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Corporate Governance, Financial Innovation and Performance: Evidence from Taiwan's Banking Industry

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Abstract: This study explores the effect of corporate governance on financial innovation and the effect of financial innovation on performance in Taiwan's banking industry from 2011 to 2019. The results find that the banks have higher shareholding of institutional investors, ratio of independent directors, attendance rate of directors, average education level of directors and more directors with a financial or accounting background, the greater innovative financial services offered by banks. After 2015, the impact of corporate governance on banks' innovative financial services has increased. Moreover, the greater financial innovation services, the higher the bank profitability and value, especially after 2015. Finally, offering more innovative financial services can enhance the value of financial-holding subsidiary banks; by contrast, doing the same might negatively affect the profitability of nonfinancial-holding banks.

Keywords: corporate governance; ownership structure; board structure; financial innovation; bank performance



Citation: Wang, Lie-Huey, and Xin-Yuan Cao. 2022. Corporate Governance, Financial Innovation and Performance: Evidence from Taiwan's Banking Industry. *International Journal of Financial Studies* 10: 32. <https://doi.org/10.3390/ijfs10020032>

Academic Editor: Muhammad Ali Nasir

Received: 7 March 2022

Accepted: 5 May 2022

Published: 10 May 2022

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1. Introduction

The rapid development of financial technology is having a profound impact on the banking industry (Cruz-García et al. 2021; Hasan et al. 2020), and banking services over the last decade has evolved through financial technology. Banks' performance could be improved by generating income from fees in exchange for the convenience of innovative financial services or by enhancing the value-added services to customers. Innovation-growth hypothesis posits that financial innovation reshapes the way banks provide financial services and increases diversity of banking services (Berger 2003; Merton 1992). Therefore, the financial innovation enhances bank growth thanks to service improvement and diversity, risk-sharing and efficiency (Beck et al. 2016; Lee et al. 2021; Cho and Chen 2021). The literature has shown that banks located in countries with a higher level of financial innovation exhibit better growth of assets, loans and profits. It is important to a country to cope with financial innovation for its financial development by strengthening banks' performance and providing more diverse financial services. Overall, financial innovation is forcing the banking industry to confront changes, and it is worth studying more in-depth on whether it has impacted banks.

In recent years, Taiwan's government has promoted financial technology innovation and development. In 2015, the Establish a Digital Financial Environment 3.0 Project was implemented, and in 2016, the Financial Supervisory Commission issued the FinTech Development Strategy White Paper and proposed a vision of digital technology innovation and smart finance development. On 4 May 2017, the Regulations Governing Financial Technology Innovative Experimentation (also referred to as the Financial Regulatory Sandbox) were adopted. In September 2018, the first FinTech Space in Taiwan was established, and startups and corporate laboratories were recruited.

The rapid development of digital technology has prompted banks to adjust their conventional business model; the progression has entailed a move from conventional

physical branch banking (Bank 1.0) to Internet banking (Bank 2.0), mobile banking (Bank 3.0) and, finally, to banking everywhere (Bank 4.0) (King 2018). In response to the trend of financial technology, the banking industry has sought to recruit digital finance talents, to minimize the number of bank branches and to reduce the costs of operation via adopting artificial intelligence systems. According to the statistics on the number of domestic bank branches between 2011 and 2020 published by the Financial Supervisory Commission in Taiwan, the number of domestic bank branches reached a peak of 3460 in 2014, and then gradually decreased. As of 2020, the number stood at 3403.

Studies have discovered that firms' willingness to engage in financial innovation is closely related to corporate governance. Specifically, a good corporate governance system can effectively enhance innovation performance (Balsmeier et al. 2017; Chi 2017; Xiao and Zhao 2012). For example, when the shareholding ratio of directors in a firm is high, the directors are aligned with firm in terms of interests, and this drives investment in financial innovation (Chi 2017). Moreover, a higher ratio of independent directors has more influence on innovation activities (Balsmeier et al. 2017). Research has also indicated that financial innovation is positively correlated with the performance of banks (Cheng 2018; El-Chaarani and El-Abiad 2018; Liu 2019).

In 2015, the financial industry in Taiwan officially entered the Bank 3.0 phase. Since then, the government has promoted financial technology innovation and development in the financial industry. Therefore, 2015 is a crucial year in the development of financial innovation in the Taiwan's banking industry. The financial-holding subsidiary banks (called FHC banks) have larger market shares and abundant resources and can provide comprehensive financial services. They face greater market competition than independent banks (or called nonfinancial-holding banks, non-FHC banks), but in a more competitive market, they can readily spend resources on investment and development of financial innovation (Huang and Chiang 2014). In this study, we analyze the correlation between corporate governance, financial innovation and performance in Taiwan's banking industry before and after 2015. It should be an important topic for emerging markets whose financial innovation is in the developing stage and for the future competition of the banking industry.

This study makes the following three contributions. First, the effect of technology development on the banking industry has been widely discussed and mainly focuses on the phenomenon of the new financial industry; instead, a few studies empirically examine how the correlation between corporate governance and financial innovation impact banks' performance. Besides, our paper considers the effect of corporate governance of financial innovation in an emerging country, in particular, in contrast to previous studies that had focused on advanced economies. We explore this issue within the context of financial innovation development in Taiwan and find that banks have higher shareholding of institutional investors, ratio of independent directors, attendance rate of directors, average education level of directors and more directors with a financial or accounting background, the greater innovative financial services offered by banks. These could offer an additional insight to the existing research literature, and let government authority and financial supervisors understand the impact of corporate governance on bank financial innovation investment. Second, Taiwan's banking industry is in the early stages of financial innovation development. Hence, given that financial innovation data are limited, we retrieved relevant data directly from bank official websites and annual reports and then sorted and archive the data manually. To analyze the effect of financial innovation on bank performance, the number of innovative financial services offered by each bank is applied as the proxy variable for measuring financial innovation. Our study should be provided a reference to researching banking financial innovation issues under the limited data. Third, after 2015, the effect of corporate governance on financial innovation in Taiwan's banking industry increased. Although the innovative financial services have increased, the return on equity has decreased because the industry has not reached the required economies of scale. In addition, offering more innovative financial services can increase the value of FHC banks; by contrast, doing the same might negatively affect the performance of non-FHC banks.

This research contributes to providing new evidence that banks of an emerging country should pay close attention to the economics of scale and scope of innovative financial services, they will experience less short-term profitability as innovative financial services providing increases. However, innovative financial services will improve banks' franchise value especially for FHC banks in the long run.

The remainder of this paper is organized as follows. Section 2 is the literature review and presentation of hypotheses. Section 3 introduces the samples, variables and models. Section 4 presents the analysis and discussion of the empirical results. Section 5 is the conclusion.

2. Literature Review

Minetti et al. (2015) discover that ownership structure has a negative moderation effect on a firm's innovation investment. Choi et al. (2012) find that ownership concentration does not have a significant effect on firms' technological innovation performance, however, some ownership types (e.g., institutional or foreign shareholders) do have a positive effect. Ortega-Argiles et al. (2005) state that ownership and control structures are significant for a firm's undertaking of innovation activities. Tang and Zuo (2014) indicate that family-owned companies are more likely to engage in innovative development. Rong et al. (2017) reveal that institutional investors' shareholding significantly affects a firm's investment in innovative activity, and Xiao and Zhao (2012) suggest that government shareholding has a negative effect on financial innovation by banks. According to Chi (2017), if the shareholding ratios of directors and blockholders are higher, the bank tends to exhibit higher investment in financial innovation. From agency theory perspective, shareholders from different domains have different interests in monitoring and different preferences with regard to a bank's financial innovation activities. In Taiwan, the ownership structure of banks is generally dominated by institutional holdings. The average institutional investor ownership ratio is over 65%. Moreover, since 1990, Taiwan has promoted the privatization of state-owned banks. At present, only 6 banks remain state-owned bank. In our study, the ownership structure includes the shareholding ratio of directors (Jensen and Meckling 1976), the shareholding ratio of institutional investors (Pound 1988), whether the bank is a FHC bank (Huang and Chiang 2014). We propose the following hypothesis:

Hypothesis 1 (H1). *Ownership structure affects a bank's financial innovation.*

Balsmeier et al. (2017) demonstrate that a higher ratio of independent directors has a strong effect on a firm's innovation activities. Furthermore, independent directors have a positive moderating effect on a corporation's innovation investment (Chen et al. 2016; Lu and Wang 2018). Fu (2019) considers that having a CEO with a shorter tenure and more independent directors can encourage a firm's innovation. According to Gu (2020), innovation investment is negatively correlated with board size but positively correlated with the ratio of independent directors. Independent directors play dual roles, on one hand, they safeguard the interests of shareholders based on agency theory; on the other hand, they also provide advice and resources based on resource dependence theory. Thus, they play an important role in influencing the innovative financial services offered by a bank. In our study, the board structure includes the board size (Lin and Chang 2016), ratio of independent directors (Jensen and Meckling 1976) and attendance ratio of directors (Lin 2009). We propose the following hypothesis:

Hypothesis 2 (H2). *Board structure affects a bank's financial innovation.*

Talke et al. (2010) contend that the diversity of the top-management team (TMT) promotes innovation activities in a firm. Shen et al. (2020) believe that academic experience among the TMT can promote a firm's innovation and improve its performance. Studies have also contended that the board members with technological specialties is significantly and positively correlated with innovation (Li et al. 2019) and that an authoritative board

director can provide a firm with new perspectives and help promote innovative activity (Chen and Zhao 2019). Moreover, Li (2010) indicates that a CEO with a higher education level increases a firm's innovation intention. From resource dependence perspective, certain background characteristics of directors might influence their appetite for risk and the ability to manage financial innovation. Therefore, in our study, the background traits of directors include the average education level of directors, and the ratio of directors with a financial or accounting or legal background (Nien et al. 2017). We propose the following hypothesis:

Hypothesis 3 (H3). *Background traits of directors affect a bank's financial innovation.*

According to El-Chaarani and El-Abiad (2018), internet banking and a wide dispersion of ATMs are significantly and positively correlated with bank performance. The innovation of financial products is positively correlated with a bank's performance (Cheng 2018). In addition, the number of design and function patents held by a commercial bank is significantly and positively correlated with its performance (Liu 2019). Chang (2017) explores whether the training of digital finance professionals has an effect on bank performance and verifies that financial innovation has a positive influence on bank performance. However, Zhao et al. (2022) find that FinTech innovation reduces banks' profitability and asset quality for large state-owned commercial banks. In our study, financial innovation is measured by innovative financial services (i.e., digital services, data applications and artificial intelligence) offered by banks (Thakor 2020). We propose the following hypothesis:

Hypothesis 4 (H4). *Financial innovation has a positive correlation with a bank's performance.*

Based on the discussion of the aforementioned literature, our research models that examine the relationships between (1) corporate governance (including ownership structure, board structure and background traits of directors) and financial innovation, and (2) financial innovation and bank performance are exhibited as Figure 1.

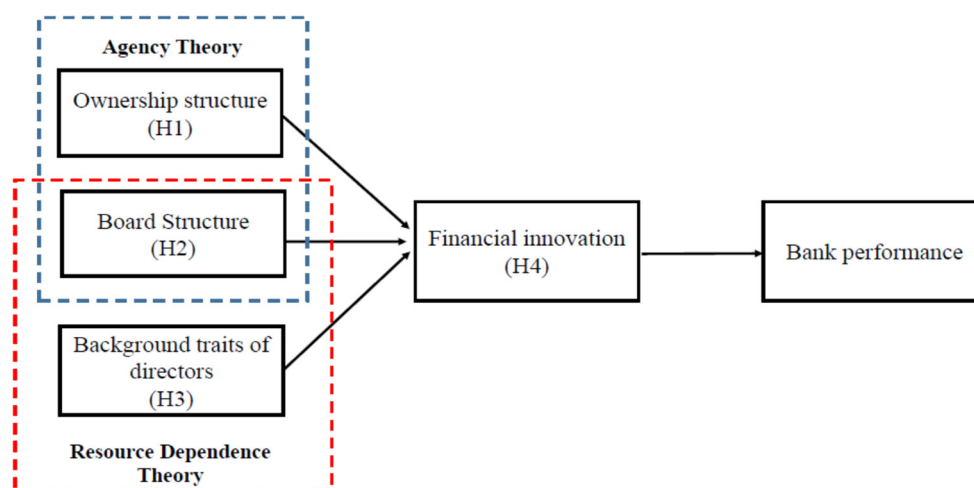


Figure 1. Research model of the relationship between corporate governance, financial innovation and performance.

3. Samples and Methods

3.1. Samples

We selected domestic banks in Taiwan as research subjects and collected relevant data from 2011 to 2019. Excluding those with insufficient empirical data, 24 commercial banks (216 yearly observations) were selected—14 FHC banks and 10 non-FHC banks. Corporate governance and financial data were retrieved from the Taiwan Economic Journal database. Taiwan's banking industry is still in the early phase of financial innovation.

Although financial innovation is growing year by year, relevant data remain insufficient and incomplete. Therefore, we retrieve data from official bank websites and annual reports and then organize and archive them manually. In addition, Taiwan's financial industry officially entered the Bank 3.0 phase in 2015, and since then, the innovative financial services offered by banks have increased. Hence, we set year 2015 as the year of demarcation to divide the research period into two periods: 2011–2014 and 2015–2019.

3.2. Variables

The empirical variables are divided into four categories, namely bank performance, financial innovation, corporate governance and bank-specific characteristics. We define profitability as the measured variables for bank performance, such as return on assets (ROA), return on equity (ROE) (Nien et al. 2017; Owen and Temesvary 2018), net interest margin (NIM) (Tan 2019), non-interest income (nonNIM) (Gulati et al. 2019) and Tobin's Q (Fu 2019; Li et al. 2019).

Given that data on bank financial innovation are limited, we apply the innovative financial services offered by banks as the proxy variable for financial innovation. We referred to the official websites and annual reports of the 24 commercial banks and classified the 28 innovative financial services into three types, namely digital services (14 items), data applications (7 items) and artificial intelligence (7 items).¹ We discover that the innovative financial services offered by the 24 commercial bank have increased annually. Particularly after 2015, the increase becomes rapid. From 2011 to 2014, the average number of items offered by banks of FHC and non-FHC are 5.9 and 4.8, respectively. However, the average number of items offered by banks of FHC and non-FHC are 17.8 and 13.3 during 2015–2019, respectively.

Furthermore, studies have indicated that the corporate governance variables that affect innovation investment are the ownership structure, board structure and the background traits of directors (Jensen and Meckling 1976; Lin and Chang 2016; Nien et al. 2017; Pound 1988). In our empirical models, variables such as the shareholding ratio of directors (Jensen and Meckling 1976), shareholding ratio of institutional investors (Pound 1988), whether the bank is a FHC bank (Huang and Chiang 2014), board size (Lin and Chang 2016), ratio of independent directors (Jensen and Meckling 1976), attendance rate of directors (Lin 2009), average education level of directors and ratio of directors with a financial or accounting or legal background (Nien et al. 2017) are incorporated. The empirical models also control the effect of bank-specific characteristics, namely the capital adequacy ratio, bank size (Chiu 2019) and bank age (Chen et al. 2016; Fu 2019). The operational definitions of the mentioned variables are presented in Table 1.

Table 1. Definition of variables.

Variable	Definition
Bank performance	
Return on assets (ROA)	$(\text{Net income after tax} / \text{average total assets}) \times 100$
Return on equity (ROE)	$(\text{Net income after tax} / \text{average shareholder equity}) \times 100$
Net interest margin (NIM)	$(\text{Net interest income} / \text{total assets}) \times 100$
Noninterest net income rate (nonNIM)	$(\text{Net fee income} + \text{other noninterest net income}) / \text{total assets} \times 100$
Tobin's Q (TobinQ)	$(\text{Year-end share price} \times \text{total number of ordinary shares outstanding} + \text{book value of long- and short-term liabilities}) / \text{total assets}$
Financial innovation	
Number of innovative financial services offered by banks (FIBUSINESS)	FIBUSINESS = \sum innovative financial services _i . The innovative financial services offered by the banks are classified into three types (i.e., digital service, data application and artificial intelligence). A total of 28 innovative financial services are offered by Taiwan's banks
Corporate governance	
Shareholding ratio of directors (BODHOLD)	$(\text{Number of shares of directors} / \text{total number of ordinary shares outstanding}) \times 100$
Shareholding ratio of institutional investors (INSTHOLD)	$[\text{Number of shares of legal entity (including government agencies, domestic financial institutions, domestic trust funds, domestic corporations, other domestic legal entities, overseas financial institutions, overseas legal entities and overseas trust funds)} / \text{total number of ordinary shares outstanding}] \times 100$
FHC bank (FHC)	Presented by a dummy variable. A financial-holding subsidiary bank, FHC = 1; a nonfinancial-holding bank, FHC = 0
Board size (BODSIZE)	Total number of directors
Ratio of independent directors (INDRATIO)	$(\text{Number of independent directors} / \text{total number of directors}) \times 100$
Attendance rate of directors (ATTEND)	$[\sum \text{actual attendance of each board director} / \sum (\text{actual attendance of each board director} / \text{attendance rate})] \times 100$
Average education level of directors (EDU)	Assign numerical values to the education level of directors: senior high school and below = 1, university = 2, master's degree = 3, doctoral degree = 4; average education level of directors = the sum of the education level numerical values of directors / total number of directors in the year
Ratio of directors with a financial or accounting background (ACCOUNT)	$(\sum \text{number of directors with a financial or accounting background} / \text{total number of directors}) \times 100$
Ratio of directors with a legal background (LAW)	$(\sum \text{number of directors with a legal background} / \text{total number of directors}) \times 100$
Bank-specific characteristics	
Capital adequacy ratio (CAR)	$\text{CAR} = (\text{Tier I} + \text{Tier II} + \text{Tier III (Capital funds)}) / \text{risk weighted assets} \times 100$
Bank size (SIZE)	Natural logarithm of the total assets
Bank age (AGE)	Years since the bank was founded

3.3. Empirical Models

The empirical data are of both cross-sectional and time series types. Given that the dummy variables do not change over time and collinearity may occur due to the fixed intercept term, the two-way panel data random-effects model is employed for empirical analysis (Pindyck and Rubinfeld 1998). We construct the following empirical equations to verify Hypotheses 1–4.

$$\text{FIBUSINESS}_{it} = \alpha_0 + \beta_1 \text{BODHOLD}_{it} + \beta_2 \text{INSTHOLD}_{it} + \beta_3 \text{BHC}_{it} + \beta_4 \text{CAR}_{it} + \beta_5 \text{SIZE}_{it} + \beta_6 \text{AGE}_{it} + u_i + \delta_t + \varepsilon_{it} \quad (1)$$

$$\text{FIBUSINESS}_{it} = \alpha_0 + \beta_1 \text{BODSIZE}_{it} + \beta_2 \text{INDRATIO}_{it} + \beta_3 \text{ATTEND}_{it} + \beta_4 \text{CAR}_{it} + \beta_5 \text{SIZE}_{it} + \beta_6 \text{AGE}_{it} + u_i + \delta_t + \varepsilon_{it} \quad (2)$$

$$\text{FIBUSINESS}_{it} = \alpha_0 + \beta_1 \text{EDU}_{it} + \beta_2 \text{ACCOUNT}_{it} + \beta_3 \text{LAW}_{it} + \beta_4 \text{CAR}_{it} + \beta_5 \text{SIZE}_{it} + \beta_6 \text{AGE}_{it} + u_i + \delta_t + \varepsilon_{it} \quad (3)$$

$$\text{PERFORMANCE}_{it} = \alpha_0 + \beta_1 \text{FIBUSINESS}_{it} + \beta_2 \text{CAR}_{it} + \beta_3 \text{SIZE}_{it} + \beta_4 \text{AGE}_{it} + u_i + \delta_t + \varepsilon_{it} \quad (4)$$

Equations (1)–(3) is used to examine the correlation between corporate governance and financial innovation, the dependent variable FIBUSINESS is the number of innovative financial services offered by banks. Equation (4) is used to examine the correlation between financial innovation and performance, the dependent variable PERFORMANCE is bank performance, the five dependent variables are namely ROA, ROE, NIM, nonNIM and TobinQ, respectively. u_i and δ_t are firm-effects and year-effects, respectively, and ε_{it} is the residual term. The definition of variables is presented in Table 1.

4. Empirical Results

4.1. Descriptive Statistical Analysis and Difference Comparison

Panel A in Table 2 displays that the medians of ROA, ROE and Tobin's Q are 0.65%, 8.64% and 0.10, respectively, where a greater difference in ROE is evident between banks. From 2011 to 2019, the median of the innovative financial services offered (FIBUSINESS) by the 24 commercial banks is 10, and the shareholding ratio of the institutional investors is approximately 66.26% on average, implying that Taiwan's banking industry is dominated by institutional shareholders. The board size is approximately 12, the median of the independent director ratio is 25% and the average of attendance rate of directors reaches 90.17%. The median of the average education level of directors is 2.92; hence, the directors with a master's degree are about the average. The average rate of directors with a financial accounting or legal background is 37.54% and 16.09%, respectively. In addition, Panels B and C in Table 2 show that the median of the innovative financial services offered by the FHC banks is 12.5, which is three items more than the median among the non-FHC banks. The FHC banks also have a higher shareholding ratio of institutional investors, independent director ratio and ratio of directors with a financial or accounting or legal background than do non-FHC banks.²

Table 2. Descriptive statistics of variables.

Variable	Panel A: All Sample			Panel B: FHC Banks			Panel C: Non-FHC Banks		
	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
ROA	0.692	0.650	0.362	0.692	0.690	0.286	0.692	0.600	0.449
ROE	8.653	8.640	3.276	8.606	8.720	2.840	8.720	8.640	3.825
NIM	0.005	0.004	0.005	0.006	0.004	0.006	0.005	0.004	0.002
nonNIM	0.012	0.011	0.004	0.013	0.011	0.005	0.012	0.011	0.003
TobinQ	0.110	0.100	0.048	0.120	0.110	0.056	0.095	0.090	0.029
FIBUSINESS	11.279	10.000	6.629	12.500	12.000	7.046	9.551	8.000	5.586
BODHOLD	17.497	11.040	15.503	15.327	8.885	15.377	20.569	20.510	15.242
INSTHOLD	66.260	68.260	16.417	68.710	70.400	9.811	62.791	64.260	22.315
BODSIZE	12.670	12.000	3.389	13.119	13.000	3.601	12.034	12.000	2.967
INDRATIO	27.096	25.000	7.930	27.876	26.136	8.597	25.991	25.000	6.769
ATTEND	90.177	91.620	5.829	90.129	90.380	5.279	90.246	92.610	6.560
EDU	2.902	2.923	0.357	3.019	3.077	0.318	2.736	2.778	0.344
ACCOUNT	37.548	33.333	0.259	44.826	40.000	0.290	27.367	26.970	0.160
LAW	16.096	9.096	0.198	17.485	9.091	0.233	14.153	10.556	0.134
CAR	85.027	118.910	62.429	135.865	132.015	19.414	13.055	13.220	1.730
SIZE	20.974	21.196	1.019	21.512	21.639	0.829	20.211	20.088	0.740
AGE	26.465	17.000	20.452	13.571	14.000	3.567	44.719	58.000	20.593

Notes: Definition of the variables is presented in Table 1.

The Table 3 reports the difference comparison *t*-test for before and after 2015, FHC and non-FHC banks, high and low innovation. Panel A in Table 3 displays that ROE, nonNIM and TobinQ are lower after 2015. This result explains that banks actively invested in innovative financial services, but their performance did not enhance. This may be due to the intense competition among banks or diseconomies of scale. Panel B in Table 3 shows that NIM, nonNIM, TobinQ and innovative financial services of FHC banks are significantly higher than non-FHC banks. Panel C in Table 3 shows that a bank of high innovative financial services has a higher net interest margin than a bank of low innovative financial services. It may be most of the innovative financial services used by customers are related to traditional net interest margin businesses.³

Table 3. The difference comparison *t*-test.

Variable	Panel A: Before vs. After 2015			Panel B: FHC vs. Non-FHC Banks			Panel C: High vs. Low Innovation		
	Before	After	<i>t</i> -Test	FHC	Non-FHC	<i>t</i> -Test	High	Low	<i>t</i> -Test
ROA	0.722 ^a	0.667	−1.119	0.692	0.692	0.014	0.689	0.692	−0.060
ROE	9.026	8.359	−1.4946 *	8.606	8.720	−0.265	8.612	8.671	−0.114
NIM	0.016	0.012	1.287 *	0.006	0.005	3.018 ***	0.013	0.011	1.752 **
nonNIM	0.005	0.004	−2.143 **	0.013	0.012	1.377 *	0.004	0.005	−0.584
TobinQ	0.116	0.104	−1.930 **	0.120	0.095	3.997 ***	0.112	0.108	0.601
FIBUSINESS	5.447	15.916	18.715 ***	12.500	9.551	3.323 ***	20.345	8.161	19.775 ***

Notes: ^a is the mean value. Definition of the variables is presented in Table 1. The asterisks ***, ** and * indicate significance levels of 1%, 5% and 10%, respectively.

4.2. Corporate Governance, Financial Innovation and Performance

The Table 4 reports the results of correlation between corporate governance and financial innovation. During the study period, in general, the more directors with a legal background, the fewer innovative financial services offered by banks. However, the higher shareholding of institutional investors, ratio of independent directors, attendance rate of directors, average education level of directors and more directors with a financial or accounting background, the more innovative financial services offered by banks. After 2015, the impact of corporate governance on innovative financial services offered by banks increases. This result is consistent with past literature findings that ownership (Chi 2017;

Choi et al. 2012; Ortega-Argiles et al. 2005; Xiao and Zhao 2012), board structure (Balsmeier et al. 2017; Chen et al. 2016; Fu 2019; Gu 2020; Lu and Wang 2018) and background traits of directors (Li 2010; Shen et al. 2020) are correlated with banks' investment in innovation. However, we did not find a significant correlation between the shareholding of directors and financial innovation, which is different from the previous literature (Chi 2017).

Table 4. The correlation between corporate governance and financial innovation.

Variable	Panel A: 2011–2014 Period			Panel B: 2015–2019 Period		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
BODHOLD	−0.027 (1.287)			0.021 (0.614)		
INSTHOLD	0.040 (2.162)			0.226 *** (9.721)		
FHC	−0.825 (0.333)			39.320 *** (12.956)		
BODSIZE		−0.389 *** (5.089)			0.343** (2.387)	
INDRATIO		0.032 (0.662)			0.302 *** (6.589)	
ATTEND		0.003 (0.087)			0.351 *** (10.285)	
EDU			2.126 *** (2.689)			−1.117 (1.342)
ACCOUNT			2.684 ** (2.318)			5.779 *** (8.157)
LAW			−2.329 * (1.747)			−3.347 * (1.974)
CAR	0.014 (1.002)	0.002 (0.300)	−0.001 (0.071)	−0.195 *** (11.667)	−0.036 *** (3.686)	−0.023 ** (2.199)
LNSIZE	1.156 ** (2.526)	1.532 *** (4.342)	1.034 *** (2.981)	0.596 (0.905)	3.881 *** (8.952)	5.426 *** (11.726)
AGE	0.056 * (1.959)	0.015 (0.685)	0.032 (1.471)	0.419 (10.959)	0.028 (0.947)	0.133 *** (4.043)
Constant	−22.734 ** (2.557)	−22.774 *** (3.012)	−23.394 *** (3.365)	−31.184 ** (2.361)	−108.729 *** (12.589)	−98.922 *** (10.476)
Firm-effect	yes	yes	yes	yes	yes	yes
Time-effect	yes	yes	yes	yes	yes	yes
Adj. R ²	0.017	0.141	0.065	0.448	0.318	0.257
F-statistic	1.282	3.610 ***	2.102 *	17.105 ***	10.170 ***	7.863 ***
Durbin-Watson	0.867	0.925	0.913	0.867	0.764	0.644

Note: Model 1 is Equation (1) used to verify H1. Model 2 is Equation (2) used to verify H2. Model 3 is Equation (3) used to verify H3. Definition of the variables is presented in Table 1. The value in parentheses is the t-value of the coefficient estimates. The asterisks ***, ** and * indicate significance levels of 1%, 5% and 10%, respectively.

The Table 5 reports the results for correlation between financial innovation and bank performance.⁴ In Taiwan, the financial innovation of the banking industry was still in its infancy during 2011–2014. Not many banks provide innovative financial services, and the market competition is low, it can be profitable. Panel A in Table 5 shows that innovative financial activities have a positive impact on ROA, ROE and nonNIM. Under the encouragement and promotion of the Taiwan government, the banking industry has actively invested in financial innovation, and the innovative financial services provided have increased year by year after 2015. However, the market competition has also become intense. Panel B in Table 5 shows that ROE is negatively affected whereas a positive effect is observed in NIM, non-NIM and Tobin's Q.⁵ Our empirical findings are consistent with past literature findings that financial innovation contribute to improved bank performance (Cheng 2018; El-Chaarani and El-Abiad 2018).

Table 5. The correlation between financial innovation and bank performance.

Panel A: 2011–2014 Period					
Variable	ROA	ROE	NIM	nonNIM	TobinQ
FIBUSINESS	0.033 *** (3.383)	0.305 *** (3.025)	0.001 (4.301)	0.001 *** (2.754)	0.001 (1.193)
CAR	0.002 (1.296)	−0.006 (0.421)	0.000 * (1.855)	0.000 (0.479)	0.001 *** (6.947)
LNSIZE	−0.045 (0.651)	1.324 * (1.771)	−0.003 *** (3.893)	−0.001 * (1.778)	−0.052 *** (5.908)
AGE	0.007 * (1.719)	0.067 (1.426)	0.000 (0.813)	0.000 (0.152)	0.001 (2.276)
Constant	1.145 (0.821)	−21.272 (1.391)	0.068 *** (4.301)	0.039 ** (2.546)	1.063 *** (5.848)
Firm-effect	yes	yes	yes	yes	yes
Time-effect	yes	yes	yes	yes	yes
Adj. R ²	0.090	0.181	0.129	0.025	0.025
F-statistic	3.363 ***	5.036 ***	4.525 ***	1.619	16.230 ***
Durbin-Watson	1.606	1.795	1.427	1.339	1.514
Panel B: 2015–2019 Period					
Variable	ROA	ROE	NIM	nonNIM	TobinQ
FIBUSINESS	−0.003 (0.895)	−0.080 ** (2.248)	0.001 *** (11.687)	0.001 *** (3.271)	0.002 *** (4.978)
CAR	0.002 * (1.947)	0.002 (0.247)	0.000 *** (6.079)	0.000 (1.334)	0.001 *** (6.403)
LNSIZE	−0.055 (1.074)	1.352 *** (3.373)	−0.005 *** (11.880)	0.004 *** (5.594)	−0.031 *** (6.554)
AGE	0.006 * (1.834)	0.039 (1.510)	0.000 (0.313)	0.000 (0.518)	0.001 ** (2.372)
Constant	1.520 (1.457)	−20.189 ** (2.506)	0.104 *** (11.687)	−0.067 *** (4.512)	0.654 *** (6.778)
Firm-effect	yes	yes	yes	yes	yes
Time-effect	yes	yes	yes	yes	yes
Adj. R ²	0.024	0.111	0.559	0.181	0.181
F-statistic	1.721	3.596 ***	38.688 ***	7.567 ***	12.525 ***
Durbin-Watson	1.742	1.506	1.197	1.269	1.039

Notes: Equation (4) is used to verify H4, the five dependent variables are namely ROA, ROE, NIM, non-NIM and TobinQ, respectively. Definition of the variables is presented in Table 1. The value in parentheses is the t-value of the coefficient estimates. The asterisks ***, ** and * indicate significance levels of 1%, 5% and 10%, respectively.

Besides, considering the endogeneity of Equations (1)–(4), we also use the two-stage simultaneous equations (2SLS) to analyze the correlation between financial innovation and bank performance. The results of the second-stage regression analysis are shown in Table 6. During 2011–2014, the innovative financial services only positively related to ROA and ROE. Except NIM, the innovative financial services positively related to the banks' ROA, ROE, nonNIM and TobinQ after 2015. The results are the same as the results of Table 5.

Finally, we further to make some robustness analyses. Taking the top 25% of the number of innovative financial services offered by banks as high financial innovation, we divide the sample of two groups: high financial innovation and low financial innovation. The dummy variable High is used as an indicator to distinguish high and low levels of financial innovation. In Equation (4), we add an additional interaction variable FIBUSINESSE × High to analyze how the difference in high and low levels of financial innovation impacted on bank performance. Besides, we also consider the year of 2015 and after as a dummy variable, and add an additional interaction variable FIBUSINESSE × After to the Equation (4) to measure the impact of new regulations after 2015. The results are presented in Table 7.

Table 6. The effect of financial innovation on bank performance considering endogeneity.

Panel A: 2011–2014 Period					
Variable	ROA	ROE	NIM	nonNIM	TobinQ
FIBUSINESS	0.122 ** (0.059)	1.299 ** (0.536)	0.001 (0.001)	−0.001 (0.001)	−0.001 (0.003)
Adj. R ²	0.0098	0.0174	0.0139	0.3176	0.3820
Wald χ^2	14.89 **	22.08 ***	4.03	24.73 ***	82.61 ***
Panel B: 2015–2019 Period					
Variable	ROA	ROE	NIM	nonNIM	TobinQ
FIBUSINESS	0.060 * (0.001)	0.613 ** (0.271)	−0.001 (0.001)	0.001 * (0.001)	0.006 ** (0.003)
Adj. R ²	0.1980	0.3501	0.1203	0.4473	0.3612
Wald χ^2	16.33 **	35.43 ***	31.48 ***	85.69 ***	46.84 ***

Notes: The results of the first-stage regression analysis and the firm-specific variables are not presented in Table 6. Definition of the variables is presented in Table 1. The value in parentheses is the t-value of the coefficient estimates. The asterisks ***, ** and * indicate significance levels of 1%, 5% and 10%, respectively.

In Panel A of Table 7, the coefficients of FIBUSINESSE \times High for ROA and TobinQ are 0.006 and 0.001, respectively, and are significant. The results show that the greater financial innovation services provided by the bank, the higher the bank's profitability and value. In Panel B of Table 7, the coefficients of FIBUSINESSE \times After are 0.259 and 0.002 for ROE and TobinQ, respectively, and are significant. The evidence shows that after 2015, innovative financial services can enhance bank profitability and value.

Table 7. The results of robustness analysis.

Panel A: The Impact of High and Low Levels of Financial Innovation					
Variable	ROA	ROE	NIM	nonNIM	TobinQ
FIBUSINESS	−0.009 (0.007)	−0.034 (0.086)	0.001 (0.001)	0.000 (0.000)	0.001 (0.001)
FIBUSINESS \times High	0.006 ** (0.003)	0.050 (0.033)	0.001 (0.001)	0.000 (0.000)	0.001 * (0.001)
Adj. R ²	0.2661	0.1951	0.0955	0.3636	0.3035
Wald χ^2	70.94 **	54.54 ***	43.46 ***	107.87 ***	193.18 ***
Panel B: The Impact of New Regulations Issue after 2015					
Variable	ROA	ROE	NIM	nonNIM	TobinQ
FIBUSINESS	−0.002 (0.012)	−0.140 (0.133)	−0.001 (0.001)	0.000 (0.000)	−0.001 (0.001)
FIBUSINESS \times After	0.011 (0.013)	0.259 * (0.136)	−0.001 (0.001)	0.000 (0.000)	0.002 * (0.001)
Adj. R ²	0.2277	0.1982	0.0944	0.3611	0.3415
Wald χ^2	46.50 **	54.15 ***	32.24 ***	79.61 ***	275.08 ***

Notes: The results of the firm-specific variables are not presented in Table 7. Definition of the variables is presented in Table 1. The value in parentheses is the t-value of the coefficient estimates. The asterisks ***, ** and * indicate significance levels of 1%, 5% and 10%, respectively.

4.3. The FHC Banks and Non-FHC Banks Analysis

Table 8 reports the results of correlation between corporate governance and financial innovation for FHC and non-FHC banks. Panel A in Table 8 shows that, during the study period, FHC banks have the higher shareholding of directors, attendance rate of directors, and more directors with a financial or accounting background, they tend to provide more innovative financial services. Panel B in Table 8 shows that, after 2015, non-FHC banks have the higher shareholding of institutional investors, attendance rate of directors and

more directors with a financial or accounting background, they provide more innovative financial services.

From the perspective of agency theory, the higher the shareholding of the directors of FHC banks, the higher the level of investment in financial innovation based on the consideration of the overall interests in the financial holding group. However, non-FHC banks have higher shareholding of institutional investors, based on the bank's profitability and market competitiveness, institutional shareholders will promote banks to invest in financial innovation. In addition, the higher attendance rate of directors, the stronger the directors' supervision of the bank. Directors will support the bank's investment in financial innovation. Finally, based on the theory of resource dependence, directors have a financial or accounting background, they improve banks to invest more financial innovation and to enhance the competitiveness of banks.

Table 8. The correlation between corporate governance and financial innovation for FHC and non-FHC banks.

Panel A: FHC Banks						
Variable	2011–2014 Period			2015–2019 Period		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
BODHOLD	0.061 ** (2.058)			0.122 ** (2.482)		
INSTHOLD	0.014 (0.397)			0.012 (0.419)		
BODSIZE		−0.109 (1.145)			0.092 (0.750)	
INDRATIO		0.081 (1.297)			0.011 (0.281)	
ATTEND		−0.078 (1.395)			0.160 *** (3.510)	
EDU			−1.042 (1.141)			0.327 (0.325)
ACCOUNT			4.934 *** (3.628)			0.706 (1.162)
LAW			−5.192 *** (3.489)			−2.290 (1.330)
CAR	0.002 (0.171)	0.003 (0.189)	−0.002 (0.170)	−0.040 ** (2.531)	0.092 *** (4.249)	−0.044 ** (2.600)
LNSIZE	1.460 (2.846)	1.322 ** (2.627)	0.787 (1.645)	−0.243 (0.337)	−0.901 (1.502)	−1.124 (1.579)
AGE	1.114 (10.027)	1.063 *** (8.341)	0.997 *** (10.087)	2.350 *** (22.300)	2.027 *** (17.294)	2.391 *** (21.845)
Constant	−39.778 *** (3.345)	−28.035 ** (2.372)	−19.529 * (1.810)	−10.841 (0.638)	−1.740 (0.122)	9.749 (0.599)
Firm-effect	yes	yes	yes	yes	yes	yes
Time-effect	yes	yes	yes	yes	yes	yes
Adj. R ²	0.430	0.459	0.447	0.895	0.867	0.893
F-statistic	9.304 ***	8.766 ***	8.420 ***	118.964 ***	76.258 ***	96.489 ***
Durbin-Watson	0.731	0.751	0.823	0.624	0.714	0.608

Table 8. Cont.

Panel B: Non-FHC Banks						
Variable	2011–2014 Period			2015–2019 Period		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
BODHOLD	−0.020 (1.191)			−0.081 (1.374)		
INSTHOLD	−0.005 (0.431)			0.244 *** (6.283)		
BODSIZE		−0.078 (0.877)			0.297 (0.547)	
INDRATIO		0.016 (0.245)			0.281 (1.282)	
ATTEND		0.041 (1.249)			0.266 *** (4.999)	
EDU			1.852 ** (2.391)			−3.646 *** (2.897)
ACCOUNT			−0.958 (0.609)			13.449 *** (5.124)
LAW			1.878 (1.034)			−0.085 (0.024)
CAR	−0.901 *** (7.234)	−0.865 *** (8.829)	−0.655 *** (4.958)	0.903 *** (3.030)	0.787 *** (3.144)	1.121 *** (3.868)
LNSIZE	0.383 (1.199)	0.131 (0.306)	0.234 (0.545)	3.071 ** (2.343)	1.664 ** (2.316)	1.606 * (1.882)
AGE	−0.046 *** (2.806)	−0.033 ** (2.176)	−0.021 (1.321)	0.207 *** (3.970)	0.011 (0.398)	0.083 *** (2.726)
Constant	11.171 ** (1.819)	11.461 (1.219)	4.286 (0.504)	−85.400 *** (3.334)	−66.760 *** (3.127)	−31.692 * (1.916)
Firm-effect	yes	yes	yes	yes	yes	yes
Time-effect	yes	yes	yes	yes	yes	yes
Adj. R ²	0.369	0.364	0.207	0.317	0.196	0.208
F-statistic	5.559 ***	4.717 ***	2.698 **	5.552 ***	2.952 **	3.143 **
Durbin-Watson	1.194	1.228	1.108	0.723	0.761	0.746

Note: Model 1 is Equation (1) used to verify H1. Model 2 is Equation (2) used to verify H2. Model 3 is Equation (3) used to verify H3. Definition of the variables is presented in Table 1. The value in parentheses is the t-value of the coefficient estimates. The asterisks ***, ** and * indicate significance levels of 1%, 5% and 10%, respectively.

Table 9 reports the results of correlation between financial innovation and performance for FHC and non-FHC banks. Panel A in Table 9 shows that, during 2011–2014, the effect of the financial innovation on bank performance is not obvious. Because during this period, financial innovation in Taiwan's banking industry is still in its infancy, and there were few financial innovation services provided, so the correlation with bank performance was not significant. Panel B in Table 9 shows that, after 2015, FHC banks provide more innovative financial services, it can increase their value; however, non-FHC banks provide more innovative financial services, their ROA, ROE and non-MIN may decrease. FHC banks have larger market shares and abundant resources, thus they have the advantages of scale and scope economy compared to non-FHC banks. Therefore, innovative financial services can enhance the value of FHC banks in the long run. However, non-FHC banks should be more prudent to evaluate the contribution that innovative financial services can bring to the bank.

Table 9. The correlation between financial innovation and performance for FHC and non-FHC banks.

Panel A: 2011–2014 Period										
Variable	FHC Banks					Non – FHC Banks				
	ROA	ROE	NIM	nonNIM	TobinQ	ROA	ROE	NIM	nonNIM	TobinQ
FIBUSINESS	0.025 (1.659)	0.159 (1.162)	0.000 (4.165)	0.000 (0.393)	−0.001 (0.698)	0.021 (1.086)	0.227 (1.009)	0.000 (0.049)	0.000 (0.309)	0.001 (1.032)
CAR	0.002 (0.631)	0.006 (0.263)	0.000 (0.953)	0.000 *** (3.102)	0.001 *** (3.731)	0.110 *** (3.267)	0.563 (1.337)	0.001 *** (2.606)	0.000 *** (2.573)	0.004 * (1.785)
LNSIZE	−0.037 (0.411)	2.293 *** (2.949)	−0.006 *** (4.132)	−0.003 ** (2.545)	−0.072 *** (5.650)	−0.316 ** (2.665)	−1.842 (1.071)	0.000 (0.277)	−0.003 * (2.003)	0.002 (0.130)
AGE	0.043 * (1.682)	0.518 ** (2.404)	0.000 (0.275)	0.000 (1.568)	0.008 (2.036)	0.015 (3.397)	0.111 * (1.776)	0.000 * (1.920)	0.000 ** (2.668)	0.000 (0.530)
Constant	0.676 (0.323)	−47.792 ** (2.610)	0.136 ** (4.165)	0.073 *** (3.101)	1.478 *** (5.267)	4.966 ** (2.134)	33.847 (1.009)	0.001 (0.049)	0.063 ** (2.587)	−0.004 (0.017)
Firm-effect	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year-effect	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Adj. R ²	0.170	0.077	0.200	0.116	0.116	0.214	0.108	0.303	0.219	0.219
F-statistic	3.822 ***	1.903 ***	4.448 ***	2.810 **	15.268 ***	3.647 **	1.057	5.236 ***	3.733 **	0.884
Durbin-Watson	1.732	1.673	1.594	1.447	1.428	1.832	2.033	1.669	1.315	1.058
Panel B: 2015–2019 Period										
Variable	FHC Banks					Non – FHC Banks				
	ROA	ROE	NIM	nonNIM	TobinQ	ROA	ROE	NIM	nonNIM	TobinQ
FIBUSINESS	0.003 (0.502)	0.059 (0.882)	0.000 (8.646)	0.000 (1.577)	0.002 ** (2.388)	−0.019 *** (2.959)	−0.194 *** (3.330)	0.000 (2.021)	0.000 *** (3.135)	0.001 (1.156)
CAR	0.003 * (1.769)	0.030 (1.569)	0.000 ** (2.037)	0.000 (0.641)	0.000 * (1.792)	0.144 *** (6.084)	0.874 *** (4.673)	0.000 (0.199)	0.000 * (1.951)	0.007 *** (3.552)
LNSIZE	−0.029 (0.610)	2.155 *** (4.613)	−0.006 *** (9.300)	0.006 *** (4.944)	−0.062 *** (8.820)	−0.231 *** (3.427)	−0.461 (1.018)	−0.001 (1.472)	−0.003 *** (4.644)	−0.002 (0.281)
AGE	0.005 (0.361)	−0.062 (0.458)	0.000 (0.238)	0.000 (1.078)	0.001 (0.292)	0.013 *** (5.197)	0.092 *** (5.637)	0.000 (0.801)	0.000 *** (6.080)	0.000 (1.238)
Constant	0.792 (0.691)	−42.107 *** (3.563)	0.139*** (8.646)	−0.117*** (4.370)	1.369 *** (8.339)	3.090 ** (2.294)	3.915 (0.428)	0.025 ** (2.021)	0.059 (5.088)	0.014 (0.091)
Firm-effect	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year-effect	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Adj. R ²	0.021	0.227	0.650	0.291	0.291	0.462	0.471	0.165	0.403	0.403
F-statistic	1.364	4.771 **	33.065***	8.085***	15.250 ***	11.511 ***	10.029 ***	3.415 **	9.254 ***	4.664 ***
Durbin-Watson	1.742	1.337	1.360	1.495	0.846	1.595	1.557	1.157	0.855	1.205

Notes: Equation (4) is used to verify H4, the five dependent variables are namely ROA, ROE, NIM, non-NIM and TobinQ, respectively. Definitions of the variables is presented in Table 1. The value in parentheses is the t-value of the coefficient estimates. The asterisks ***, ** and * indicate significance levels of 1%, 5% and 10%, respectively.

5. Conclusions

In recent years, the rapid development of digital technology has prompted changes in the business model of banks. The business model has shifted from conventional physical bank branches to internet banking and then to mobile banking. In our study, the number of innovative financial services offered by a bank is used as the proxy variable to measure financial innovation. The results find that, during 2011–2019, the banks have higher shareholding of institutional investors, ratio of independent directors, rate of directors' attendance, average education level of directors and ratio of directors with a financial or accounting background, the greater innovative financial services offered by banks. After 2015, the influence of corporate governance on banks' innovative financial services has increased. Moreover, the greater financial innovation services, the higher the bank profitability and value, especially after 2015. Finally, offering more innovative financial services can enhance the value of financial-holding subsidiary banks; by contrast, doing the same might negatively affect the profitability of nonfinancial-holding banks.

From the point of view of agency theory, the higher the shareholding of directors and institutional investors, the shareholders' personal interests are consistent with the

firm's interests and will support the bank's investment innovation. From the perspective of agency theory of board structure, the higher attendance rate of directors, the stronger the directors' supervision of the bank, which will support the bank's investment in financial innovation. From the perspective of resource dependence theory, the more directors with a financial or accounting background, they will approve the bank's investment in financial innovation. These could offer an additional insight to the existing research literature. In addition, banks will experience less profitability as innovative financial services providing increases because of diseconomies of scale in the short run. However, innovative financial services will enhance banks' franchise value especially for FHC banks in the long run. Our research contributes to providing new evidence that banks of an emerging country should pay close attention to the economics of scale and scope of innovative financial services. This could provide a reference to government authority and financial supervisors.

Due to data limitations, our study did not discuss the effects of ownership by different identities and attributes, such as government, financial industry, consortium legal person, technology legal person, trusted service manager, third party payment and telecom operator, these institutional investors will affect the innovative financial services offered by a bank. How will bank's loans grating, deposits and capital raising be affected by innovative financial services? The aforementioned issues can be extended for the future research. Furthermore, cross-country comparison research considering regulation and governance differences can be further investigated.

Author Contributions: Conceptualization, methodology, validation, and writing—review and editing, L.-H.W.; formal analysis, L.-H.W. and X.-Y.C.; data curation and writing—original draft preparation, X.-Y.C. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

Notes

- ¹ Digital service has 14 items, including personal internet banking, mobile banking, digital banking and mobile payment; data application has 7 items, including big data analysis, machine learning, cloud computing and financial blockchain; artificial intelligence has 7 items, including robo-advisor, finance automation, social marketing and biometric APP authentication.
- ² The Pearson correlation coefficients and variance inflation factor (VIF) are used to test the correlation and collinearity between variables. The correlation coefficient of most variables ranges between -0.477 and 0.630 . In addition, the value of FIV of FHC dummy variable is 14.17 , but that of the remaining variables is less than 10 .
- ³ In our empirical data, more than 50% of the 28 innovative financial services offered by Taiwan's banks are related to internet banking, mobile banking, digital banking and electronic payment.
- ⁴ Considering the impact of lagged factors of innovative financial services, in Equation (4), in addition to $FIBUSINESS_{it}$, we also add an additional variable $FIBUSINESS_{it-1}$. The results find that, during the period of 2011–2014, there is no significant correlation between bank performance and the number of innovative financial services, whether in the current period or the previous period. However, both ROA and ROE are significantly correlated with current number of innovative financial services during 2015–2019. This result may be related to the accounting period assumption, which make the current performance of the bank highly correlated with innovative financial services of the same period.
- ⁵ The endogeneity may be present in innovative financial services and bank performance, the dynamic GMM (Arellano and Bover 1995; Blundell and Bond 1998) is also adopted for analysis. The results are similar to the results in Table 5.

References

- Arellano, Manuel, and Olympia Bover. 1995. Another Look at the Instrumental Variable Estimation of Error Component Models. *Journal of Econometrics* 68: 29–51. [\[CrossRef\]](#)
- Balsmeier, Benjamin, Lee Fleming, and Gustavo Manso. 2017. Independent boards and innovation. *Journal of Financial Economics* 123: 536–57. [\[CrossRef\]](#)
- Beck, Thorsten, Tao Chen, Chen Lin, and Frank M. Song. 2016. Financial innovation: The bright and the dark sides. *Journal of Banking and Finance* 72: 28–51. [\[CrossRef\]](#)
- Berger, Allen N. 2003. The economic effects of technological progress: Evidence from the banking industry. *Journal of Money, Credit, and Banking* 35: 141–76. [\[CrossRef\]](#)

- Blundell, Richard, and Stephen Bond. 1998. Initial Conditions and Moment Restrictions in Dynamic Panel Data Models. *Journal of Econometrics* 87: 115–43. [\[CrossRef\]](#)
- Chang, Ruei-Fen. 2017. The Analysis of the Relationship of Financial Innovation and Bank Profitability. Master's thesis, Department of Wealth and Taxation Management, National Kaohsiung University of Applied Sciences, Kaohsiung, Taiwan. (In Chinese)
- Chen, Chung-Jen, Bou-Wen Lin, Ya-Hui Lin, and Yung-Chang Hsiao. 2016. Ownership structure, independent ard members and innovation performance: A contingency perspective. *Journal of Business Research* 69: 3371–79. [\[CrossRef\]](#)
- Chen, Xinsheng, and Yang Zhao. 2019. Authoritative professional directors, executive incentive, and innovation activity. *Journal of Management Sciences in China* 3: 40–52. (In Chinese)
- Cheng, Chi-Feng. 2018. The Effect of Financial Innovation on Bank's Management Efficiency and Productivity. Master's thesis, Department of Finance, Nanhua University, Chia-yi, Taiwan. (In Chinese)
- Chi, Chen-Yen. 2017. The Effect of Corporate Governance on Financial Innovation—Taiwan's Financial Industry as an Example. Master's thesis, Department of Industrial Management and Information, Southern Taiwan University Science and Technology, Tainan, Taiwan. (In Chinese)
- Chiu, Li-Ching. 2019. The impact of auditor industry specialization and bank ownership on bank credit risk. *Journal of Management and System* 26: 43–47. (In Chinese)
- Cho, Tsui-Yueh, and Yi-Shuan Chen. 2021. The impact of financial technology on China's banking industry: An application of the metafrontier cost Malmquist productivity index. *North American Journal of Economics and Finance* 57: 101414. [\[CrossRef\]](#)
- Choi, Suk Bong, Byung Il Park, and Paul Hong. 2012. Does ownership structure matter for firm technological innovation performance? The case of Korean firms. *Corporate Governance: An International Review* 20: 267–88. [\[CrossRef\]](#)
- Cruz-García, Paula, Juan Fernández de Guevara, and Joaquín Maudos. 2021. Bank competition and multimarket contact intensity. *Journal of International Money and Finance* 113: 102338. [\[CrossRef\]](#)
- El-Chaarani, Hani, and Zouhour El-Abiad. 2018. The impact of technological innovation on bank performance. *Journal of Internet Banking and Commerce* 23: 1–33.
- Fu, Yishu. 2019. Independent directors, CEO career concerns, and firm innovation: Evidence from China. *The North American Journal of Economics and Finance* 50: 101037. [\[CrossRef\]](#)
- Gu, Shanshan. 2020. Effects of corporate governance on R&D investment in Marine technology enterprises. *Journal of Coastal Research* 110: 167–70.
- Gulati, Rachita, Anju Goswami, and Sunil Kumar. 2019. What drives credit risk in the Indian banking industry? *An empirical investigation. Economic Systems* 43: 42–62.
- Hasan, Rashedul, Mohammad Kabir Hassan, and Sirajo Aliyu. 2020. Fintech and Islamic finance: Literature review and Research agenda. *International Journal Islamic Economics and Finance Studies* 3: 75–94. [\[CrossRef\]](#)
- Huang, Tai-Hsin, and Tien-Lin Chiang. 2014. Relationship between market competitiveness and financial innovation in Taiwan's banking industry. *Journal of the Central Bank* 36: 15–52. (In Chinese)
- Jensen, Michael C., and William H. Meckling. 1976. Theory of the firm: Managerial behavior, agency costs and ownership structure. *Journal of Financial Economics* 3: 305–60. [\[CrossRef\]](#)
- King, Brett. 2018. *Bank 4.0: Banking Everywhere, Never at a Bank*. Hoboken: John Wiley & Sons.
- Lee, Chi-Chuan, Xinrui Li, Chin-Hsien Yu, and Jinsong Zhao. 2021. Does FinTech innovation improve bank efficiency? Evidence from China's banking industry. *International Review of Economics and Finance* 74: 468–83. [\[CrossRef\]](#)
- Li, Chien-Ping. 2010. Empirical study on the sources of internal innovation power in enterprises. *Journal of Technology Management Research* 30: 220–23. (In Chinese)
- Li, Yunhe, Yu Liu, and Feixue Xie. 2019. Technology directors and firm innovation. *Journal of Multinational Financial Management* 50: 76–88. [\[CrossRef\]](#)
- Lin, Kun-Li, and Yuan Chang. 2016. Corporate governance reform, board structure, and its determinants in the banking industry evidence from Taiwan. *Emerging Markets Finance and Trade* 52: 2001–17. [\[CrossRef\]](#)
- Lin, Yu-Cheng. 2009. Correlation between the Motivation and Ability of the Board of Directors, Strategic Resources Input, and Business Performance. Master's thesis, Department of Accounting, National Chengchi University, Taipei, Taiwan. (In Chinese)
- Liu, Li-Ling. 2019. A Study on the Determinants of Taiwan Commercial banks' Performance. Master's thesis, Department of Finance, National Taipei University of Business, Taipei, Taiwan. (In Chinese)
- Lu, Jun, and Wei Wang. 2018. Managerial conservatism, board independence and corporate innovation. *Journal of Corporate Finance* 48: 1–16. [\[CrossRef\]](#)
- Merton, Robert C. 1992. Financial innovation and economic performance. *The Journal of Applied Corporate Finance* 4: 12–22. [\[CrossRef\]](#)
- Minetti, Raoul, Pierluigi Murro, and Monica Paiella. 2015. Ownership structure, governance, and innovation. *European Economic Review* 80: 165–93. [\[CrossRef\]](#)
- Nien, Chi-Wei, Chang-Yuan Chang, and Min-Cheng Hsu. 2017. The linkage between board diversity and corporate risk. *Cross-Strait Banking and Finance* 5: 69–111. (In Chinese)
- Ortega-Argiles, Raquel, Rosina Moreno, and Jordi Surinach Caralt. 2005. Ownership structure and innovation: Is there a real link? *The Annals of Regional Science* 39: 637–62. [\[CrossRef\]](#)
- Owen, Ann L., and Judit Temesvary. 2018. The performance effects of gender diversity on bank boards. *Journal of Banking and Finance* 90: 50–63. [\[CrossRef\]](#)

- Pindyck, Robert S., and Daniel L. Rubinfeld. 1998. *Econometric Model and Economics Forecast*. Singapore: Irwin.
- Pound, John. 1988. Proxy contests and the efficiency of shareholder oversight. *Journal of Financial Economics* 20: 237–65. [[CrossRef](#)]
- Rong, Zhao, Xiaokai Wu, and Philipp Boeing. 2017. The effect of institutional ownership on firm innovation: Evidence from Chinese listed firms. *Research Policy* 46: 1533–51. [[CrossRef](#)]
- Shen, Huayu, Fengyun Lan, Hao Xiong, Jun Lv, and Jianhui Jian. 2020. Does top management Team's academic experience promote corporate innovation? Evidence from China. *Economic Modelling* 89: 464–75. [[CrossRef](#)]
- Talke, Katrin, Sören Salomo, and Katja Rost. 2010. How top management team diversity affects innovativeness and performance via the strategic choice to focus on innovation fields. *Research Policy* 39: 907–18. [[CrossRef](#)]
- Tan, Yong. 2019. Competition and profitability in the Chinese banking industry: New evidence from different ownership types. *Journal of Industry, Competition and Trade* 20: 503–26. [[CrossRef](#)]
- Tang, Yue-Jun, and Jing-Jing Zuo. 2014. Characteristics of ownership, blockholders' governance, and corporate innovation. *Journal of Financial Research* 6: 177–92. (In Chinese)
- Thakor, Anjan V. 2020. Fintech and banking: What do we know? *Journal of Financial Intermediation* 41: 100833. [[CrossRef](#)]
- Xiao, Sheng, and Shan Zhao. 2012. Financial development, government ownership of banks and firm innovation. *Journal of International Money and Finance* 31: 880–906. [[CrossRef](#)]
- Zhao, Jinsong, Xinghao Li, Chin-Hsien Yu, Shi Chen, and Chi-Chuan Lee. 2022. Riding the FinTech innovation wave: FinTech, patents and bank performance. *Journal of International Money and Finance* 122: 102552. [[CrossRef](#)]