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## Article

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Article

# The Impact of the Regulatory Sandbox on the Fintech Industry, with a Discussion on the Relation between Regulatory Sandboxes and Open Innovation

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**Abstract:** As the fintech industry grows around the world, regulatory issues continue to be a hot topic within the industry. To overcome regulatory barriers of the fintech industry, regulatory sandboxes have been adopted. The regulatory sandboxes are beneficial to create a fintech ecosystem, but their effectiveness has not been empirically supported. This study aims to find the expected effects of regulatory sandboxes on fintech venture investments empirically. We conducted an analysis using a country-level comparative research method. To analyze it, we selected nine forerunning countries which have initially adopted regulatory sandboxes. For the purpose of validations, a comparative analysis and a regression analysis were conducted. In the results, we found that the adoption of regulatory sandboxes had very positive influences on the growth of the fintech venture investment. The results implied that regulatory sandboxes may play a vital role in increasing the influx of venture capital into the fintech venture ecosystem by removing regulatory uncertainty. The findings of this research contribute to providing the empirical evidences to policy makers in interpretations of the positive impact of regulatory sandboxes.

**Keywords:** fintech; regulatory sandbox; venture; investment; venture capital; financial innovation

## 1. Introduction

As the fintech industry grows around the world, many countries are setting up various support systems to enhance the competitiveness of fintech technology and foster the industry. Several countries in particular introduced the fintech regulatory sandboxes, one of the support systems. The regulatory sandbox is a safe, testing space where participants can test their new business model, innovative products, services, and delivery mechanisms, without immediately incurring all the normal regulatory consequences of engaging in the activity in question [1]. The reasons for introducing such regulatory sandboxes are as follows. In the financial sector, regulations have been tightened to protect consumers and investors ever since the global financial crisis, making it difficult to determine whether or not to ease off these regulations. Moreover, it is not easy to know the effects of new technologies such as fintech, and whether it would have a positive effect on society or not [2,3].

However, excessive regulation can occasionally negatively impact a company's ability to innovate and compete in its market. In fact, despite Korea being an IT power nation, the growth of its domestic fintech industry has been sluggish. Pre-regulation by law was the biggest cause. Korean fintech firms hindered by regulations often found it difficult to proceed with their businesses [4]. Therefore, tests need to be conducted outside of regulations for a certain period of time. After looking at the results of these tests, regulators can decide whether or not to release the new services (or products) on the market and ease off on these regulations [4,5] These regulatory sandboxes will benefit both

fintech companies and policy making authorities [6,7]. The Financial Conduct Authority (FCA) of the United Kingdom stated that the regulatory sandbox is a rich source of case studies to inform our understanding of this technology [6].

The regulatory sandboxes are expected to facilitate innovation in the fintech industry. Many experts also believe they will help small firms such as startups and ventures to lead innovation and attract investment. In addition, one of the primary goals of regulatory sandboxes is to attract the attention of investment sources such as banks, private equity, and venture capital funds [8]. In reality, the United Kingdom, which was the first country to introduce the regulatory sandbox, has many competitive fintech technologies and companies and is also considered to be one of the most active fintech markets at present [9,10]. Moreover, most leading countries in fintech have also introduced regulatory sandboxes and consequently, have seen a marked increase in expectations for the effectiveness of regulatory sandboxes. However, it is not clear what kinds of effect could be expected in detail, and therefore it is not easy to determine the success or failure of regulatory sandboxes [5]. One of the reasons why it is not easy to determine the success or failure of sandboxes seems to be that there is no study of what expected effects might be seen after introducing the regulatory sandboxes. Many articles about fintech tend to focus on the fintech service management and innovation. The research on fintech industry regulations is mostly focused on how to regulate fintech's activities in the traditional financial markets. This is the most popular topic among fintech regulation researchers because as many fintech companies have entered the market, many problems have appeared. Furthermore, regulation is an important factor in the activation and innovation of fintech [11–13]. This study is on fintech regulations which many researchers are interested in and aims to look critically at the effectiveness of regulatory sandboxes through cross-country comparisons. This study will be the first empirical research to verify the effectiveness of regulatory sandboxes.

The purpose of this research is to understand the impact of regulatory sandbox adoption on the scale of investments in fintech through empirical data analysis. The rationale behind this approach is that the activation of venture companies is an essential element and significant indicator of the fintech ecosystem. In order to achieve these goals, we first looked at how the scale of fintech venture investment in the countries that introduced regulatory sandboxes has changed since their introduction. Subsequently, we compared these results with other countries that did not introduce regulatory sandboxes. The first group of countries which introduced regulatory sandboxes, consisted of the United Kingdom, Singapore, Hong Kong, Australia, India, Canada, Malaysia, and Japan. There were two criteria for choosing these countries. First, these countries had introduced regulatory sandboxes for longer than a year, as of July 2018. The second was that these countries had existing fintech venture companies with investments in them, so data needed for this analysis existed. The second, which compared a group of countries that had not introduced regulatory sandboxes was selected from among the top 40 countries in the global competitiveness index of the World Economic Forum (WEF). We selected these countries because it was necessary to select countries with similar environments to the first group to control for variables. The reason why the WEF global competitiveness index was chosen was because it included indicators such as ICT penetration and financial systems, which enabled us to select countries with similar environments to the nine countries of the first analysis group. Moreover, the reasons why we limited the scope of our research to venture firms are as follows: First, venture and startup firms are one of the important elements that make up the fintech ecosystem [14], and the new fintech wave is also driven by ventures and startups [11,15]. Second, the growth of new technology-based ventures and startups is one of the goals of regulatory sandboxes [1].

The contributions and differences of our research are as follows: First, it is the first empirical study to identify the expected effects of regulatory sandboxes, especially focusing on the fintech venture investment. Second, it is the first study to compare and analyze the performances of the countries that have introduced regulatory sandboxes. Third, the results of this study can be used as basis for predicting how the regulatory sandboxes will affect the fintech industry. Fourth, the results of this study can be used as a critical frame of reference for regulators and future researchers.

## 2. Fintech Industry and Fintech Regulatory Sandboxes

Fintech, a combination of two words—finance and technology—revolves around providing traditional financial services in new forms using technology [16–18]. The market size of fintech is growing rapidly worldwide [14]. Different areas of the fintech industry range from payment, billing, lending, wealth management, money transfer, mortgage, and real estate to insurance, personal finance, capital market, blockchain, and crypto currency [12,19].

These fintech industries have been growing and concerns about fintech are growing simultaneously. Since the 2008 financial crisis, governments have been providing rigorous regulations for protecting consumers and maintaining sustainability in the market [5,13]. However, the emergence of fintech has posed big challenges to the regulators and regulatory policies [5]. These rigorous regulations are also stated as being critical hinderances to the growth and innovation of the fintech industry [20,21]. After all, many countries have decided to introduce regulatory sandboxes in their fintech industries [5]. As above-mentioned, a regulatory sandbox is a “safe space” in which businesses can test innovative products, services, business models, and delivery mechanisms, without immediately facing all of the normal regulatory consequences of engaging in the activity in question [1]. Another definition is a “framework” set up by a financial sector regulators to allow small scale, live testing of innovations by private firms in controlled environments (operating under a special exemption, allowance, or other limited, time-bound exception) under the regulator’s supervision [22].

Participants in the regulatory sandboxes may test their services or products over a period of time, beyond the scope of regulations to determine whether their solutions have positive effects on the customers and markets. Regulators may simultaneously look at the impact of new solutions and thus determine whether they are against regulations. Regulators can mitigate regulations relatively quickly, if they need to be relaxed. Therefore, these regulatory sandboxes may eventually solve the problem of delayed market release due to regulatory uncertainty. In addition, it can lead to cost saving and innovation [7,23].

The countries where such regulatory sandboxes have been introduced are the United Kingdom, Australia, Denmark, Singapore, Hong Kong, etc. Moreover, many other countries are considering introducing sandboxes. In addition to these forerunning countries, countries where technological advances are somewhat behind, such as Sierra Leone in Africa, have adopted regulatory sandbox programs to support their fintech industry [24,25]. The list of countries introducing and proposing regulatory sandboxes as of April 2019 is set out in Table 1 [5].

The contents of forerunning countries’ regulatory sandboxes are as follows. The United Kingdom was the first country to introduce the regulatory sandbox to its fintech industry in 2015. FCA selected companies to participate in the regulatory sandbox by evaluating them according to five criteria: scope, genuine innovation, consumer benefit, need for sandbox, and background research [1]. Currently, a total of 375 companies have applied to the regulatory sandbox since 2015, and of them, 118 companies have been selected [27]. The FCA seeks to provide these firms with five advantages: the ability to test products and services in a controlled environment, reduced time-to-market at a potentially lower cost, support in identifying appropriate consumer protection, safeguards to build into new products and services, and better access to finance [1]. This regulatory sandbox and other actively supportive policies are regarded as critical drivers of the fintech industry’s growth by experts [9].

Hong Kong introduced the regulatory sandbox to its financial sector in June 2016. Financial institutions as well as startups working with or without fintech firms were allowed to participate [5]. In addition, Securities and Futures Commissions (SFC) have the authority to attach accreditation conditions to minimize the risks that investors may incur during the testing period [26]. They do not clearly specify which regulations can be relaxed or exempted, and the level of deregulations is being set flexibly according to the circumstances of companies [28]. As of the end of March 2019, 48 new technology products or services have been allowed in the regulatory sandbox and 32 pilot trials have been completed and the products have subsequently been rolled out [29].

**Table 1.** The countries introduced and proposed the regulatory sandbox (April 2019) <sup>1</sup>.

Classification	Continent	Countries	
Introduced countries	North America	Canada Denmark UK	
	Europe	The Netherlands Norway Switzerland Brunei Hong Kong Japan India	
	Asia	Malaysia Singapore Taiwan South Korea Thailand Abu Dhabi Bahrain Dubai	
	Middle East	Australia Sierra Leone	
	Oceania		
	Africa		
	Proposed countries	North America	USA Ireland
		Europe	Spain
		Asia	Indonesia

<sup>1</sup> Source: (1) Web pages and related news articles from various financial institutions, (2) Zetzsche, D.A., et al. [26], and (3) Legal Consulting Company’s Web Page.

The Monetary Authority of Singapore (MAS) published its guidelines for the financial regulatory sandbox in June 2016. The companies who participate in it are selected by determining whether the fintech services are innovating, solving major issues of consumers and industries, and providing benefits. The regulatory sandbox of MAS aims to transform Singapore into the center of smart finance industry. MAS seeks to achieve these objectives: increasing efficiency; managing risks more effectively; creating new opportunities; and improving people’s lives through the regulatory sandbox [30]. The Australian Securities and Investments Commission (ASIC) introduced the regulatory sandbox in 2016. ASIC allows both fintech firms and traditional financial companies to participate in it [31] and target business areas and investment amounts are limited to protect investors [32].

The period when participants are allowed to play in the sandboxes is typically limited either by a rule or on a case-by-case basis. United Kingdom and Brunei have allowed a six-month period and Australia, Thailand and Malaysia have twelve months [5]. Extensions of the period are generally available. As such, although the objectives of each country’s regulatory sandbox guidelines are similar, the details of the guidelines are different country to country. As described above, some countries restrict the type of enterprise and business sectors which are able to participate in the sandboxes. Some researchers insist that these restrictions are counter-productive to the sandbox’s objectives and eventually reduce economies of scale and the value of innovation [5]. The detailed features of each country’s regulatory sandbox are shown in Table 2 below.

**Table 2.** Features of each country’s fintech regulatory sandbox (based on the guidelines of the financial authorities’ reports [1,11,22,33]).

<b>Countries</b>	<b>Categories</b>	<b>Details</b>
<b>UK</b>	Organization in charge	FCA (Financial Conduct Authority)
	Targets	Finance/IT companies & Fintech companies
	Features	Testing period in the regulatory sandbox: 3–6 months. FCA seeks to provide the appliers with five advantages: the ability to test products and services in a controlled environment, reduced time-to-market at potentially lower cost, support in identifying appropriate consumer protection, safeguards to build into new products and services, and better access to finance. * These have been the basis for other countries’ regulatory sandbox guidelines.
<b>Hong Kong</b>	Organization in charge	HKMA (Hong Kong Monetary Authority)
	Targets	Bank
	Features	Testing period in the regulatory sandbox: case-specific decisions. They do not clearly specify which regulations can be relaxed or exempted, and the level of deregulations is being set flexibly according to the circumstances of companies.
<b>Singapore</b>	Organization in charge	MAS (Monetary Authority of Singapore)
	Targets	Finance /IT companies & Fintech companies
	Features	Testing period in regulatory sandbox: case-specific decisions. The purposes of the regulatory sandboxes are a. increase efficiency; b. manage risks better; c. create new opportunities; or d. improve people’s lives.
<b>Australia</b>	Organization in charge	ASIC (Australian Securities and Investment Commission)
	Targets	Fintech companies
	Features	Testing period in the regulatory sandbox: 6~12 months. The number of investors and Investment amounts are limited.
<b>India</b>	Organization in charge	RBI (Reserve Bank of India)
	Targets	FinTech companies including startups, banks, financial institutions, and any other company partnering with or providing support to financial services businesses.
	Features	Testing period in the regulatory sandbox: case-specific decisions. Time and degree of deregulation are determined and applied on a case-by-case basis.
<b>Canada</b>	Organization in charge	CSA (Canadian Securities Administrators)
	Targets	Fintech companies and startups
	Features	Testing period in the regulatory sandbox: case-specific decisions. Registration and exemptive relief granted to firms in the CSA. Regulatory Sandbox are time limited. The time limit will be determined on a case-by-case basis.



**Table 2.** *Cont.*

Countries	Categories	Details
Malaysia	Organization in charge	BNM (Bank Negara Malaysia)
	Targets	Finance and Fintech companies
	Features	Testing period in the regulatory sandbox: within 12 months. One of the main goals of the Malaysian fintech regulatory sandboxS is financial institutions’ efficiency and risk management. The Bank has a lot of decision-making authority.
The Netherlands	Organization in charge	AFM & DNB (Autoriteit Financiële Markten & De Nederlandsche Bank)
	Targets	Available to all financial services companies
	Features	Testing period in the regulatory sandbox: case-specific decisions. If something illegal happens under the monitoring by the supervisor, it can be stopped immediately. The role of the supervisor seems to be rather big. They also consider whether the appliers violate the EU laws.
Japan	Organization in charge	JFSA (Japan Financial Services Agency)
	Targets	Finance/IT companies and Fintech companies Any company, including foreign companies, can apply to use this regulatory regime in Japan. AI, IoT, big data, and blockchain projects are explicitly mentioned as the most prospective and suitable areas.
	Features	Testing period in the regulatory sandbox: within 12 months. Japanese regulatory sandboxes also include foreign companies operating in Japan.

\* UK is the first country that has introduced a fintech regulatory sandbox. So, UK’s guide lines of a regulatory sandbox were recognized as a basic role model in most countries.

### 3. Previous Researches and Hypotheses

A related strand of literature addresses that the growth of micro and small companies such as ventures and startups is affected by the regulations [15,20,34]. These studies mention that companies in the countries that have favorable policies to certain industries may have more benefits, such as cost saving, than those in the countries that have strong regulatory policies [35]. They also argue that the companies in countries that have favorable policies are also easier to innovate because compliance costs prevent innovation [15,20,36]. While rigorous regulations protect investors, they may also lead to high transaction costs and regulatory compliance costs that prevent investors from taking risks, and consequently may discourage investment. Therefore, previous researches say that rigorous regulations could ultimately have negative effects on micro and small firms that need more investment. The more relaxed regulations, the more positive response of the stock market could be, they insist [15].

More relaxed regulations can also benefit product innovation, because less regulation to the market could intensify competitions and will lead to lower prices and better qualities [3]. One study revealed that product and service legislation deter business activities in general, and some laws and compliance hinder competitiveness in particular [3]. In fact, despite Korea being an IT power nation, the growth of the domestic fintech industry was sluggish. Pre-regulation by law was the biggest cause. Korean fintech firms blocked by regulations were in difficult situations to proceed with their businesses [4]. For the above reasons, policymakers are trying to limit the negative effects of regulation on innovative industries. The regulations on the innovative industries like the fintech industry need to be systematically checked for potential conflicts and synergies [37].

Many experts say that introducing regulatory sandboxes help make proper policies in the same vein and it also will help fintech startups to save time and reduce cost. In fact, FCA expects the sandboxes to reduce the time to market by thirty-three percent and to facilitate the fintech's access to finance, thereby raising its valuation by fifteen percent. Moreover, the following 30% of companies that graduated from the first UK regulatory sandbox (2016.7–2017.1) succeeded in attracting investment. Furthermore, fintech companies have increased their average investment by 6.6 times after graduating from the regulatory sandbox. Based on these facts, this is one further argument where the regulatory sandbox can contribute to the activation of venture capital in the fintech sector [5].

For both reasons, they also expect to enable innovation to reach the market [5]. Some other previous studies found that the fintech and the regulatory sandboxes contribute to poverty reduction. The study, based on a survey of 3000 people in Ghana and Egypt, found small loans provided by fintech firms were very useful for household finances. The results of the study say that small loans of fintech services have contributed positively to poverty reduction [38]. In addition to this research, the United Kingdom, Australia, Canada, Hong Kong, Singapore, and others, which are the countries that introduced the sandboxes, are hosts to a predominant number of the top 100 fintech firms [39]. These countries are also evaluated to have relatively well-equipped policies, including the regulation of sandboxes, infrastructure, and ecosystems, to promote fintech industries [40,41]. These examples show that regulations and the growth of the fintech industry are closely related. Nonetheless, there are no discussions on the direct and indirect effects of regulatory sandboxes empirically. Therefore, the effects of fintech regulatory sandboxes need further empirical research.

In this research, we propose a country level comparative methodology to analyze the effectiveness of the introduction of the regulatory sandboxes on the investment scale of fintech venture companies. The rationale behind this methodology is that the main policy effect of the regulatory sandbox is to activate a fintech industry ecosystem. From this perspective, it is highly desirable to analyze the investment scale of fintech venture companies for validation of the impact of regulatory sandboxes because fintech venture companies have initiated most innovations in the area of financial business by their disruptive technologies and creative business models [42,43]. In the United Kingdom, where the first fintech regulatory sandbox was introduced, fintech startups and venture companies were most likely to benefit from regulatory sandboxes [30]. Therefore, in order to determine whether the regulatory sandboxes contribute to the activation of the fintech industry or not, this research needs to be limited to the research of fintech venture companies, which are one of the main constituents of the industry. In the previous studies on the determinants of investment decisions by angel investors and venture capitalists, one of the major investment determinants was found to be the growth potential of companies and their industries [44]. Moreover, another study argued that ventures and startups are important components of the fintech ecosystem; therefore, the change in the investment size of venture companies can be a key indicator for determining the activation of the industry.

The purpose of this research is to investigate the effect of regulatory sandboxes on the investment scale of investment companies in nine countries that have introduced them. In order to improve the reliability and validity of the results, we compared the results with the countries that did not introduce the regulatory sandboxes. In this research, analysis method was used to analyze the detailed change trend of investment scale. Nine countries were selected including the United Kingdom, Singapore, Hong Kong, Australia, India, Canada, Malaysia, The Netherlands, and Japan. It has been one or two years since they introduced the regulatory sandboxes (as of July 2018). In this paper, we have labeled these nine countries as the "A group". The fintech areas that are subject to the analysis are all areas of fintech such as financial accounting services, financial data analysis, payment services, financial consulting services, consumer finance, loan services, insure-Tech, robo-advisor, and investment services. As mentioned above, what we tried to understand through this research were the effects that occurred due to the introduction of regulatory sandboxes. The effects of the latter were measured by the change in the investment scale of the fintech venture companies in the countries that introduced the regulatory sandboxes. The hypotheses are as follows.



**Hypothesis 1.** *The total amount of investment in fintech ventures will increase after the introduction of the regulatory sandboxes.*

**Hypothesis 2.** *The average amount of investment in fintech ventures will increase after the introduction of the regulatory sandboxes.*

**Hypothesis 3.** *The number of investments in fintech ventures will increase after the introduction of regulatory sandboxes.*

## 4. Methodology

### 4.1. Methods

#### 4.1.1. Scheme of Analysis

This research tried to implement the methodology of combining pre–post analysis, comparison analysis, and regression analysis with time-series intervention analysis. To determine the effect of introducing the regulatory sandboxes, we conducted a pre–post analysis on the A group where regulatory sandboxes were introduced. As a result, we were able to identify the changes before and after the introduction of the sandboxes. After this analysis, to validate the result from the pre–post analysis, the validation process was conducted in comparison with the “B group”, where regulatory sandboxes were not introduced. Then, regression analysis was conducted by using multiple regression analysis extracting the influence of factors (sandbox and others). Multiple regression analysis is a statistical methodology that is often used to reveal the causality of factors in the social science field [45]. In many cases, multiple regression analysis has been applied to study economic phenomena such as venture investment [45,46]. The detailed analysis process is shown in Table 3 below.

**Table 3.** The process of the analysis.

	Pre-Post Analysis	Comparison Analysis	Regression Analysis
Order	1	2	3
Purpose	To confirm the changes before and after sandbox introduction.	Comparison differences between A and B group.	Extracting the influence of factors (sandbox and others).
Target	Intra-group A (pre/post)	Inter-group A–B	All group
Methods	Paired samples <i>t</i> -test (or Wilcoxon W test)	Independent samples <i>t</i> -test (or Mann–Whitney U test)	Multiple Regression analysis
Assumptions	<ol style="list-style-type: none"> <li>1. Test of Normality (Shapiro–Wilk)</li> <li>2. Test of Equality of Variances (Levene’s)</li> </ol>	<ol style="list-style-type: none"> <li>1. Test of linearity</li> <li>2. Autocorrelation</li> <li>3. Residual plots</li> </ol>	

#### 4.1.2. Pre–Post Analysis

First, a pre–post analysis was conducted to see if there was any change in the investment scale before, and after, the adoption of the regulatory sandbox. The total amount of fintech investment, average investment, and number of investments in the nine countries that introduced sandboxes were extracted for each period before and after the introduction. Before analyzing the two samples, the test of normality (Shapiro–Wilk Test) and the test of equality of variances (Levene’s Test) were performed. Because the size of each sample was nine, Wilcoxon W Test, a nonparametric test, was performed in parallel with the paired-samples *t*-test. In order to test the hypothesis that the scale of investment (1. total investment, 2. average investment, and 3. number of investments) after the adoption of the

sandbox was greater than those before the adoption of the sandbox, a one-sided test was conducted with a 95% confidence level.

#### 4.1.3. Comparison Analysis

It was necessary to perform a comparative analysis with the group that did not introduce regulatory sandboxes (B group) after statistically confirming the change in the scale of fintech investment in sandbox adopting countries in the pre–post analysis previously conducted. For this analysis, the rate of change in investment scale (total investment, average investment, and number of investments) before and after the introduction of sandboxes in each country was extracted. In order to compare the samples between the groups A and B, the samples were subjected to the test of normality (Shapiro–Wilk Test), and the test of equality of variances (Levene’s Test) was performed. Since the number of samples was very small, the Mann–Whitney test, a nonparametric test, was performed in parallel with the Independent samples *t*-test. In order to test the hypothesis that the investment scale after the introduction of the regulatory sandboxes was greater than those before the introduction, a one-sided test was conducted with a 95% confidence level.

#### 4.1.4. Regression Analysis

Multiple regression analysis was used to determine the explanatory power of the regulatory sandbox on the increased investment in fintech. The previous methods only statistically confirmed that there was an increase in the scale of investments of fintech in countries adopting regulatory sandboxes. However, factors other than the regulatory sandbox may also have affected the outcome. Other factors (financial development and innovation capacity) in the target countries, being part of the A group, may also contribute to the increase in fintech investment. The detailed components of control variables are shown in Table 4 below.

**Table 4.** Components of control variables <sup>1</sup>.

Control Variables	Financial Market Development	Innovation
Components of the variable	1. Financial services meeting business needs	1. Capacity for innovation
	2. Affordability of financial services	2. Quality of scientific research institutions
	3. Financing through local equity market	3. Company spending on R&D
	4. Ease of access to loans	4. University-industry collaboration in R&D
	5. Venture capital availability	5. Government procurement of advanced technology products
	6. Soundness of banks	6. Availability of scientists and engineers
	7. Regulation of securities exchanges	7. PCT (Patent Cooperation Treaty) patent applications
	8. Legal rights index	8. Intellectual property protection

<sup>1</sup> Source: (1) World Economic Forum, The Global Competitiveness Report 2017–2018.

To control these factors, hierarchical regression analysis was performed to report the difference in explanatory power between regression models. Most of the countries that introduced regulatory sandboxes may have had such a result (increasing the scale of fintech investment) mainly because their financial system was highly advanced, mature, and had excellent technological innovation capabilities. From the viewpoint that fintech creates innovative services and products by applying creative technology to the financial industry, the maturity of financial markets and technological innovation capabilities are very important factors in the development of the fintech industry [32].

An efficient financial sector allocates the resources saved to the entrepreneurial or investment projects with the highest expected rates of return. Business investment is critical to productivity. Therefore, the economy requires sophisticated financial markets that can make capital available for private-sector investment from such sources as loans from a sound banking sector, venture capital, and other financial products. Innovation is especially important for economies, as they approach the frontiers of knowledge, and the possibility of generating more value by integrating and adapting exogenous technologies tends to disappear. In general, companies must develop and design new business model by using cutting-edge technologies. This progression requires environments that are conducive to innovative activities (R&D) and supported by both public and private sectors. In this context, we intend to use “financial market development” and “innovation” among WEF’s global national competitiveness index as control variables. Fortunately, WEF (World Economic Forum, the Global Competitiveness Report 2017–2018) provided two indexes (Financial market development and Innovation capacity) with 16 sub-variables in Table 4 above.

To find out the explanatory power of the sandbox variable on the scale of investment in fintech, three regression models were created. Model 1 had Financial Market Development as its only independent variable. In Model 2, two control variables were applied. Finally, Model 3 used both control variables and the sandbox variable. Analyzing the three regression models, step by step, increases the explanatory power for each step, revealing the explanatory power of the sandbox variable. The detailed regression analysis models are shown in Table 5 below.

**Table 5.** The detailed regression models.

Regression Models	Equations	Variables
Model 1	$Y = B_1(X_1) + C_1 + E_1$	Y: Dependent Variable
Model 2	$Y = B_1(X_1) + B_2(X_2) + C_2 + E_2$	X <sub>1</sub> : Financial market development
Model 3	$Y = B_1(X_1) + B_2(X_2) + B_3(X_3) + C_3 + E_3$	X <sub>2</sub> : Innovation X <sub>3</sub> : Sandbox
Diagnostic test	<ol style="list-style-type: none"> <li>Linearity test (Residual plot: satisfied)</li> <li>Autocorrelation test (D–W Static: Y<sub>1</sub> = 2.59, Y<sub>2</sub> = 2.42, Y<sub>3</sub> = 2.33)</li> <li>Collinearity test (VIF: X<sub>1</sub> = 1.42, X<sub>2</sub> = 1.23, X<sub>3</sub> = 1.18)</li> </ol>	

## 4.2. Variables and Data

### 4.2.1. Variables

Venture investment is often carried out in the form of series of investments. In this research, to analyze the changes according to the time of introduction more precisely, we calculated single investment amounts rather than the total series of investment. In this research, we analyzed the amount of investment (in USD) in which the investment execution of fintech venture investment was completed. Another indicator of the activation of venture investment was the average investment. Indeed, when a particular market turns into a positive situation, the average investment rises. Thus, hedges of legal and institutional risks, such as regulatory sandboxes, can increase the average investment in high-tech industries such as fintech. In this research, we investigated the effect of regulatory sandboxes by examining the fluctuation of average investment amounts. The number of venture investments can be an indicator of the activation of venture investment. This is because the number of venture investments tends to increase when venture investment is active. The purpose of this research was to examine the effects of regulatory sandboxes on the change of venture investment. The number of venture investments analyzed in this research was limited to the completion of the investment execution, and it was considered as one investment when various investors participated in the same investment case. The detailed operational definitions of variables are shown in Table 6 below.

**Table 6.** Operational definitions of variables.

Category	Variables	Abbr.	Operational Definition	Source
Dependent Variable	The change of total amount	Am_change	Growth rate of total investment	Preqin’s Global Investment Database
	The change of average investment	Avr_change	Growth rate of average amount of investment	
	The change of the number of deals	Deal_change	Growth rate of the number of investment deals	
Independent Variable	Sandbox introduction	Sandbox	The Regulatory Sandbox introduction (0: not introduced, 1: introduced)	Each country’s financial regulatory authority
Control Variable	Financial market development	Fin_Mardev	The degree of financial market development	World Economic Forum, 2017 Global Competitiveness Index Framework
	Innovation	Innovation	The degree of national innovation capability	

4.2.2. Set Analysis Target and Period

For the purpose of our research, this research was applied to 9 countries that introduced regulatory sandboxes. As of July 31, 2018, the timing for the introduction of regulatory sandboxes by countries was based on the websites of each country’s regulators and articles in major economic newspapers. The time that of the introduction of regulatory sandboxes was determined by not only when legislation proceeds, but also when legislation is announced. The reason for including the announcement of the introduction of the regulatory sandboxes was that investors are sensitive to regulatory trends, and government related laws and guidelines were also considered to be enforced and tend to move ahead. We also compare the investment scale (total investment amount, average investment amount, and number of investments) before, and after, the introduction of the regulatory sandboxes and investment after 1–2 years, in order to understand the effect of the introduction of the regulatory sandboxes.

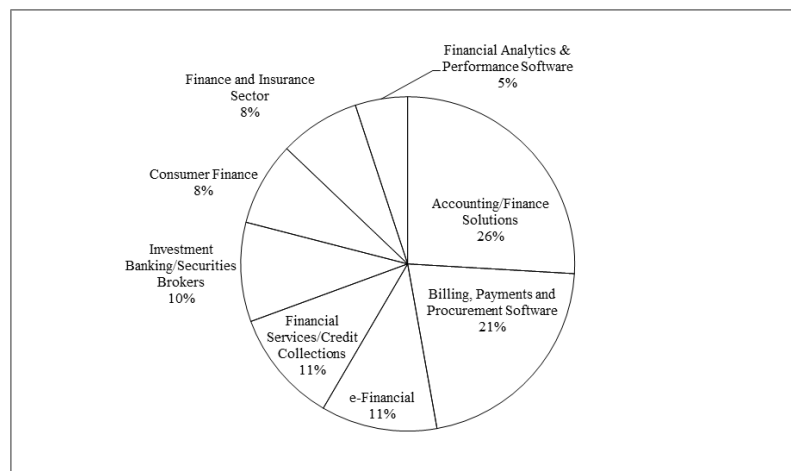
From June 2013 until July 2018 was the timeframe in which we obtained data. Countries that had introduced regulatory sandboxes since then, or countries with less than one year since the introduction of regulatory sandboxes in July 2018, were excluded from the analysis. In addition, to improve the accuracy of the analysis results, countries with no clear time of entry and countries without investment information were excluded from the analysis. However, it was difficult to assume clearly whether the change in the investment scale attributed to the introduction countries was due to the introduction of the regulatory sandboxes or the overall growth trend of the fintech industry itself. In order to overcome this problem and to improve the objectivity and reliability of the results, it was necessary to further analyze the trend of the investment scale of the countries which are located in the same region as the analyzed countries and which had not introduced regulatory sandboxes. These results would then be compared with the 9 countries mentioned above. In order to select the B group for comparison, the A group (9 countries) that introduced regulatory sandboxes were classified into four regions (Western Europe, Asia, Oceania, and North America). To select countries in the B group, 9 countries were selected using the National Competitiveness Index, which is published annually by the World Economic Forum (WEF). The nine countries, which were selected as the B group because they have similar NCI scores to the A group, are as follows: the United States, Germany, France, Ireland, Belgium, Korea, New Zealand, Spain, and China. The control group (B group) was selected from among the top 40 countries in the global competitiveness 2017 index of the World Economic Forum (WEF), because we have to select countries with similar environments to the first group. In the concept of fintech, the reason why we chose the WEF global competitiveness index to determine the B group was because it included indicators such as the maturity of financial systems and ICT capacity, which allowed for us to choose countries with similar environments to the nine countries of the first analysis group to be selected. Table 7 shows the selected countries that satisfied these criteria.

**Table 7.** The list of A group and B group countries.

Region	A Group (Nine Countries)	B Group (Nine Countries)
West Europe	UK, The Netherlands	France, Germany, Ireland, Spain, Belgium
Asia	Singapore, Hong Kong, India, Malaysia, Japan	China, South Korea
North America	Canada	US
Oceania	Australia	New Zealand

4.2.3. Data Collection

For the purpose of this research, we reviewed the investment information of fintech venture companies from January 1, 2007 to July 31, 2018 (5875 total), sourced by Preqin’s global investments database (Source: Preqin’s global investment DB, <https://www.preqin.com/products/preqin-pro>). From the 5875 data, we used the 3296 data (729 for the A group and 2567 for the B group). The A group contained 729 venture investments in 9 countries, including the United Kingdom, Singapore, Hong Kong, Australia, India, Canada, Malaysia, The Netherlands, and Japan, which all had introduced the regulatory sandboxes for more than a year (as of July 2018). The investment data of 9 countries was confirmed as the analysis target. Figure 1 shows the fintech industry sector shown in the data. Table 8 shows the descriptive statistics for collected data.



**Figure 1.** The percentage of investment in fintech by sector in the A group countries.

**Table 8.** Descriptive statistics for collected data.

	Sandbox	Am_change	Avr_change	Deal_change
Mean	0	-0.232	0.0864	-0.230
	1	0.377	1.57	-0.388
Median	0	-0.218	0.0221	-0.230
	1	0.327	1.26	-0.404
Standard deviation	0	0.404	0.509	0.326
	1	0.322	1.06	0.265
Skewness	0	1.44	0.327	0.324
	1	0.322	0.913	0.875
Std. error skewness	0	0.717	0.717	0.717
	1	0.717	0.717	0.717
Shapiro-Wilk	0	0.124	0.954	0.355
	1	0.453	0.589	0.452

Note. Shapiro-Wilk Test: A low *p*-value suggests a violation of the assumption of normality.

## 5. Results

### 5.1. Pre–Post Analysis

First, two samples were tested for normality (Shapiro–Wilk Test). As a result, paired samples of total investment ( $p > 0.05$ ) and number of investments ( $p > 0.05$ ) were found to satisfy normality of samples. However, the average investment amount ( $p < 0.01$ ) did not satisfy the normality of samples. Therefore, to analyze the average investment, we decided to use Wilcoxon W Test, a nonparametric test method. As a result of analysis, the Hypotheses 1 and 2 was supported ( $p < 0.05$ ) in the analysis of the total amount of investment and the average investment, but the Hypothesis 3 was not supported in the analysis of the number of investments ( $p > 0.05$ ). Table 9 shows the results of the analysis.

**Table 9.** The results of the Pre–Post Analysis.

		Test	Statistic	df	<i>p</i>
Pre_Invest	Post_Invest	Student’s <i>t</i>	−2.54	8.00	0.017
		Wilcoxon W	3.00		0.010
		Shapiro–Wilk	0.867		0.113
Pre_Avr	Post_Avr	Student’s <i>t</i>	−3.22	8.00	0.006
		Wilcoxon W	0.00		0.002
		Shapiro–Wilk	0.804		0.023
Pre_Deal	Post_Deal	Student’s <i>t</i>	3.06	8.00	0.992
		Wilcoxon W	44.00		0.995
		Shapiro–Wilk	0.890		0.199

Note. 1.  $H_a$  Measure 1 < Measure 2. 2. Shapiro–Wilk Test: A low *p*-value suggests a violation of the assumption of normality.

### 5.2. Comparison Analysis

For comparison between groups in group A and group B, the samples were subjected to the normality test (Shapiro–Wilk Test) and the test of equality of variances (Levene’s Test). All samples passed the normality test and the test of equality of variances to meet the assumptions for *t*-test. Nevertheless, since the number of samples was very small, the Mann–Whitney test, a nonparametric test, was performed in parallel with the independent samples *t*-test. As a result of analysis, the hypothesis was supported ( $p < 0.01$ ) in the analysis of the total amount of investment. The hypothesis was supported ( $p < 0.01$ ) in the average investment, but the hypothesis was not supported in the analysis of the number of investments ( $p > 0.05$ ). Table 10 shows the results of the analysis.

**Table 10.** The results of the comparison analysis.

		Test	Statistic	df	<i>p</i>
Pre_Invest	Post_Invest	Student’s <i>t</i>	−3.54	16	0.001
		Mann–Whitney U	8.00		0.001
		Shapiro–Wilk	0.925		0.158
		Levene’s	0.0843		16
Pre_Avr	Post_Avr	Student’s <i>t</i>	−3.77	16	<0.001
		Mann–Whitney U	5.00		<0.001
		Shapiro–Wilk	0.955		0.516
		Levene’s	3.4436		16
Pre_Deal	Post_Deal	Student’s <i>t</i>	1.13	16	0.863
		Mann–Whitney U	29.00		0.851
		Shapiro–Wilk	0.925		0.161
		Levene’s	0.8642		16

Note. 1. Levene’s Test: A low *p*-value suggests a violation of the assumption of equal variances. 2. Shapiro–Wilk Test: A low *p*-value suggests a violation of the assumption of normality.



5.3. Regression Analysis

To test Hypothesis 1, the result of performing a hierarchical regression analysis was that the explanatory power increased ( $p < 0.01$ ) to 42.2% when the sandbox variable was added. In addition, in model 3, the sandbox variable had the largest relative influence ( $B = 7.04, p < 0.05$ ). The relative influence of financial market development ( $B = -1.58, p > 0.05$ ) and Innovation Capacity ( $B = 4.22, p > 0.05$ ) was shown. Even this was not reliable because the significance level ( $p > 0.05$ ) was high. Therefore, Hypothesis 1 was supported. To test Hypothesis 2, the result of performing a hierarchical regression analysis was that the explanatory power increased ( $p < 0.05$ ) to 54.1% when the sandbox variable was added. In addition, also, in model 3, the sandbox variable had the largest relative influence ( $B = 7.98, p < 0.05$ ). The relative influence of financial market development was ( $B = -3.37, p > 0.05$ ) and Innovation Capacity ( $B = 2.78, p > 0.05$ ) was shown. Even this was not reliable because the significance level ( $p > 0.05$ ) was high. Therefore, Hypothesis 2 was supported. To test Hypothesis 3, the result of the hierarchical regression analysis was that the explanatory power increased to 14.2% when the sandbox variable was added, but it was out of statistical confidence level ( $p > 0.05$ ). In addition, also, in model 3, the sandbox variable had the largest relative influence ( $B = -4.22, p > 0.05$ ). Even this was not reliable because the significance level ( $p > 0.05$ ) was high. The relative influence of financial market development was ( $B = 3.86, p > 0.05$ ) and Innovation Capacity ( $B = 2.78, p > 0.05$ ) was shown. Even this was not reliable because the significance level ( $p > 0.05$ ) was high. Therefore, Hypothesis 3 was rejected. Detailed results are shown in Tables 11 and 12.

**Table 11.** Model comparisons and model fit measures.

Hypothesis	Model	R	R <sup>2</sup>	Adjusted R <sup>2</sup>	S.E. of Estimate	ΔR <sup>2</sup>	ΔF	p
H1	1	0.252	0.064	0.005	0.471677	0.064	1.085	0.313
	2	0.350	0.122	0.005	0.471583	0.059	1.006	0.376
	3	0.738	0.544	0.447	0.351677	0.422	12.972	0.01
H2	1	0.072	0.005	-0.057	1.140832	0.005	0.084	0.776
	2	0.172	0.030	-0.100	1.163652	0.024	0.379	0.798
	3	0.755	0.571	0.479	0.801119	0.541	17.648	0.007
H3	1	0.308	0.094	0.038	0.293877	0.094	1.678	0.214
	2	0.377	0.142	0.027	0.295466	0.047	0.828	0.316
	3	0.542	0.293	0.142	0.277488	0.151	3.007	0.169

**Table 12.** Model 3 coefficients.

Hypothesis	Predictor	B	S.E.	Stand. B.	t	p
H1	Intercept	-1.154	0.847		-1.362	0.195
	Fin_MarkDev	-0.119	0.162	-0.158	-0.733	0.476
	Innovation	0.306	0.170	0.361	1.802	0.093
	Sandbox	0.647	0.180	0.704	3.602	0.003
H2	Intercept	0.192	1.930		0.100	0.922
	Fin_MarkDev	-0.596	0.369	-0.337	-1.615	0.129
	Innovation	0.554	0.387	0.278	1.432	0.174
	Sandbox	1.720	0.409	0.798	4.201	0.001
H3	Intercept	-1.563	0.668		-2.339	0.035
	Fin_MarkDev	0.184	0.128	0.386	1.441	0.172
	Innovation	0.099	0.134	0.184	0.736	0.474
	Sandbox	-0.246	0.142	-0.422	-1.734	0.105

## 6. Discussion: The Relation between Regulatory Sandbox and Open Innovation

### 6.1. Summary of the Research Results

Through the research, the empirical analysis showed that the introduction of regulatory sandboxes had positive effects on venture investment in fintech industry. The nine countries (the United Kingdom, Singapore, Hong Kong, Australia, India, Canada, Malaysia, The Netherlands, and Japan) which introduced the regulatory sandboxes showed a remarkable increase in the size of venture investment (total investment and average investment). Hypothesis 1 predicted that the introduction of a regulatory sandbox would have a positive effect on the increase in the total amount of fintech venture investment. The effect of this variable was statistically significant in analysis 1, 2, and 3, providing overall support for this hypothesis. In detail, the total investment amount increased by 37.7% ( $p < 0.05$ ) on average. In addition, the total investment increased in eight countries. Hypothesis 2 predicted that the introduction of a regulatory sandbox would have a positive effect on the increase in the average amount of fintech venture investment. The effect of this variable is statistically significant in analysis 1, 2, and 3, providing overall support for this hypothesis. And the average investment amount showed a remarkable growth rate of 86.4% ( $p < 0.05$ ). The average investment amount increased in nine countries. As a result, it showed that the total investment amount, and the increase of the average investment amount of the country that introduced regulatory sandboxes, was higher than those that did not. However, Hypothesis 3 was not supported by these analyses. The result means that it is difficult to confirm that the number of investments in the introduction countries of the regulatory sandboxes was higher than that of non-introduction countries.

### 6.2. Regulatory Sandbox and Open Innovation

This research provides important policy implications. First, the introduction of regulatory sandboxes has an effect that promotes the investment of venture capital into the fintech industry. In the high-tech industry, the activation of venture investment is an important factor in the early-stage industrial maturity. This significant increase in the total amount of venture investment can be evidence that the regulatory sandboxes are functioning systematically as a practical deregulation device. Second, the introduction of the regulatory sandboxes provides a policy effect that reduces legal and institutional risks by eliminating uncertainty through the adoption of flexible and inclusive business models in startups of the new industry, fintech. While governments support new industries with platforms and policies, they also play an essential role in the sustainability of innovation by providing business friendly regulations [47]. The results show a significant increase in the average amount of venture investment in the fintech sector after the introduction of sandboxes compared to the non-introduced countries provide significant implications.

In addition, there are also some hints, which might be interpreted as suggesting the possibility that aggressive adoption of the regulatory sandbox provides positive incentives for venture capital to new industrial fields (artificial intelligence, blockchain, big data, etc.) that require intensive fostering, such as the fintech industry. From the perspective of creative venture companies driving innovation, the role of venture investment in an open innovation ecosystem is indispensable factor. From the perspectives of Schumpeterian entrepreneurial cyclical dynamics of open innovation, cooperative efforts between government and conglomerates are required to foster and sustain market open innovation, which is produced by a new combination, a creative unification of technology and markets including financial system such as VC and M&A [48]. In addition, the business-friendly regulatory environment strongly promotes open innovation systems by enabling new business models created through intensive collaboration with the private sector. Therefore, it seems reasonable to assume that the regulatory sandbox will act as a catalyst for creating an open innovation ecosystem by promoting the inflow of investment into the innovation ecosystem.

### 6.3. Regulatory Sandbox and Open Innovation in Fintech

Through this research, we confirmed that the regulatory sandbox serves as a positive catalyst for investments in the fintech sector. In addition, since the nine countries that adopted the regulatory sandbox had more sophisticated financial systems, we tried to prove the causal relationship using the development of the financial market as a control variable. Nevertheless, there are plenty of possibilities for other factors affecting investment in the fintech sector besides the regulatory sandbox. In addition, the ultimate goal of the adoption of the regulatory sandbox is the commercialization of new and innovative financial services. That is why many fintech startups are testing their business model on a test bed called a regulatory sandbox. It will be difficult for larger incumbent firms to match small creative startup firms at producing value-creating fintech business models and applications. As a result, it would be appropriate for larger firms to outsource, including M&A and JV, their fintech applications, instead of making directly them in-house [49].

In this context, the innovative business model of fintech ventures commercialized through the regulatory sandbox can be an attractive investment factor for venture capitalists and corporate venture capitals. In the United Kingdom, the first country to adopt a regulatory sandbox, 30% of venture companies that graduated from the regulatory sandbox received venture investment, and the average investment amount increased 6.6 times. In this context, it is not unreasonable to postulate that the regulatory sandbox has the expected effect of promoting investment in the fintech sector. Consequently, the regulatory sandbox greatly contributes to creating an open innovative ecosystem for fintech business by providing collaborating environments between a government and larger incumbent firms and fintech startups.

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