The impact of Fintech on bank development: A meta-analysis investigation

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Abstract: *To test whether the results of the empirical literature on bank Fintech are affected by the characteristics of specific research, the paper selects existing high-quality empirical literature to conduct a meta-analysis. It finds that the empirical estimation results conducted across various studies are influenced significantly by factors such as sample interval, estimation methods, measurement indicators for Fintech and bank development, and the inverse of the model count. Specifically, the probability of obtaining significant estimation findings increases with earlier sample start-time and the use of risk or Fintech index data; however, the inverse is true for more models adopted, or the use of dynamic panel estimation methods. Meanwhile, the probability of obtaining significant positive estimation findings increases with the wider sample coverage. Furthermore, estimating methods, and measurement indices for Fintech or bank's risk, all significantly contribute to the significant negative estimation results. Moreover, the funnel plot asymmetry analysis reveals the existence of publication biases in the sample research; the greater the significance of the empirical estimation results, the higher the probability of publication for the article. Therefore, it is vital to consider the heterogeneity and possible publishing biases among the extant empirical research when examining the impact of Fintech on bank development.*

Keywords: *Fintech, bank development, meta-analysis, meta-regression.*

JEL Classification: *G21, O16, O33, C99.*

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Introduction

Throughout the years, a substantial body of literature has developed around bank Fintech. Nevertheless, a consensus on the relationship between Fintech and various aspects of bank development, such as financial performance, management efficiency, and stability, has yet to be reached. With the potential for Fintech to revolutionize financial services and enable banks to leverage economies of scale and scope (Schindler, 2017), it is generally accepted that Fintech has a positive impact on bank development (Kayed et al., 2024). However, with the introduction of financial stability from Fintech (Financial Stability Board, 2017), the associated risks are increasingly acknowledged. Some research suggests that there may also be a negative effect on Fintech-related banking (Geng et al., 2023). This indicates that the impact of Fintech on bank development remains a topic of debate, as research results may differ based on variations in sample size, sample selection period, modeling approaches, and control variables. Given the importance of banks in the financial system, it is critical to combine the relationship between Fintech and bank development.

Currently, there is a limited amount of literature examining bank Fintech, yet no specific review articles focus on Fintech's impact effect. A few review papers have addressed the opportunities, challenges, and development trends related to bank Fintech (Murinde et al., 2022; Pandey, 2024), yet they do not provide a comprehensive overview of the research in this area. Additionally, several review studies have examined the relationship between artificial intelligence, machine learning, or blockchain, and bank development (Patel et al., 2022; Sadok et al., 2022); however, these studies tend to focus on specific aspects of Fintech rather than adequately considering its impact effect.

The disagreement over the impact of Fintech on bank development serves as the primary driving force behind this paper. The paper aims to investigate the impact effect of Fintech on bank development by using the meta-analysis method. It is a literature review method that synthesizes and re-estimates existing empirical research (Weichselbaumer & Winter-Ebmer, 2005). As a quantitative empirical research technique, meta-analysis leverages the heterogeneity found in regression models from the selected literature as independent variables, with the estimation results acting as the dependent variable in a multiple regression analysis. This methodology effectively highlights variations in empirical outcomes linked to differences in statistical methods, deviation of model error, and research datasets, quantifying how these factors contribute to inconsistencies in research findings (Bel & Fageda, 2009; Stanley & Jarrell, 2005a). Moreover, this method helps identify potential publication biases that could occur during the dissemination process, improving the reliability of empirical results and avoiding theoretical limitations.

The paper makes two significant contributions to the existing literature. First, it is the inaugural article to perform a meta-analysis in the realm of bank Fintech, thereby expanding and enriching the current body of knowledge on the topic. Second, it theoretically examines the effects of Fintech on bank development and carries out an empirical analysis to identify factors that may result in varying impact effects. These insights will assist countries in devising and executing policies related to bank Fintech.

The remainder of this paper is organized as follows. Section 1 reviews the established bank Fintech literature from a theoretical and practical perspective. Section 2 illustrates the data collection, coding, and model design required by the meta-analysis approach. The findings of the meta-analysis and the publication bias discussion are presented in Section 3. The conclusion forms the final portion.

1. Theoretical background

1.1 Opportunity and challenge for bank Fintech

Financial technology, or Fintech, as defined by the National Economic Council (2017), refers to encompassing a wide spectrum of technological innovations that impact a broad range of financial activities, including payments, investment management, capital raising, deposits and lending, insurance, regulatory compliance, and other activities in the financial services space. The significance of Fintech lies in its ability to make financial services more accessible, efficient, and user-friendly. The banking industry, being a significant part of the financial sector, has been at the forefront of embracing these technological advancements (Schindler, 2017). Credit cards, debit cards, and cash dispensing devices like automated teller machines (ATMs) have been gradually introduced in banks since the 1960s. Then, as telephones and information technology gained popularity in the 1970s and 1980s, the impact of information technology on bank development was evident in the changes made to certain backend systems as well as financial products and services (McKendrick, 1992). At the turn of the millennium, the IT boom established a rational foundation for the banking sector (Gangopadhyay et al., 2022). The evolution of electronic banking continued to strengthen the impact of information technology on bank development, primarily manifested in the organizational structures of banks (Onay & Ozsoz, 2013). Following the 2008 financial crisis, emerging financial technologies, such as artificial intelligence, blockchain, cloud computing, big data, and the internet of things, have overturned the traditional banking business model and forced banks to upgrade and transform to meet the demands of customers (Financial Stability Board, 2017). Fintech drives banks to go digital and transform towards more customer-centric (Jünger & Mietzner, 2020) and its applications in the banking sector continue to expand.

However, the bank faces issues of both increased risk and degraded stability, in addition to the opportunity to fully exploit economies of size and scope brought about by Fintech (Marinč, 2013). On one hand, emerging Fintech platforms are not only entering markets that conventional banks might not service well, but they are also upending the established methods of financial intermediation (Cai, 2018; Jagtiani & Lemieux, 2018). Furthermore, this unfavorable sentiment would increase if Fintech advances were limited to non-financial startups (Chen et al., 2019). For this reason, rumors occasionally circulate that Fintech platforms may eventually replace bank credit in certain areas or nations (Hodula, 2022). Conversely, when Fintech is applied unregulated to the banking industry, it has grown to be a force that threatens the stability of banks (Macchiavello, 2018). Accordingly, authorities worldwide are now paying attention to the supervisory and regulatory challenges brought up by Fintech (Financial Stability Board, 2017).

1.2 Empirical evidence and dispute for bank Fintech

While debates persist regarding bank Fintech, there is a general consensus that Fintech advances bank growth. Is this consensus supported by empirical evidence? Some scholars have carried out pertinent empirical research in an attempt to provide an answer to this focus. In this section, we examine the following two key issues: (1) Do the findings of existing empirical research support the mainstream proposition? (2) What particular features of the research do these empirical studies have?

We conducted a literature search using the Web of Science database, employing keywords such as Fintech, Internet information technology (IT), communication technology, digital, artificial intelligence (AI), blockchain, cloud computing, big data, internet of things, machine learning, data mining, and other related terms. Subsequently, we filtered the articles according to the following criteria: (1) The inclusion of one or more empirical models examining the relationship between Fintech and bank development. (2) Publication in a high-impact journal, as indicated by a high SCImago Journal Rank (SJR), and classified within Q1 or Q2, with Q1 representing the highest tier of journal influence. In conclusion, we have 43 empirical studies that highlight the relationship between Fintech and bank development. Tab. 1 illustrates how this topic has been expanding rapidly since 2017, with the majority of studies published in 2023 and 2024. This is due to three factors: (1) A consensus on the definition of Fintech as technology-enabled innovation in financial services that may lead to new business models, applications, processes, or products with a material impact on the provision of financial services; (2) The emergence of bank Fintech as a hot topic due to accumulated financial risks and financial disintermediation that accompany the rapid development of Fintech; and (3) The accumulation of data from Fintech's development, offering the opportunity for scholars to carry out empirical research.

Tab. 1: List of 43 empirical studies of bank Fintech – Part 1

Date	Author	Sample period	Estimation method	Region
2007	**Beccalli**	1995–2000	Ordinary least square method	France and other 4 European
2013	**Onay and Ozsoz**	1990–2008	Fixed effect	Turkey
2017	**Filip et al.**	2007–2013	Random effect	Poland
2017	**Mocetti et al.**	2006–2016	Fixed effect	Italy
2018	**Qiao et al.**	2010–2015	GMM	China
2020	**Carbó-Valverde et al.**	2016	Fixed effect	Spanish
2020	**Chen et al.**	2011–2016	Random effect	China

Tab. 1: List of 43 empirical studies of bank Fintech – Part 2

Date	Author	Sample period	Estimation method	Region
2020	**Cheng and Qu**	2008–2017	Fixed effect	China
2020	**Forcadell et al.**	2003–2016	GLS	Australia and other 13 developed countries
2020	**Phan et al.**	1998–2017	GMM	Indonesia
2021	**Lee et al.**	2003–2017	GMM	China
2021	**Sheng**	2011–2018	Random effect	China
2021	**Wang et al.**	2011–2018	Random effect	China
2021	**Yao and Song**	2011–2019	GMM	China
2022	**Banna et al.**	2011–2018	Random effect	Angola and other 29 African countries
2022	**Cao et al.**	2011–2018	Fixed effect	China
2022	**Cheng et al.**	2008–2019	Fixed effect	China
2022	**Pierri and Timmer**	2007–2010	Fixed effect	US
2022	**Zhao et al.**	2003–2018	GMM	China
2023	**Fang et al.**	2007–2021	Fixed effect	China
2023	**Geng et al.**	2008–2018	Fixed effect	China
2023	**Guo and Zhang**	2008–2019	Fixed effect	China
2023	**Hao et al.**	2011–2020	Fixed effect	China
2023	**Khan et al.**	2010–2022	GMM	Saudi Arabia
2023	**Nguyen-Thi-Huong et al.**	2015–2021	GMM	Vietnam
2023	**Wang et al.**	2005–2022	Fixed effect	China
2023	**Wang et al.**	2014–2019	Fixed effect	China
2023	**Wu et al.**	2011–2019	Fixed effect	China
2023	**Wu et al.**	2007–2019	GMM	China
2023	**Zhang et al.**	2013–2021	GMM	China
2023	**Zhao et al.**	2013–2020	GMM	China
2024	**Chen and Shen**	2011–2018	GMM	China
2024	**Hu et al.**	2011–2020	Fixed effect	China
2024	**Karim and Lucey**	2013–2021	Fixed effect	Malaysia
2024	**Ren et al.**	2014–2020	Fixed effect	China
2024	**Safiullah and Paramati**	2003–2018	GMM	Australia
2024	**Tang et al.**	2011–2021	Fixed effect	New Zealand
2024	**Wang et al.**	2011–2019	Fixed effect	China
2024	**Wu et al.**	2008–2022	Fixed effect	China
2024	**Xu and Yang**	2011–2019	Fixed effect	China

Tab. 1: List of 43 empirical studies of bank Fintech – Part 3

Date	Author	Sample period	Estimation method	Region
2024	**Yu**	2005–2020	GMM	China
2024	**Zhao et al.**	2010–2021	GMM	China
2024	**Zhu and Guo**	2016–2019	Fixed effect	China

Source: own

The initial phase of conducting an empirical study on bank Fintech is to determine how to measure the level of Fintech. There are three ways to gauge the degree of Fintech, per the empirical literature currently in publication (Tab. 2). The first method is the Fintech index, which consists primarily of two data sources. To construct the complete index, one must employ principal component methods (PCA) after identifying frequently searched keywords on Baidu, a major search engine in China, or within a bank's annual report. These terms are relevant to bank Fintech and typically consist of five words or more. Subsequently, PCA is applied to integrate these into a singular, encompassing index (Yao & Song, 2021). Another metric is the Internet finance development index, which is devised and disseminated by academic institutions and contains data at three levels: national, prefectural city, and county (Hu et al., 2024; Sheng, 2021). A second approach to measuring the extent of bank Fintech is through the ratio of information technology expenditures to all non-interest expenses. This information can be found directly in the annual report of the bank (Beccalli, 2007; Carbó-Valverde et al., 2020). Simultaneously, some researchers incorporate data from non-bank sources that are closely related to Fintech, such as P2P trading volume and the total number of Fintech companies established (Chen et al., 2017; Lee et al., 2021). The third method of quantification employs a dummy variable that is assigned a value of 1 or 0 based on whether the bank engages in Fintech activities (Zhang et al., 2022).

Beyond the dependent variable, another primary concern is the selection of methodologies for measuring bank development. Three methods have been employed to measure bank development in previous studies. The first is the financial index, which is a representation of the bank's financial condition. These indices include metrics such as return on asset (ROA), return on equity (ROE), net interest margin (NIM), liquidity ratio, and growth rate of deposits, among others (Chen et al., 2020; Karim & Lucey, 2024). A second method is the efficiency index which takes into account profit, cost, and management efficiency (Ren et al., 2024; Zhao et al., 2022). These factors are pertinent to the impact of Fintech on bank development. The third is the risk index, which quantifies the risk of banks by incorporating

Tab. 2: Measurements method for the level of Fintech in the existing literature

Indicator types		Calculation formula
Fintech index	Composite index	Synthesized by using the methods of the methods of principal component analysis and factor analysis
	Internet finance development index	Designed and published by academic institutions
Information technology expense ratio		Information technology expenses to non-interest expenses
Dummy variable		The value would be 1 if the bank has related Fintech activities

Source: own

metrics such as the *Z*-score (Banna et al., 2022; Safiullah & Paramati, 2024), the non-performing loan ratio (NPL) (Zhao et al., 2023), and additional risk indicators.

In the domain of model specification, there exists a significant debate on the definition of Fintech's contribution to bank development. A consensus among many scholars holds that Fintech has a linear impact on banks' development (Cheng et al., 2022; Wu et al., 2023). However, some researchers suggest that Fintech's impact is u-shaped rather than linear (Wang et al., 2021). Additionally, it is still uncertain if the lag of the proxy variable representing bank development should be included in the model (Zhao et al., 2023). Meanwhile, as everyone knows, the models can only function properly at some point in time if the cumulative impact of the bank development is taken into account (Qiao et al., 2018). As a result, the statistical techniques employed in the current scholarly literature vary as well. As Tab. 1 illustrates, the majority of the literature uses the ordinary least square (OLS) method, along with fixed effect (FE) and random effect (RE) methodologies, to estimate the impact of Fintech on bank development. Yet, the estimation results are unable to capture the true impact size of Fintech on bank development because of endogenous issues brought on by measurement errors, two-way causation, and missing factors. To more precisely determine the relationship between Fintech and bank development, certain researchers estimate the model using the generalized moment methods (GMM) and instrument variable (IV) techniques (Phan et al., 2020; Safiullah & Paramati, 2024). And what variables fall under the category of tool variables? The lag of the independent variable, internet penetration ratio, and the average income level of the city where the bank's R&D facilities are located have been identified as potential candidates (Cheng & Qu, 2020; Hu et al., 2024; Mocetti et al., 2017). However, the ability of these macro and meso-level instrumental variables to address endogeneity remains a contentious issue. The optimal selection of instrumental variables and the identification of the most appropriate instruments continue to be subjects of scholarly debate.

Moreover, variations in data structures, sampling intervals, and geographic regions likely contribute to the observed heterogeneity in empirical findings. In addition to getting more precise dynamic information and minimizing multicollinearity, panel data are conducted in practically all of the current literature. Tab. 1 displays an overview of the sampled literature, comprising 1 cross-sectional dataset, 14 dynamic panel datasets, and 28 static panel datasets. Apart from this, it demonstrates that sampled banks are spread across more than 50 countries from 1990 and 2022, with sample periods ranging from 1 to 20 years. It is also evident that the majority of studies concentrate on bank Fintech in China, given that 29 articles are authored by Chinese scholars. These variations may lead to the heterogeneity observed in the empirical estimation results across the articles.

Is there a consensus within the existing literature regarding the bank Fintech impact effect? This study aggregates empirical findings based on the classification of proxy variables for bank development and Fintech. As is shown in Tab. 3, the following observations are made: (1) The majority of models utilize financial indicators as proxies for bank development. The selection of 134 financial and 63 non-financial variables as proxies indicates a preference for financial variables among scholars because bank financial data is readily available in annual reports. (2) Identifying a suitable proxy to reflect the Fintech level remains challenging. Tab. 3 shows that 110 models incorporate the Fintech index, while 43 models use the IT expense ratio. Although a majority of the models include a dummy variable, it is widely recognized that such variables cannot precisely capture the true Fintech level of a bank; they merely indicate the presence or absence of financial technology in commercial banks. (3) Empirical findings regarding the impact of Fintech on bank development are inconclusive. With 37 studies showing non-significant results, and 102 and 58 studies reporting positive and negative effects, respectively, it implies that the current empirical findings are heterogeneous and potentially influenced by various factors.

Based on the aforementioned, it is clear that the specifics of each study influence the effects of Fintech on bank development, making it challenging for us to reach a generally consistent conclusion. Nevertheless, identifying the specific factors within these studies that sway the empirical results is crucial. To this end, a comprehensive meta-analysis of the existing literature is warranted.

Tab. 3: Statistics of empirical results on the relationship between Fintech and bank development

Indicators		Positive	Negative	Non-significant	Total
Dependent variables	Financial variables	66	43	25	134
	Non-financial variables	36	15	12	63
	Subtotal	102	58	37	197
Independent variables	Index variables	55	47	8	110
	IT expense ratio	17	14	12	43
	Non-index variable	14	13	17	44

Note: When negative indicators for bank development, such as "bank risk," etc., are documented, the data in the "positive" and "negative" columns are presented in reverse order.

Source: own

2. Research methodology

2.1 Data

Meta-analysis has evolved since the 1990s into the most sophisticated technique for literature retrospective analysis in the social sciences, humanities, and natural sciences. The data were gathered following the procedures shown in Fig. 1.

Initially, we identified keywords that would help us focus on publications related to the intersection of the bank and Fintech. Considering both traditional and cutting-edge financial technologies, we utilized the following search string: TI = (bank AND (Fintech OR financial technology OR IT OR information technology OR internet OR phone OR mobile OR AI OR artificial intelligence OR blockchain OR cloud computing OR data OR digital))

We conducted our search in the reputable economic databases of the Web of Science and initially identified 18,043 potential studies. To ensure the quality and relevance of the studies, we limited our scope to journal articles published in economic journals ranked Q1 or Q2 by the SJR index. After the exclusion

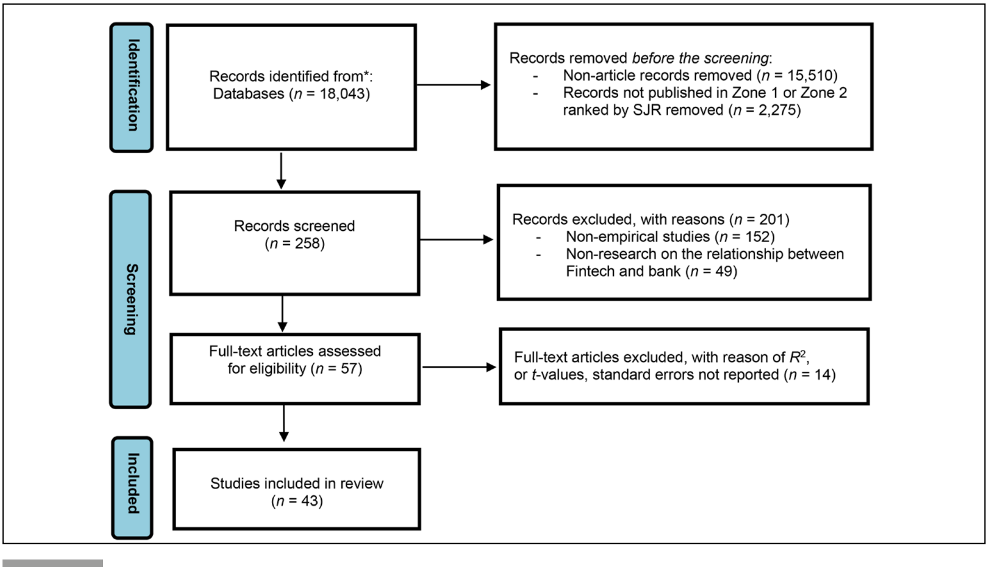

Fig. 1: Fintech literature search flow diagram

Source: own

of the non-empirical studies and those not directly examining the relationship between Fintech and banking, we were left with 57 articles for full-text review.

Our selection criteria for the empirical articles were stringent: the articles had to provide a detailed report of empirical results, particularly the correlation coefficients between variables, and the sample characteristics. Where possible, the articles should also include estimated coefficients for independent variables, *t*-values, standard errors, or other statistical values that can be converted into correlation coefficients. Through this rigorous exclusion process, we finally included 43 empirical studies in our meta-regression analysis, as detailed in Tab. 1.

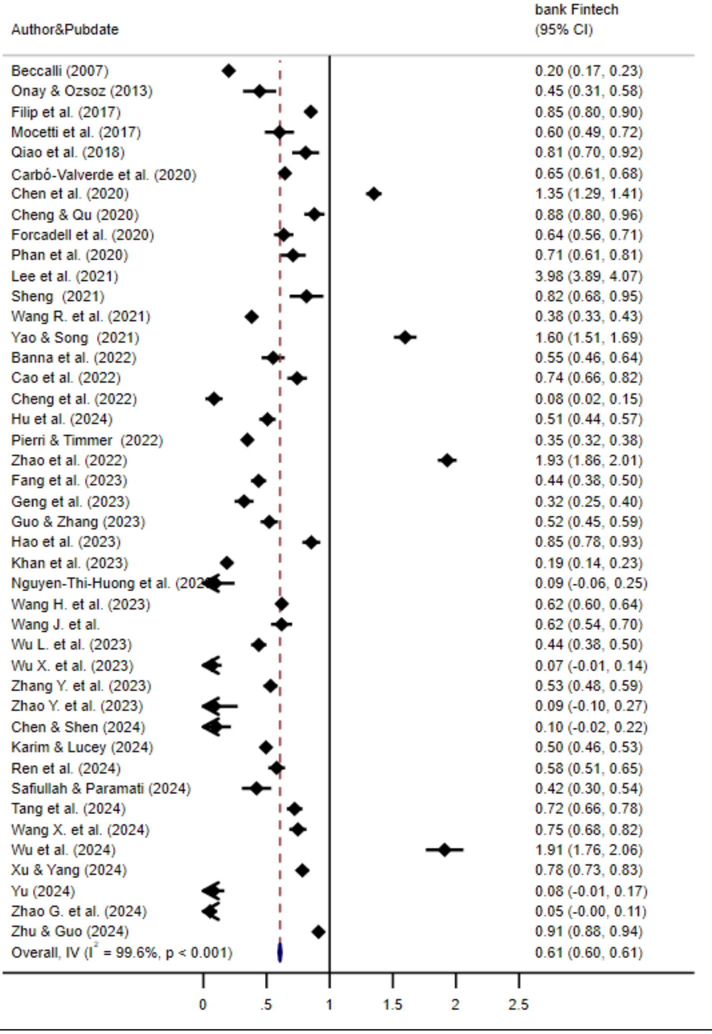

Fig. 2: **Forest plot of the existing empirical studies on bank Fintech**

Note: The first effect size in each article is shown by the diamond plot, which is converted using the Fisher *Z* method.

Source: own

The majority of the chosen empirical studies have been published since 2017, with the sample bank data encompassing 33 years from 1990 to 2022. The sample includes banks from both developing and economically advanced countries, including China, the European Union, the United Kingdom, Australia, and several countries in Africa. In the meantime, the literature addresses a broad spectrum of topics related to Fintech, including its impact on bank efficiency, risk, and financial performance, among numerous other areas.

As shown in Fig. 2, the diamond shapes representing the effect sizes of the individual studies do not cross the null effect line (a vertical line at the scale of 1), indicating that the calculated effect sizes of the studies are statistically significant. The overall effect size is 0.61, which is greater than 0.5 but less than 1 (Stanley & Jarrell, 1998), suggesting that Fintech significantly impacts the development of banks. The I-squared result is significantly greater than 50%, indicating heterogeneity in the impact of Fintech on bank development across the studied, suggesting that the influence of Fintech on bank development may vary depending on the characteristics of the selected samples.

2.2 Variables

The paper employs meta-analysis to evaluate whether the empirical estimation results reported in the existing literature are influenced by specific research characteristics. Consequently, choosing the right variables is essential. Three variables – *significance, positive significance* (labeled as "*Positive*"), and *negative significance* (labeled as "*Negative*") – are selected as the dependent variables per the goal of the study. The values of these variables are ascertained through the application of *t*-statistics to assess the significant relationships among the variables in the empirical studies (Stanley & Jarrell, 2005). The *significance* value is 1 when Fintech significantly influences bank development; otherwise, it is coded as 0. The value of *Positive* is 1 when Fintech has a significant positive impact on bank development; otherwise, it is coded as 0. The degree of *Negative* is 1 when Fintech hinders a bank's growth; otherwise, it is coded as 0.

We selected the *sample observations* (*Observations*), *start year* (*Start*), *end year* (*End*), *region* (*Region*), and estimation *method* (*Method*) based on the general guideline for selecting moderator variables that capture the fundamental features of the empirical literature. The last two variables, *Region* and *Method*, are considered fictitious. The value of the *Region* is coded as 1 if the sample bank is restricted to a single nation; otherwise, it is coded as 0. Moreover, the *Method*'s value is coded as 1 when the model employs a dynamic panel estimation approach; otherwise, it is coded as 0.

Concurrently, we employ six dummy variables, one for each, to capture the features of Fintech and bank development. *EffDev*, *RiskDev*, and *FinDev* are the three dummy variables used to reflect the development characteristics of banks across the studies. Additionally, we characterize Fintech features within each study using three dummy variables: *FintechIndex*, *IT*, and *Dummyindex*. The matching value is coded as 1 if any indicator is used in the individual study; otherwise, it is coded as 0.

Furthermore, to correct for potential biases arising from the extraction of multiple data sets from a single article, we employ the *Weight* variable followed by Weichselbaumer and Winter-Ebmer (2005), which is defined as the inverse of the number of models estimated within each study.

All of the variable information as well as the descriptive statistics for the sample data are shown in Tab. 4.

Tab. 4: Variables description for meta-regression analysis – Part 1

Variable	Description	Obs.	Mean	Std. dev.	Min	Max
Significance	Dummy variable. When Fintech has a significant effect on bank development, the value is 1, otherwise it is 0.	197	0.802	0.399	0	1
Positive	Dummy variable. When Fintech has a significantly positive effect on bank development, the value is 1, otherwise it is 0.	197	0.437	0.497	0	1

Tab. 4: Variables description for meta-regression analysis – Part 2

Variable	Description	Obs.	Mean	Std. dev.	Min	Max
Negative	Dummy variable. When Fintech has a significantly negative effect on bank development, the value is 1, otherwise it is 0.	197	0.376	0.486	0	1
Observations	Number of the observations	197	1,449.218	1,750.019	114	7,619
Start	Start year of the sample data	197	2,005.376	7.764	1,990	2,016
End	End year of the sample data	197	2,015.838	6.343	2,000	2,022
Region	Dummy variable. When the sample bank is limited to one country, the value is 1, otherwise it is 0.	197	0.873	0.334	0	1
Method	Dummy variable. When the model adopts dynamic panel estimation method, the value is 1, otherwise it is 0.	197	0.203	0.403	0	1
FinDev	Dummy variable. When the model adopt financial variable representing bank development, the value is 1, otherwise it is 0.	197	0.350	0.478	0	1
EffDev	Dummy variable. When the model adopt efficient variable representing bank development, the value is 1, otherwise it is 0.	197	0.254	0.436	0	1
RiskDev	Dummy variable. When the model adopt risk variable representing bank development, the value is 1, otherwise it is 0.	197	0.330	0.471	0	1
FintechIndex	Dummy variable. When the model adopt Fintech index representing the level of Fintech, the value is 1, otherwise it is 0.	197	0.558	0.498	0	1
IT	Dummy variable. When the model adopt IT expense ratio representing the level of Fintech, the value is 1, otherwise it is 0.	197	0.218	0.414	0	1
DummyFin	Dummy variable. When the model dummy variable to represent whether the bank adopt financial technology, the value is 1, otherwise it is 0.	197	0.223	0.418	0	1
Weight	Reciprocal of the models number	197	0.484	0.343	0.08	1

Source: own

2.3 Model specification

We formulated the following three meta-regression equations following the meta-regression equation's general pattern.

$$ys_{ij} = \beta_0 + \sum_{k=1}^{K} \beta_k Z_{ijk} + \sigma_{ij} \quad (1)$$

$$yp_{ij} = \beta_0 + \sum_{k=1}^{K} \beta_k Z_{ijk} + \sigma_{ij} \quad (2)$$

$$yn_{ij} = \beta_0 + \sum_{k=1}^{K} \beta_k Z_{ijk} + \sigma_{ij} \quad (3)$$

where: *i*, *j* = 1, 2, ..., *N*; *k* = 1, 2, ..., *K*; ys_{ij}, yp_{ij} and yp_{ij} – the significant regression result, the positive significant regression result, and the negative significant regression result of the impact of Fintech on bank development in the j^{th} estimation of the i^{th} study, respectively; Z_{ijk} – a set of proxy variables that characterize the model design features leading to differences in empirical results, including *Observations*, *Start*, *End*, *Region*, *Method*, *FinDev*, *EffDev*, *RiskDev*, *FintechIndex*, *IT*, *DummyFin*, and *Weight*; β – the meta-regression coefficients to be estimated; σ – the random disturbance term in the meta-regression analysis.

Given that each of the dependent variables is dichotomous, we employ the probit model to conduct separate meta-regression estimates for the three aforementioned models.

3. Results and discussion

3.1 Results of meta-regression

We employed the probit method to conduct a meta-regression analysis on the three aforementioned models, with the dependent variables representing the significant effect, positive significant, and negative significant effects of Fintech on bank development. The estimation results are shown in columns (1–3) in Tab. 5.

As demonstrated in Tab. 5, column (1), the moderator variables *Start*, *Method*, *RiskDev*, *FintechIndex,* and *Weight* exhibit significant coefficients at varying significance levels ranging from 1% to 10%, indicating their significant impacts on the empirical findings to date. Among these, the greater probability of obtaining significant effects of Fintech on bank development is higher when the sample data begins earlier or when more model designs are considered. In addition, given that the coefficients are positive, including *RiskDev*, or the Fintech index to the model increases the probability of obtaining significant estimation findings; however, this probability is decreased when the dynamic panel model is used.

Tab. 5, column (2) displays the estimation findings, with the dependent variable being the positive significant effect of Fintech on bank development. The probability of receiving significant positive estimate results is reduced regardless of which Fintech indicator is included in the model. However, the coefficient for the *End* variable is positive and significant at the 5% level, suggesting that a greater sample size increases the probability of obtaining significant positive estimation findings.

Tab. 5, column (3) presents the estimation findings, with the dependent variable being the negative significant effect of Fintech on bank development. There are more factors influencing the probability of obtaining a significant negative impact of Fintech on bank development when comparing the results in columns (1–2). Firstly, notwithstanding the *Method* variable, the significantly positive coefficient of the *Start* demonstrates that advancing the sample start date substantially can greatly raise the probability of receiving negative significant regression results. Secondly, the *RiskDev* coefficient, which is positive and significant at the 5% level, indicates that there is a higher probability of receiving significant negative regression findings when utilizing the risk indicator for bank development. Thirdly, all variables indicative of the Fintech level exhibit significant coefficients, indicating that the type of Fintech indicators employed will influence the probability of receiving significant negative regression findings.

Based on these findings, it can be concluded that diverse study features significantly influence the empirical findings of Fintech on bank development, particularly the negative significant effect. Furthermore, it can be observed that the inclusion of different Fintech indicators in the model can have a significant impact on the empirical research's outcome.

Tab. 5: The meta-regression estimation for Fintech's effect on bank development – Part 1

	(1)	(2)	(3)
	Significance	**Positive**	**Negative**
Observations	−0.0000 (0.7140)	−0.0001 (0.1410)	0.0001 (0.1220)
Start	0.0776** (0.0240)	−0.0045 (0.8350)	0.0402* (0.0920)
End	−0.0079 (0.8550)	0.0705** (0.0380)	−0.0300 (0.3580)
Region	0.7190 (0.1680)	0.2460 (0.5650)	0.3210 (0.3420)
Method	−4.8900*** (0.0000)	0.2000 (0.5030)	−0.5940* (0.0660)

Tab. 5: **The meta-regression estimation for Fintech's effect on bank development – Part 2**

	(1)	(2)	(3)
	Significance	Positive	Negative
FinDev	0.8080 (0.1290)	0.0902 (0.8330)	0.9150 (0.2190)
EffDev	0.9170 (0.1630)	0.2780 (0.5750)	0.8010 (0.3300)
RiskDev	1.2110** (0.0380)	−0.5750 (0.1950)	1.6680** (0.0250)
FintechIndex	4.6530*** (0.0000)	−5.4990*** (0.0000)	5.5970*** (0.0000)
IT	0.2050 (0.8070)	−4.9210*** (0.0000)	5.0660*** (0.0000)
DummyFin	−0.4970 (0.5250)	−5.6230*** (0.0000)	5.2920*** (0.0000)
Weight	1.2030* (0.0710)	0.1250 (0.7610)	0.4580 (0.3150)
_cons	−140.8000** (0.0120)	−127.8000** (0.0150)	−27.4900 (0.5570)
N	197	197	197
Pseudo R^2	0.3852	0.1098	0.1425

Note: *P*-values are reported in parentheses; ***, **, and * indicate significance at the 1, 5, and 10% levels, respectively.

Source: own

Consequently, this underscores the importance of focusing not only on getting comprehensive data but also on selecting appropriate variables for the model in the research of Fintech on bank development.

3.2 Publication bias discussion

The issue of publication bias is likely to occur throughout the meta-regression analysis process. This occurs because publications with significant empirical findings have a higher chance of being published (Stanley & Jarrell, 2005). Conversely, if the empirical result is not statistically significant, the researchers often deem it meaningless or unhelpful, leading to cessation or postponement. However, this issue can substantially undermine the reliability of the meta-regress results, especially when it comes to the effect size being drastically overstated. Thus, while performing meta-regression analysis, this problem should be verified using the funnel asymmetry test method (Stanley, 2008), with funnel plots and linear regression estimation being typical identification methods.

In a funnel plot, the abscissa represents the effect size, while the ordinate represents the standard error. It is possible to determine whether or not there is publication bias in the body of current research by examining the shapes of the scattered points in the chart. The symmetrical distribution of the effect points around the line of merged effects indicates the absence of publication bias; asymmetry suggests its presence. To normalize the effect sizes for funnel plot analysis in our meta-analysis, we initially applied Fisher's *Z* transformation to the collected correlation coefficients as detailed in Formula (4). This step primarily serves to normalize the effect size.

$$\text{Fisher } Z\,(R_i) = 0.5 * \log\,((1 + r_i)/(1 - r_i)) \quad (4)$$

where: r_i is the correlation coefficients of the i^{th} individual literature, R_i is the effect size of the i^{th} individual literature.

Subsequently, Fig. 3 depicts our constructed funnel plot, with the ordinate indicating the standard error and the abscissa representing the effect magnitude. It is discovered that:

(1) The most impact points of studies are primarily located on the left side of the effect merging line, not symmetrically distributed on both, and (2) certain effect points are dispersed outside of the funnel plot. The first observation indicates the presence of publication bias within the current body of research, while the second finding indicates heterogeneity.

To identify the contributing factors or effect pathways leading to publication bias, additional analysis using the linear regression approach is required. Following Stanley's (2008) research, we estimate Equation (5).

$$R_{ij} = \beta_0 + \beta_1(1/SE_{ij}) + \varepsilon_{ij} \quad (5)$$

where: i, j = 1, 2, ..., N; R_{ij} – the effect size in the j^{th} estimation of the i^{th} study; the term of $1/SE_{ij}$ denotes the precision, which is the inverse of the standard error; the intercept β_0 serves as an indicator of the presence of publication bias, with its sign indicating the direction of this bias; a significant deviation of β_0 from zero suggests the existence of publication bias (if not, it is inferred that there is no publication bias); the slope coefficient β_1 reflects the relationship between the effect size estimates and the precision of the studies; a significantly positive β_1 indicates that studies with more substantial empirical results are more likely to be published.

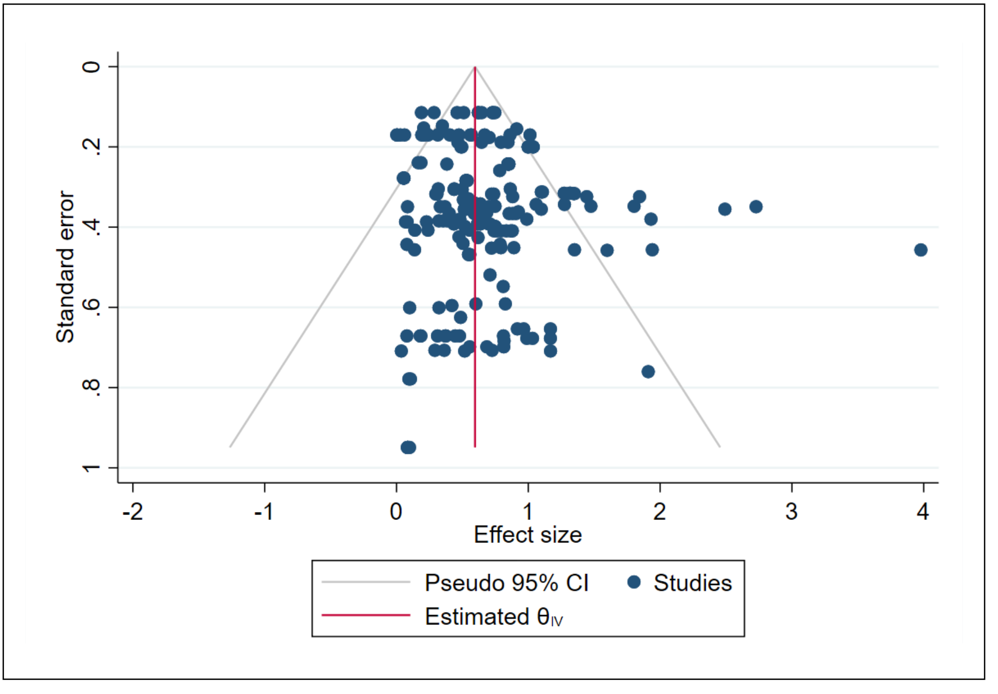

Fig. 3: Funnel plot with pseudo 95% confidence limits

Source: own

Appropriate grouping variables must be selected to achieve the research objective of assessing whether publication bias exists in the empirical studies. Three types of Fintech indicators used by the literature currently in publication serve as the appropriate grouping variable, as our research focus is on bank Fintech. Initially, we transform the effect size using Fisher's Z as the dependent variable, followed by the application of the ordinary least square method to estimate the formulas for each of the three groups. Tab. 6 presents the findings.

Tab. 6: Results by using OLS for the Funnel asymmetry test (dependent variable: effect size)

	(1)	(2)	(3)
	FintechIndex	*IT*	*DummyFin*
1/*SE*	−0.0095*** (0.0015)	0.0160*** (0.0012)	−0.0061*** (0.0013)
_cons	0.8760*** (0.0689)	−0.3160*** (0.0375)	0.4270*** (0.0606)
N	197	197	197
R^2	0.1240	0.5070	0.0730

Note: Standard errors are reported in parentheses; ***, **, and * indicate significance at the 1, 5, and 10% levels, respectively.

Source: own

It concludes that: (1) Evidence of publication bias is present in the extant empirical research, as the coefficients for the reciprocal of standard error in columns (1–3) are significantly different from zero at the 1% level. (2) The coefficients for the intercept term in columns (1–3) are significantly different from zero, suggesting that the existing research results display heterogeneity. (3) The *R*-squared values in columns (1–3), vary significantly and reflect the complexity of the relationships between the independent variables and the effect size; they also highlight the need for a nuanced understanding of the factors influencing the effect size in empirical research. (4) All things considered, given the small sample size, caution is advised when accepting these estimated results.

Conclusions

Both theoretically and practically, the research of Fintech on bank development is essential. As depicted in Tab. 3, 51.78% of the empirical results suggest that Fintech has a beneficial effect on bank development; however, the conclusions, when considered collectively, are not entirely consistent with these empirical findings. Consequently, this research conducts a meta-analysis and publication bias analysis to assess the robustness and potential biases in bank Fintech research, synthesizing and comparing data from 197 samples across 43 existing empirical studies.

It finds that the analysis of the impact of Fintech on bank development reveals a complex landscape in which current estimations are not only inconsistent across studies but are also deeply influenced by the intricacies of research design. The variability in findings can be attributed to several research characteristics, most notably the data structure, the analytical models, and the estimation methods. Furthermore, the impact of Fintech on bank development is not a one-dimensional phenomenon; instead, it is a multifaceted issue. This impact is particularly influenced by the intervals over which samples are drawn, the metrics used to assess bank development and Fintech's level, the estimation methods, and the number of models used. Additionally, the asymmetry observed in the funnel plot test indicates the presence of publication bias within the published literature. This necessitates a cautious interpretation of the existing empirical evidence and underscores the need for a more nuanced approach to understanding the relationship between Fintech and bank development. While our study offers insights into the impact of Fintech on bank development, it has two primary limitations. First, the analysis is constrained by the availability and quality of published research, which may not fully represent the breadth of ongoing exploration in this field. Second, our reliance on existing literature is subject to publication bias, potentially favoring studies with more significant findings.

Thus, future research should concentrate more on the following areas: (1) In-depth analysis of factors influencing the development of bank Fintech. This study reveals the heterogeneous impact of Fintech on banks, which is subject to a variety of influencing factors, including research characteristics such as, e.g., data structure. Therefore, it is recommended that future research should delve deeper into identifying and summarizing the key factors influencing the development of bank Fintech, and thoroughly examine the individual and collective effects of Fintech on bank development, providing a solid empirical foundation for policy formulation. (2) Innovation in measurement methods for accurately assessing the impact of Fintech. In light of the diverse results that different estimation methods may yield in the relationship between Fintech and bank development, it is suggested that the academic and practical communities continue to innovate in methodology. This innovation will help establish a more robust theoretical framework, thereby providing precise and scientific evidence for the formulation of Fintech policies. (3) Promoting in-depth development of bank Fintech. More than half of the empirical studies indicate a positive impact of Fintech on bank development, highlighting the significant role Fintech plays in fostering bank growth. Consequently, it is recommended that banking institutions increase their investment in Fintech, and actively utilize Fintech to innovate in services, products, and organizational models, thereby comprehensively enhancing the financial performance and management efficiency of banks. (4) Strengthening the prevention and management of Fintech risks. The dual-edged nature of Fintech's impact suggests that while it can promote bank development, it may also introduce risks. Therefore, it is recommended that regulatory authorities intensify their oversight while encouraging commercial banks to leverage financial technologies to strengthen risk prevention capabilities, ensuring the stability and security of the financial system.

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