylum Şehvez Ergüzel "Forecast Share Prices with Artificial Neural Network in Crisis Periods" Journal of Business Research-Turk, vol. 6, pp. 16-28, 2014.

Oylum Şehvez Ergüzel, Hakan Tunahan , Sinan Esen (2016) "Measuring The Globalization Of Cities From The New Regionalism Perspective",Springer Plus ,Vol. 5

,pp. 1536 - ,ISSN: ,DOI: 10.1186/s40064-016-3179-0
,(Q2)http://springerplus.springeropen.com/articles/10.1186/s40064-016-3179-0

Papers Presented at International Conferences

Oylum Şehvez Ergüzel, Seren Özsoy, Ecenur Demir. "FinTech and Supply Chain Finance", II.Congress of International Digital Business, Management and Economics, Yönetim ve Ekonomi Kongresi', September, 9-11, Tarsus, Turkey, 2022

Ecenur Demir, Seren Özsoy, Oylum Şehvez Ergüzel "Digital Transformation in the Supply Chain: Augmented Reality", 2nd Congress of International Digital Business, Management and Economics, September, 9-11, Tarsus, Turkey, 2022

Oylum Şehvez Ergüzel, Samet Özdemir, Seren Özsoy. "Discovering and Syhentezimgof Key Entreperenurship Competencies", 8th International Entrepreneurship Social Sciences Congress, November, 17-19, Aksaray, Turkey, 2022

Oylum Şehvez Ergüzel, Hakan Tunahan, "A Different Approach to Global Supplier Risk: A Finance Based Model" ,2nd National Congress on Transportation and Logistics, November, 22-23, Sakarya, Turkey, 2018

Samet Güner, Oylum Şehvez Ergüzel, Halil İbrahim Cebeci, Evaluation of Operational Effectiveness of International Airports: A Regional Comparison, 2nd National Congress on Transportation and Logistics, November, 22-23, Sakarya, Turkey, 2018

Oylum Şehvez Ergüzel, Büşra Gezikol. "The Impact of International Economic Relation on Human Development Index: Case of Developing Countries", Istanbul Finance Congress (IFC), November 2-3, Istanbul, Turkey. 2017

Umut Sanem Çitci, Oylum Şehvez Ergüzel, Ebru Özeren "Isomorphism and Authenticity on the Way to be a Global Company: A Case Study Of Turkish Company", 3rd International Conference on Theory & Practice (ICTP, 2017), Adelaide, Australia ISBN: 978-0-9953980-5-4, 2017

Book Chapters

Oylum Şehvez Ergüzel, Seren Özsoy, Ecenur Demir, "Fintech and Supply Chain Finance", Necmettin Erbakan Üniversitesi Yayınları, Edt: Deran, Ali., Şahin, Serkan., Süygün M. Sami, 197 -218, 2022

Oylum Şehvez Ergüzel, Seren Özsoy, “Digitalization in International Trade”, Current Approaches and Evaluations in International Trade and Logistics, Efe Pub. Edt. Hüseyin Kutlu and Ebubekir Karabacak, 2021

Honors and Awards

Best Paper Award 2022, “The Impact of Digitalization on Export of High Technology Products: A Panel Data Approach”, Journal of International Trade and Development (JITED), 2022

Awards of Best Thesis in the last 5 Years, 2016, Sakarya University Institute of Social Sciences