BANK EFFICIENCY AND THE BOND MARKETS

EVIDENCE FROM THE ASIA AND PACIFIC REGION

Donghyun Park, Shu Tian, and Qiongbing Wu

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Donghyun Park (dpark@adb.org) is a principal economist and Shu Tian (stian@adb.org) is an economist at the Economic Research and Regional Cooperation Department, Asian Development Bank. Qiongbing Wu (l.wu@westernsydney.edu.au) is an associate professor at the School of Business, Western Sydney University, Australia.

ASIAN DEVELOPMENT BANK

ADB

6 ADB Avenue, Mandaluyong City, 1550 Metro Manila, Philippines
Tel +63 2 8632 4444; Fax +63 2 8636 2444
www.adb.org

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In this publication, "$" refers to United States dollars.
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ABSTRACT

This study examines the impact of bond markets on both bank profit and cost efficiency. By employing the stochastic frontier approach and utilizing a large micro dataset for 926 banks covering 27 economies from the Asia and Pacific region over the period from 2004 to 2017, we find that both the bond market development and bond market structure are relevant to bank efficiency. The development of bond markets generally has a positive (negative) effect on bank profit (cost) efficiency. Given the development level of the aggregate bond market, increasing the proportion of corporate bonds will enhance both bank profit and cost efficiency. Moreover, given the development level of a country's corporate bond market, a greater share of local currency corporate bonds is significantly and positively related to both bank profit and cost efficiency. In addition, increasing share of bank-issued corporate bonds in corporate bonds significantly increases (decreases) bank profit (cost) efficiency. Overall, our results point to the significant importance of local currency corporate bonds to the overall bank efficiency. Our findings provide important implications for both policy makers and bank management.

Keywords: Asia and Pacific region, bank efficiency, bond market development, bond market structure, stochastic frontier analysis

JEL codes: D20, G21, G28

I. INTRODUCTION

The essential role of the financial intermediation function provided by banks (and other financial institutions) in a country's economic activities has been well established in the finance and growth literature.[1] Empirical research has strongly supported the view that banks promote economic growth at the country, industry, and firm levels.[2] Thus, the efficiency of bank functioning is one of the major concerns of regulators and policy makers.

Given the crucial role of bank functioning to a country's economic growth, bank efficiency has become a long-lasting topical issue and has been extensively examined in economic and finance research. Much effort of the early research has gone to measuring bank efficiency (see Berger and Humphrey 1997, and Berger and Mester 1997 for a review), later research focuses more on the determinants of bank efficiency for a specific economy, for a particular group of economies, or for a particular region.[3] More recently, research attention has been drawn to explore the mechanism underlying the differences of bank efficiency across countries. Lensink, Meesters, and Naaborg (2008) find that foreign ownership negatively affects bank efficiency in the study across 105 countries over the period 1998–2003, and this negative effect is alleviated by good governance and high-quality institutions.[4] Lozano-Vivas and Pasiouras (2010) examine the effect of nontraditional activities on bank efficiency for a sample of 752 publicly traded commercial banks from 87 countries, and find that, while the inclusion of nontraditional outputs does not change the directional impact of environmental variables on bank inefficiency, regulations that restrict bank activities and enhance supervisory and monitoring powers improve both profit and cost efficiency. Using a sample of 4,053 banks from 72 countries over the period 1999–2007, Barth, Carpio, and Levine (2013) confirm that better supervision and monitoring improve bank profit efficiency, while tighter restriction on bank activities has an opposite effect. Gaganis and Pasiouras (2013) investigate the impact of financial supervision regimes on bank profit efficiency for a sample of 3,886 commercial banks operating in 78 countries over the period 2000–2006, and find that bank efficiency decreases with more number of financial sectors supervised by the central bank, greater unification of supervisory authorities, and greater independence of the central bank. Utilizing a sample of 2,007 commercial banks covering 140 countries over the period 1999–2011, Luo, Tanna, and De Vita (2016) find that financial openness directly reduces bank profit efficiency, and subsequently increases bank risk.

Banks are the primary providers of private debt, and bond markets are the major providers of public debt. While the determinants of bank efficiency have been extensively examined in the literature, how public debt affects the efficient allocation of private debt remains unexplored. Bond

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1 Levine (2005) provides an excellent review on this literature.

2 See King and Levine (1993); Levine and Zervos (1998); and Beck, Levine, and Loayza (2000) for the country level; Rajan and Zingales (1998) and Cetorelli and Gambera (2001) for the industry level; and Demirgüç-Kunt and Maksimovic (1998, 2002) for the firm level.

3 For a specific economy, see Sturm and Williams (2004) for Australia; Kwan (2006) for Hong Kong, China; Berger, Hasan, and Zhou (2009) and Sun, Harimaya, and Yamori (2013) for the People's Republic of China; Mamatzakis, Matousek, and Vu (2016) for Japan; Peng et al. (2017) for Taipei,China; Fujii, Managi, and Matousek (2014) for India; Havrylchyk (2006) for Poland; Chortareas, Kapetanios, and Ventouri (2016) and Cyree and Spurlin (2012) for the United States. For a particular group of economies or a region, see Bonin, Hasan, and Wachtel (2005) for transition economies; Chortareas, Kapetanios, and Ventouri (2013) for the European Union; Bitar, Pukthuanthong, and Walker (2018) for the Organisation and Economic Co-operation and Development countries; Haque and Brown (2017) for the Middle East and North African region; Fu, Lin, and Molyneux (2014) and Sun and Chang (2011) for the Asia and Pacific region.

4 Lensink, Meesters, and Naaborg (2008) listed two reasons for the negative association. The first reason is that foreign ownership may lower a bank's domestic credit allocation. The second reason is that higher foreign ownership may create informational disadvantages compared to more domestically held banks.

markets may affect bank efficiency in many aspects. Firstly, bond markets provide an alternative source of finance for the public and private sectors and can be a potential competitor of banks. Firms with the highest credit quality generally choose to borrow from public sources by issuing corporate bonds (Denis and Mihov 2003), which may force banks to take more risk and/or improve the efficiency of asset allocation in order to maintain profitability. Secondly, bond markets may affect bank asset quality and provide banks with a stable source of finance but at a higher cost. On one hand, banks can invest in government bonds and high-credit corporate bonds, and thus improve the liquidity and credit quality of assets, but with a lower return. On the other hand, banks can obtain a large amount of stable finance by issuing corporate bonds, which will reduce the duration gap between assets and liabilities and enhance the ability of banks to resist interest rate risk and liquidity risk; however, this also comes with higher funding cost. Therefore, the impact of bond markets on bank efficiency is an empirical issue but, to the best of our knowledge, no study has examined this issue in the literature.

This research presents novel empirical evidence on the impact of bond market development on bank efficiency across a large number of economies from the Asia and Pacific region. We focus on the Asia and Pacific region for the following reasons: First, this region is playing a more and more influential role in the world economy and, particularly after the global financial crisis, has been becoming an engine of world economic growth. Second, while the financial sector is developing fast across this region in recent decades, the region still heavily depends on the banking system as a major funding source. Thus, to understand how certain factors, particularly financial sector development, will affect bank efficiency in the region has important policy implications. Third, this region hosts many systemically important financial institutions around the world. In particular, six out of the world's top 10 largest banks by assets in 2018 are from this region.[5] Thus, the findings of this research will provide important policy implications for both regulators and policy makers. Specifically, we examine two issues: First, how the overall development of bond markets affects bank efficiency. We measure the development of bond markets, that is, the aggregate bond market, the government bond market, and the corporate bond market, by the ratio of the bond value outstanding for each market against its gross domestic product (GDP). Second, we look into the structure of bond markets for each economy, such as the relative share of government and corporate bonds in the market, the proportion of local currency denominated bonds, and the proportion of bank-issued corporate bonds in total corporate bonds, etc., and investigate how the structure of the aggregate bond market and the structure of the corporate bond market affect bank efficiency.

We address the issues by employing the stochastic frontier approach (SFA) to measure bank efficiency and utilizing a large dataset covering 27 economies from the Asia and Pacific region over the period 2004–2017. We find that both the bond market development and bond market structure are relevant to bank efficiency even controlling for country-specific factors, banking industry-specific, and bank-level characteristics. Although bond markets exert different effects on bank profit and cost efficiency, our results highlight the significant role of local currency corporate bonds in improving both bank profit and cost efficiency.

This research contributes to the literature in the following important aspects:

First, to the best of our knowledge, this is the first empirical study to comprehensively examine the impact of bond markets on bank efficiency, and it provides new empirical evidence highlighting the significant role of the public debt providers in shaping the efficiency of the private debt providers, thus

[5] See Sanders (2018) for the list of the world's top 50 largest banks in 2018.

our research has opened up fruitful avenues for future research. We find that the development of bond markets generally enhances bank profit efficiency but depresses bank cost efficiency, and this effect is more prominent for the aggregate bond market and the government bond market.[6] Given the level of the aggregate bond market, increasing the proportion of corporate bonds will improve both bank profit and cost efficiency; and among the local currency bonds, increasing the share of local currency corporate bonds will significantly increase bank profit efficiency. Also, given the development level of the corporate bond market, increasing the proportion of local currency corporate bonds has a significantly positive effect on both bank profit and cost efficiency, and increasing the share of bank-issued corporate bonds in local currency (foreign currency) corporate bonds will significantly increase (decrease) bank profit (cost) efficiency. As the first empirical study to investigate the impact of bond markets on bank efficiency, our research can be extended in many ways. For example, the research can be extended to the global sample or the samples from other regions as ours is confined to the sample from the Asia and Pacific region; also a more in-depth study on the impact of bond markets can be conducted when more detailed information on bank participation in bond markets (such as the information on bank holdings of government bonds) become available in the future; furthermore, the impact of bond markets on the overall banking sector efficiency, instead of bank-level efficiency, is a potential research topic as well.

Second, our findings have important implications for both policy makers and bank management. Distinguished from most of the existing empirical studies that focus on either bank profit efficiency or bank cost efficiency, we examine both and find that bond markets exert different effects on bank profit and cost efficiency. Our findings confirm our conjecture that bond markets can be the complementary source of finance (and investment tool) as well as a potential competitor of banks when some clients shift from bank borrowing to direct finance in the bond market via corporate bond issuance. As bond issuance will cost more than deposits with the same maturity, the development of bond markets will not only improve the efficiency of bank asset allocation but also increase bank funding cost when banks utilize bond financing. The structure of bond markets also matters to bank efficiency and increasing the proportion of local currency bonds will significantly improve bank efficiency. The findings provide important policy implications for economies with a very low level of development of bond markets or even have no bond markets, and for economies with high development level of bond markets but unbalanced structure of bond markets. Bond markets work like a two-edged sword for bank management. On the asset side, banks can invest in corporate bond markets to diversify risks in their asset portfolios, but they also face competition from corporate bond markets in that some clients will use direct financing. On the liability side, banks may obtain stable funds from the corporate bond markets, but they need to pay higher financing costs for greater funding stability.

This paper proceeds as follows. Section II describes the data and the detailed measurements of variables. Section III presents the empirical models for our study. Section IV reports the empirical results, and section V concludes.

[6] Higher profit efficiency means that given input level, banks can deliver more profit, while greater cost efficiency is that given the output level, banks have lower costs.

II. DATA AND VARIABLE MEASUREMENTS

A. Data and Sample

We utilize four major datasets derived from a number of sources: (i) The financial data on universal commercial banks are extracted from Fitch Connect, which was the original banking data provider for Bankscope database. This database provides detailed historical accounting information of banks covering a large number of countries, the bank financial data are all converted into United States dollars (USD) to ensure consistency. (ii) The data on bond markets are collected and compiled from Bloomberg, all in USD. (iii) The country-specific data are derived from the World Bank and the International Monetary Fund. (iv) The information on bank regulations and supervisions are from the World Bank surveys compiled by Barth, Carpio, and Levine (2013). Table 1 presents the detailed data sources and the measurement of each major variable.

Table 1: Variable Definitions or Measurements and Data Sources

Variables	Descriptions	Data Source
A. Variables included in the SFA estimation		
PBT	Profit before taxes	Fitch Connect
TC	Total cost, defined as the sum of interest and noninterest expense	Fitch Connect
P1	Output price of loans, defined as the ratio of interest revenue to total loans (net of loan loss provisions)	Fitch Connect
P2	Output price of other assets, defined as the ratio of noninterest revenue to other earnings assets	Fitch Connect
W1	Cost of deposits measured by the ratio of interest expense to total deposits	Fitch Connect
W2	Cost of physical capital. W_2 = (operating expense – personnel expense)/fixed asset	Fitch Connect
W3	The labor cost, defined as the ratio of personnel expense to total assets	Fitch Connect
NPI	Negative profit indicator that takes a value of 1 if $PBT > 0$, and the absolute value of PBT if $PBT < 0$	Fitch Connect
EQ	Bank equity in United States dollars (USD)	Fitch Connect
T	*T* takes a value of 1 for 2004, increases by 1 for each subsequent year, until 14 for year 2017	Not available
MADV	Dummy variable that takes a value of 1 for major advanced economy (Japan in our sample), and 0 otherwise	International Monetary Fund (IMF)
ADV	Dummy variable that takes a value of 1 for advanced economy (Australia; Hong Kong, China; Republic of Korea; Singapore; and New Zealand in our sample), and 0 otherwise	IMF
B. Bond market indicators		
TB_GDP	Total aggregate bond value outstanding divided by gross domestic product (GDP), all converted into USD, by the end of each year for each economy	Bloomberg, World Bank's World Development Indicators Database. https://databank.worldbank.org/source/world-development-indicators
CB_GDP	Aggregate corporate bond value outstanding divided by GDP, all converted into USD, by the end of each year for each economy	Bloomberg, World Bank's World Development Indicators

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Table 1 *continued*

Variables	Descriptions	Data Source
GB_GPD	Aggregate government bond value outstanding divided by GDP, all converted into USD, by the end of each year for each economy	Bloomberg, World Bank's World Development Indicators
CB_TB	The ratio of corporate bond value to the total aggregate bond value outstanding by the end of each year for each economy	Bloomberg
GB_TB	The ratio of government bond value to the total aggregate bond value outstanding by the end of each year for each economy	Bloomberg
LC_TB	The ratio of local currency bond value to the total aggregate bond value outstanding by the end of each year for each economy	Bloomberg
LCC-LC	The ratio of local currency corporate bond value to the local currency bond value outstanding by the end of each year for each economy	Bloomberg
FC_TB	The ratio of foreign currency bond value to the total aggregate bond value outstanding by the end of each year for each economy	Bloomberg
FCC_FC	The ratio of foreign currency corporate bond value to the foreign currency bond value outstanding by the end of each year for each economy	Bloomberg
LCC_CB	The ratio of local currency corporate bond value to the aggregate corporate bond value outstanding by the end of each year for each economy	Bloomberg
FCC_CB	The ratio of foreign currency corporate bond value to the aggregate corporate bond value outstanding by the end of each year for each economy	Bloomberg
LCB_LLC	The ratio of local currency bank-issued corporate bond value to the local currency corporate bond value outstanding by the end of each year for each economy	Bloomberg
LCNB_LLC	The ratio of local currency nonbank-issued corporate bond value to the local currency corporate bond value outstanding by the end of each year for each economy	Bloomberg
FCB_FCC	The ratio of foreign currency bank-issued corporate bond value to the foreign currency corporate bond value outstanding by the end of each year for each economy	Bloomberg
FCNB_FCC	The ratio of foreign currency bank-issued corporate bond value to the foreign currency corporate bond value outstanding by the end of each year for each economy	Bloomberg
C. Control variables		
fin_open1	The Chinn–Ito index was initially introduced in Chinn and Ito (2006) to measure a country's degree of capital account openness. The index is based on the binary dummy variables that codify the tabulation of restrictions on cross-border financial transactions reported in the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER). The higher value of the index indicates more openness of a country's capital account transactions. We use the normalized index ranging between 0 and 1 from the updated version of the database based on the 2017 AREAER.	Chinn and Ito (2008). This paper uses an updated database downloaded from http://web.pdx.edu/~ito/Chinn-Ito_website.htm
Inv_freedom	It measures the degree of constraint placed by a country on the cross-border investment capital flows. The index ranges between 0 and 100, a higher value of the index indicates greater freedom. An index of 100 implies that capital can move freely in and out of the country without restrictions.	The Heritage Foundation. http://heritage.org/index/

continued on next page

Table 1 *continued*

Variables	Descriptions	Data Source
inflat	Yearly inflation rates are obtained for each market, the rolling 3-year average of inflation rates of the most recent 3 years is used.	IMF's World Economic Outlook Database https://www.imf.org/external/pubs/ft/weo/2019/02/weodata/index.aspx
RgdpGrowth	Real growth rate of GDP (GDP, in USD)	World Bank's World Development Indicators Database
LnRgdp_pc	Natural log of real GDP per capita	World Bank's World Development Indicators Database
act_restrict	Index of bank activity restrictions. The index is constructed by the extent to which banks may engage in (i) underwriting, brokering and dealing in securities, and all aspects of the mutual fund industry; (ii) insurance underwriting and selling; and (iii) real estate investment, development, and management. These activities can be unrestricted, permitted, restricted or prohibited, which are assigned the values of 1–4, respectively. Higher value indicates greater restrictiveness.	Barth, Carpio, and Levine (2013)
be_req	Index of entry into banking requirements. It measures whether various types of legal submissions are required to obtain a banking license, including draft bylaws, intended organizational chart, market and business strategy, financial projections for the first 3 years, financial information on main potential shareholders, background and experience of future Board directors, background and experience of future senior managers, and source of funds to be used as capital. A value of 1 is assigned to each of these submissions, and 0 otherwise. Higher values indicate greater stringency.	Barth, Carpio, and Levine (2013)
sup_ind	Index of bank supervisory independence. It measures the degree to which the supervisory authority is independent within the government from political influence, protected by the legal system from the banking system, and is able to make decisions independently of political considerations. Higher value indicates greater independence.	Barth, Carpio, and Levine (2013)
priv_monitor	The private monitoring index is composed of information on (1) whether bank directors and officials are legally liable for the accuracy of information disclosed to the public; (2) whether banks must publish consolidated accounts; (3) whether banks must be audited by certified international auditors; (4) whether 100% of the largest 10 banks are rated by international rating agencies; (5) whether off-balance sheet items are disclosed to the public; (6) whether banks must disclose their risk management procedures to the public; (7) whether accrued, though unpaid interest or principal, enter the income statement while the loan is still nonperforming; (8) whether subordinated debt is allowable as part of capital; and (9) whether there is no explicit deposit insurance system and no insurance was paid the last time a bank failed. Thus, the maximum value of the private monitoring index is 12 and the minimum value is 0, where larger values indicate greater regulatory empowerment of the monitoring of banks by private investors.	Barth, Carpio, and Levine (2013)
bc_assets	Bank concentration ratio measuring the degree of concentration of assets in the five largest banks. Higher value indicates greater concentration of the assets.	Barth, Carpio, and Levine (2013)
bc_deposits	Bank concentration ratio measuring the degree of concentration of deposits in the five largest banks. Higher value indicates greater concentration of the deposits.	Barth, Carpio, and Levine (2013)

continued on next page

Table 1 *continued*

Variables	Descriptions	Data Source
fb_ownership	Foreign-owned banks. It measures the extent to which the banking system's assets are foreign owned, defined as the percentage of the banking system's assets in banks that was foreign controlled (e.g., where foreigners owned 50% or more bank equity).	Barth, Carpio, and Levine (2013)
gov_bank	Government-owned banks. It reports the percentage of the banking system's assets in banks that was government controlled (e.g., where government owned 50% or more equity).	Barth, Carpio, and Levine (2013)
size	Size of bank, measured as the natural logarithm of total assets (in USD)	Fitch Connect
capital_ratio	Bank capital ratio, measured as the regulatory capital divided by total assets	Fitch Connect
Year dummies	Dummy variable that takes a value of 1 for a particular year, and 0 otherwise. We use 2004 as the base year.	Not available

Source: Authors' compilation.

We start with 35 economies with data on universal commercial banks from the Asia and Pacific region and exclude banks without sufficient data to construct the bank efficiency variables. After matching the bank data with bond indicators and country-specific variables, we have complete data for 926 banks covering 27 economies over the period 2004–2017. Appendix 1 reports the list of economies and number of banks for each economy that are included in this study.

B. Measurement of Bank Efficiency

In the literature, two econometric approaches have been broadly used to estimate bank efficiency: the nonparametric data envelopment analysis (DEA) and the parametric stochastic frontier approach (SFA) techniques. For the purpose of this study, we employ SFA due to two reasons: First, DEA assumes no statistical error term, which may lead to inaccurate measurement of bank efficiency as random noise such as luck would be treated as inefficiency. Second, the DEA methods generally ignore bank input and output prices, as observed by Berger and Mester (1997), and cannot compare banks specialized in different inputs and outputs, and thus are more suitable for measuring technological rather than economic efficiency.

The stochastic production function, originally proposed by Aigner, Knox Lovell, and Schmidt (1977) and Meeusen and Vanden Broeck (1977) independently, specifies an error term with two components: the nonnegative random variables to account for technical efficiency in production and the random variables to account for the factors not controlled by firms. Over the past few decades, the original production specification has been widely applied and extended, many models have been developed to estimate the production and cost- efficient functions. Kumbhakar, Parmeter, and Zelenyuk (2017) provide an excellent review on the latest developments in the econometric estimation of productivity and efficiency using the stochastic frontier models.

To specify the inputs and outputs of banks for the efficiency frontier functions, we follow the "intermediation" approach which perceives banks as collectors of funds that are then intermediating into loans and other assets. An alternative "production" approach assumes that banks produce loans and deposits account services, using labor and capital as inputs, and the number and type of transactions or documents processed as outputs. The intermediation approach is more suitable for evaluating the efficiency of a bank as a whole, while the production approach is more appropriate for

evaluating the efficiencies of bank branches (Berger and Humphrey 1997). Consistent with the recent empirical studies (Gaganis and Pasiouras 2013; Lensink, Meesters, and Naaborg 2008; Lozano-Vivas and Pasiouras 2010; Luo, Tanna, and De Vita 2016), we classify banks in our sample as a multiproduct firms with two outputs: loans and other earning assets, and three inputs: labor, physical capital, and deposits. The measurement of input and output prices and the detailed model specifications for bank profit and cost efficiency are presented in section III.

C. Bond Market Indicators

We consider two types of indicators to capture bond market development: the size of bond markets and the structure of bond markets. Appendix 2 provides the illustration of these variables.

1. Bond Market Development Indicators

We consider three types of bond markets: the aggregate bond market that includes both corporate bonds and government bonds (*TB*), the corporate bond market (*CB*), and the government bond market (*GB*). The development of each market is measured as the ratio of the total bond value outstanding for each market to GDP. The bond value and GDP are all converted into USD. GDP data are derived from the World Bank's Development Indicators.

2. Structure of Bond Markets

We also investigate the impact of bond market structure on bank efficiency with the control of bond market development. We measure the structure of the aggregate bond market and the corporate bond market from different perspectives. For the aggregate bond market, we look at the proportion of local currency bonds (*LC_TB*) versus the proportion of foreign currency bonds (*FB_TB*), and the proportion of corporate bonds (*CB_TB*) versus the proportion of government bonds (*GB_TB*). We classify corporate bonds into local currency (*LLC*) and foreign currency corporate bonds (*FCC*) and calculate its ratio to corporate bonds (*LLC_CB* versus *FCC_CB*), and then for each currency corporate bond, we further look at the proportion of bank-issued corporate bonds versus nonbank-issued corporate bonds (e.g., *LCB_LLC* versus *LCNB_LLC* for local currency corporate bonds).[7]

D. Control Variables

Consistent with the relevant literature, we investigate the impact of bond markets on bank efficiency with the control of a number of variables including country-specific, banking industry-specific, and bank-specific variables.

1. Country-Specific Variables

Besides the conventional variables, such as real GDP growth rate (*RgdpGrowth*), natural logarithm of real GDP per capita (*LnRgdp_pc*), and inflation rate (*inflat*) to control for the macroeconomic conditions, we also include the variables of financial openness (*fin_open1*) and investment freedom

[7] We also examine the impact of government bond market structure by splitting government bonds into local currency and foreign currency government bonds, the results are mixed. The unavailability of the data on bank participation in government bond markets (e.g., bank holding of government bonds) stops us from doing further investigation. Thus, we do not report the results here.

(*Inv_freedom*) based on recent research (Luo, Tanna, and De Vita 2016). Similar to Luo, Tanna, and De Vita (2016), we utilize the Chinn–Ito index to measure financial openness, however, we use the normalized index ranging between 0 and 1 from the latest updated database to control for possible outliers.

2. Banking Industry-Specific Variables

Banking industry-specific variables are primarily the variables on bank regulations and supervisions. The data are obtained from the database compiled by Barth, Carpio, and Levine (2013) based on World Bank surveys. With the guidance and help from bank supervisors and financial economists, the World Bank has implemented four surveys that were completed in 1999, 2003, 2007, and 2012. Overall, the surveys cover 180 countries with more than 400 questions, although the number of countries varies from one survey to another. The results of each survey are publicly available on the World Bank website.[8] Rather than use the raw data from the World Bank, we use the database assembled by Barth, Carpio, and Levine (2013) for the following reasons: First, they have reviewed each of the four surveys individually by considering the time series of the answers for each country, and have corrected the inconsistencies and missing values, thus providing a more comprehensive and accurate set of data. Second, they provided summary indexes of major categories of bank regulatory and supervisory policies, which is crucial given the number of questions for each survey. The database compiled by Barth, Carpio, and Levine (2013), together with its early versions based on the early surveys, has been widely used in empirical studies.

Since the survey data span more than a decade and our sample period is from 2004 to 2017, to ensure accuracy, we use the second survey data for the variables in the sample period 2004–2005, the third survey data for the sample period 2006–2010, and the fourth survey data for the sample period 2011–2017. As the fourth survey only covers 125 countries, we use the third survey data if the fourth survey data are not available. After matching all banking industry variables, eventually we have 783 banks with 5,238 bank-year observations.

The variables selected in our study comprise of bank activity restriction index (*act_restrict*); bank entry requirement index (*be_req*), bank supervisory index (*sup_ind*), private monitoring index (*priv_monitor*), and the banking market structure variables including bank asset concentration (*bc_assets*), bank deposit concentration (*bc_deposits*), foreign ownership of bank (*fb_ownership*), and government ownership of bank (*gov_bank*).

3. Other Control Variables

Other control variables include bank-specific variables, bank size (*size*) and capital ratio (*capital_ratio*), and year dummies. We use 2004 as the base year of year dummies when running regression models.

[8] World Bank. Bank Regulation and Supervision Survey. https://www.worldbank.org/en/research/brief/BRSS.

E. Summary Statistics of the Variables

Table 2 presents the summary statistics of the major variables, while Table 3 reports the correlation matrix of the bond indicators and the control variables.

As shown in panel B of Table 2, the bond market development and the structure of bond markets vary significantly in the Asia and Pacific region. The Mean value of the ratio of total bond value outstanding to GDP, the indicator of the aggregate bond market development, is 66.2%, ranging from as high as 438.8% for Japan to the minimum of zero for Cambodia, the Lao People's Democratic Republic, and Tajikistan. The aggregate bond market is dominated by government bonds that constitute about two-thirds of aggregate bond value outstanding. About three-quarters of the bonds are denominated in local currency, and only one-quarter of the local currency bonds are corporate bonds. Banks are the major players in the corporate bond market; on average, around 30% of corporate bonds, either denominated in local or foreign currency, were issued by banks. The wide disparities in bond market development and structure across this region provide us with a rich sample for our research.

Table 2: Summary Statistics of Major Variables

Variables	NOB	Mean	SD	Minimum	Maximum
A. Variables in the SFA functions					
$Ln\_PBT\_W_3$	6,011	3.727	1.219	−0.704	7.113
$LnTC\_W_3$	6,011	4.351	1.045	0.933	7.546
$Ln\_P_1\_W_3$	6,011	0.885	0.284	−1.842	3.647
$Ln\_P_2\_W_3$	6,011	0.489	0.496	−2.770	3.466
$Ln\_W_1\_W_3$	6,011	0.320	0.523	−3.455	4.830
$Ln\_W_2\_W_3$	6,011	2.250	0.562	−0.591	6.942
LnEQ	6,011	2.668	0.856	−1.022	5.499
B. Bond market indicators					
TB_GDP	6,011	0.662	0.934	0.000	4.388
CB_GDP	6,011	0.123	0.130	0.000	0.594
GB_GDP	6,011	0.539	0.888	0.000	4.172
GB_TB	6,011	0.617	0.284	0.000	1.000
CB_TB	6,011	0.312	0.244	0.000	1.000
LC_TB	6,011	0.752	0.303	0.000	1.000
FC_TB	6,011	0.143	0.165	0.000	1.000
LCC_LC	6,011	0.252	0.221	0.000	1.000
FCC_FC	6,011	0.607	0.384	0.000	1.000

continued on next page

Table 2 *continued*

Variables	NOB	Mean	SD	Minimum	Maximum
LCC_CB	6,011	0.612	0.321	0.000	1.000
FCC_CB	6,011	0.229	0.205	0.000	1.000
LCB_LCC	6,011	0.312	0.203	0.000	1.000
LCNB_LCC	6,011	0.593	0.261	0.000	1.000
FCB_FCC	6,011	0.296	0.252	0.000	1.000
FCNB_FCC	6,011	0.509	0.324	0.000	0.980
C. Control variables in the bank efficiency functions					
size	6,011	3.671	0.988	0.638	6.603
capital_ratio	6,011	0.128	0.113	0.000	0.975
fin_open1	6,011	0.427	0.328	0.000	1.000
Inv_freedom	6,011	42.050	19.612	0.000	90.000
inflat	6,011	0.047	0.032	−0.020	0.157
RgdpGrowth	6,011	0.056	0.027	−0.054	0.173
LnRgdp_pc	6,011	3.714	0.558	2.692	4.778
act_restrict	5,780	8.280	2.047	3.000	12.000
be_req	5,786	7.575	0.586	6.000	8.000
sup_ind	5,786	1.846	0.853	0.000	3.000
priv_monitor	5,436	8.914	1.285	5.000	11.000
bc_deposit	5,529	0.581	0.136	0.322	1.000
bc_asset	5,768	0.563	0.128	0.2618	1.000
fb_ownership	5,355	0.184	0.212	0.000	0.991
gov_bank	5,511	0.330	0.279	0.000	0.753

NOB = Number of observations, SD = standard deviation, SFA = stochastic frontier approach.
Source: Authors' calculations.

Table 3: Correlation Matrix of Major Variables in Bank (In)efficiency Function

Panel A: Bond indicators															
NAME	*TB_GDP*	*CB_GDP*	*GB_ GDP*	*GB_TB*	*CB_TB*	*LC_TB*	*FC_TB*	*LCC_LC*	*FCC_FC*	*LCB_ LCC*	*LCNB_ LCC*	*FCB_FCC*	*FCNB_ FCC*	*LCC_CB*	*FCC_CB*
TB_GDP	1.000														
CB_GDP	0.377	1.000													
GB_GDP	0.991	0.251	1.000												
GB_TB	0.320	−0.192	0.362	1.000											
CB_TB	−0.220	0.425	−0.291	−0.623	1.000										
LC_TB	0.379	0.414	0.337	0.667	−0.169	1.000									
FC_TB	−0.332	−0.287	−0.305	−0.244	0.462	−0.547	1.000								
LCC_LC	−0.160	0.494	−0.238	−0.585	0.919	−0.080	0.303	1.000							
FCC_FC	0.372	0.593	0.304	−0.197	0.588	0.365	−0.077	0.608	1.000						
LCB_LCC	−0.194	−0.172	−0.178	0.222	0.102	0.166	0.247	0.094	−0.032	1.000					
LCNB_LCC	0.349	0.411	0.306	0.372	0.116	0.579	−0.041	0.204	0.464	−0.330	1.000				
FCB_FCC	0.327	0.254	0.306	−0.161	0.443	0.024	0.286	0.429	0.609	0.277	0.121	1.000			
FCNB_FCC	0.009	0.235	−0.024	0.218	0.106	0.343	0.058	0.132	0.260	−0.167	0.614	−0.247	1.000		
LCC_CB	0.363	0.526	0.305	0.401	−0.029	0.865	−0.590	0.132	0.447	−0.042	0.608	0.071	0.260	1.000	
FCC_CB	−0.145	−0.232	−0.118	−0.096	0.353	−0.363	0.889	0.173	0.106	0.235	0.123	0.411	0.178	−0.509	1.000

continued on next page

Table 3 *continued*

Panel B: Control variables

NAME	*fin_open1*	*Inv_freedom*	*inflat*	*RgdpGrowth*	*LnRgdp_pc*	*act_restrict*	*be_req*	*sup_ind*	*priv_monitor*	*bc_deposit*	*bc_asset*	*fb_ownership*	*gov_bank*
fin_open1	1.000												
Inv_freedom	0.690	1.000											
inflat	−0.354	−0.339	1.000										
RgdpGrowth	−0.547	−0.508	0.159	1.000									
LnRgdp_pc	0.667	0.462	−0.588	−0.500	1.000								
act_restrict	−0.407	−0.485	0.052	0.344	−0.120	1.000							
be_req	0.108	0.030	0.208	−0.105	−0.048	−0.336	1.000						
sup_ind	0.266	0.255	0.108	−0.255	0.041	−0.485	0.252	1.000					
priv_monitor	0.058	−0.147	0.018	−0.059	0.230	0.227	0.134	0.020	1.000				
bc_deposit	−0.094	−0.083	−0.176	0.088	0.131	0.012	0.197	−0.135	−0.171	1.000			
bc_asset	−0.052	−0.076	−0.208	0.032	0.228	0.089	0.109	−0.153	−0.144	0.958	1.000		
fb_ownership	0.370	0.335	0.120	−0.245	0.186	−0.323	0.387	0.319	0.312	0.031	−0.004	1.000	
gov_bank	−0.625	−0.675	0.164	0.592	−0.420	0.500	−0.324	−0.245	0.344	−0.095	−0.101	−0.331	1.000

Source: Authors' calculations.

III. EMPIRICAL FRAMEWORK

A. General Model

We employ the Battese and Coelli (1995) SFA model to estimate bank efficiency. This model provides unbiased systematic estimates for unbalanced panel data during which bank efficiency can be influenced by county-specific and bank-specific factors, and thus is widely used in cross-country analysis (Lozano-Vivas and Pasiouras 2010; Gaganis and Pasiouras 2013; Luo, Tanna, and De Vita 2016). This model allows us to investigate the impact of bond markets on bank efficiency while controlling for other differences at country and bank levels. The general efficiency model is presented as follows:

$$Y_{i,t} = X_{i,t}\beta + \varepsilon_{i,t} \text{ i} = 1,2, \dots, N;\ t = 1,2, \dots T \tag{1}$$

where $Y_{i,t}$ is the logarithm of pretax profit (total cost) of bank i at time t, $\uparrow \varepsilon_{i,t} = v_{i,t} - u_{i,t}$ $\left(\varepsilon_{i,t} = v_{i,t} + u_{i,t}\right)$ for the profit (cost) function. $X_{i,t}$ is a $k \times 1$ vector of (transformations of the) input and output prices of bank i at period t, β is a vector of unknown scalar parameters to be estimated. $V_{i,t}$ are random errors which are assumed to be independent and identically distributed and have $N(0, \sigma^2{}_v)$. $u_{i.t}$ are the nonnegative inefficiency terms which are assumed to be independently distributed as truncations at 0 of the $N(m_{i,t}, \sigma^2{}_u)$, and

$$m_{i,t} = z_{i,t}\xi \tag{2}$$

where $z_{i,t}$ is a $k \times 1$ vector of observable variables at t that may affect the inefficiency of bank i at period t, ξ is a $1 \times k$ vector of unknown parameters to be estimated at t. The Battese and Coelli (1995) model allows us to estimate the parameters in equations (1) and (2) in one step using maximum likelihood method.

B. Empirical Models for Bank Efficiency

We employ a multiproduct translog SFA function to estimate bank efficiency. Profit efficiency measures how close a bank can generate maximum obtainable profit given input and output prices. A bank is labeled inefficient if its profits are lower than the best-practice bank after removing the random error.

Based on translog profit function, the specific empirical SFA model for bank profit efficiency is presented as:

$$\begin{aligned}
&\ln\frac{PBT}{W_3} = \beta_0 + \beta_1 \ln\frac{P_1}{W_3} + \beta_2 \ln\frac{P_2}{W_3} + \beta_3 \ln\frac{W_1}{W_3} + \beta_4 \ln\frac{W_2}{W_3} + \beta_5 \frac{1}{2}\left(\ln\frac{P_1}{W_3}\right)^2 + \beta_6 \frac{1}{2}\left(\ln\frac{P_2}{W_3}\right)^2 + \\
&\beta_7 \frac{1}{2}\left(\ln\frac{W_1}{W_3}\right)^2 + \beta_8 \frac{1}{2}\left(\ln\frac{W_2}{W_3}\right)^2 + \beta_9 \ln\frac{P_1}{W_3}\ln\frac{P_2}{W_3} + \beta_{10} \ln\frac{P_1}{W_3}\ln\frac{W_1}{W_3} + \beta_{11} \ln\frac{P_1}{W_3}\ln\frac{W_2}{W_3} + \\
&\beta_{12} \ln\frac{P_2}{W_3}\ln\frac{W_1}{W_3} + \beta_{13} \ln\frac{P_2}{W_3}\ln\frac{W_2}{W_3} + \beta_{14} \ln\frac{W_1}{W_3}\ln\frac{W_2}{W_3} + \beta_{15} \ln EQ + \beta_{16} \frac{1}{2}(\ln EQ)^2 + \\
&\beta_{17} \ln EQ \ln\frac{P_1}{W_3} + \beta_{18} \ln EQ \ln\frac{P_2}{W_3} + \beta_{19} \ln EQ \ln\frac{W_1}{W_3} + \beta_{20} \ln EQ \ln\frac{W_2}{W_3} + \beta_{21} T + \beta_{22} T^2 + \\
&\beta_{23} \ln\frac{NPI}{W_3} + \beta_{24} MADV + \beta_{25} ADV - \mu_{i,t} + \vartheta_{i,t}
\end{aligned} \tag{3}$$

where PBT is the profit before tax, P and W denote output and input prices, respectively.

P_1 is the output price of loans, defined as the ratio of interest revenue to total loans. The loan loss provisions are excluded from total loans in order to ensure the comparable quality of this output (Havrylchyk 2006).

P_2 is the output price of other assets, measured by the ratio of noninterest revenue to other earning assets.

W_1 is the cost of deposits, measured by the ratio of interest expense to total deposits. W_2 is equal to (operating expense - personnel expense)/fixed asset, is used to measure the cost of physical capital. W_3 is the labor cost, defined as the ratio of personnel expense to total assets. To impose the homogeneity restrictions on the frontier model, we normalize all the dependent variables, input and output prices by W_3 (Berger and Mester 1997).[9]

Following previous empirical studies (Lensink, Meesters, and Naaborg 2008; Lozano-Vivas and Pasiouras 2010; Gaganis and Pasiouras 2013; Luo, Tanna, and De Vita 2016), we introduce a time trend (T = 1 for 2004 T = 2 for 2005, ..., T = 14 for 2017), in both linear and quadratic (i.e., T and T^2) terms, to control for the technological changes over time. We also include equity in the efficiency frontier function to control for the differences in risk preferences of bank managers (Berger and Mester 1997).

To handle the negative bank profits for the natural logarithmic transformation of dependent variable, we adopt the approach proposed by Bos and Koetter (2011) by introducing an independent variable, negative profit indicator (*NPI*). If a bank incurs a loss or zero profit, $PBT \leq 0$, then the dependent variable takes a value of one and *NPI* will be the absolute value of the negative PBT; if PBT is positive, then *NPI* will be assigned a value of 1. By this way, we can preserve all observations without changing the error terms of the SFA model.[10]

To control for the differences in the level of economic development, we follow the classification of the International Monetary Fund to group our sample into three: major advanced economies (e.g., Group of 7), advanced economies, emerging and developing economies. *MAVD* takes a value of 1 for major advanced economy (Japan in our sample), otherwise 0; *ADV* takes a value of 1 for advanced economies (Australia; Hong Kong, China; Republic of Korea; Singapore; and New Zealand) and otherwise 0.

$v_{i,t}$ are random errors which are assumed to be normally distributed, and u is the inefficiency term. A profit efficiency score of 0.9 would mean that the bank is earning 90% of the best-practice profits or that the bank is losing 10% of potential profit due to excessive costs, deficient revenue, or both.

[9] That is, on the efficient frontier, a doubling of all input prices exactly doubles costs, and a doubling of all input and output prices doubles standard profits.

[10] An alternative approach is to convert the nonpositive PBT by adding the absolute value of the negative PBT and 1 to the original value: $PBT + (|PBT^{min}| + 1)$. As pointed out by Bos and Koetter (2011), such a transformation may affect the error term of SFA and might also omit the information for the truncated part of the distribution of the dependent variable, which will lead to the misleading estimation of efficiency.

Based on translog cost function, the specification of the empirical SFA model for bank cost efficiency is presented as:

$$\ln\frac{TC}{W_3} = \beta_0 + \beta_1 \ln\frac{P_1}{W_3} + \beta_2 \ln\frac{P_2}{W_3} + \beta_3 \ln\frac{W_1}{W_3} + \beta_4 \ln\frac{W_2}{W_3} + \beta_5 \frac{1}{2}\left(\ln\frac{P_1}{W_3}\right)^2 + \beta_6 \frac{1}{2}\left(\ln\frac{P_2}{W_3}\right)^2 + \beta_7 \frac{1}{2}\left(\ln\frac{W_1}{W_3}\right)^2 + \beta_8 \frac{1}{2}\left(\ln\frac{W_2}{W_3}\right)^2 + \beta_9 \ln\frac{P_1}{W_3}\ln\frac{P_2}{W_3} + \beta_{10} \ln\frac{P_1}{W_3}\ln\frac{W_1}{W_3} + \beta_{11} \ln\frac{P_1}{W_3}\ln\frac{W_2}{W_3} + \beta_{12} \ln\frac{P_2}{W_3}\ln\frac{W_1}{W_3} + \beta_{13} \ln\frac{P_2}{W_3}\ln\frac{W_2}{W_3} + \beta_{14} \ln\frac{W_1}{W_3}\ln\frac{W_2}{W_3} + \beta_{15} \ln EQ + \beta_{16} \frac{1}{2}(\ln EQ)^2 + \beta_{17} \ln EQ \ln\frac{P_1}{W_3} + \beta_{18} \ln EQ \ln\frac{P_2}{W_3} + \beta_{19} \ln EQ \ln\frac{W_1}{W_3} + \beta_{20} \ln EQ \ln\frac{W_2}{W_3} + \beta_{21} T + \beta_{22} T^2 + \beta_{23} MADV + \beta_{24} ADV + \mu_{i,t} + \vartheta_{i,t} \quad (4)$$

where TC is the total cost, defined as the sum of interest and noninterest expense. Other variables are the same as those in the profit SFA model.

To investigate the impact of bond market on bank (in)efficiency while controlling for other bank-, industry-, and country-level characteristics,$m_{i,t}$ in equation (2) is specified as

$$m_{it} = \delta_0 + \delta_j Bond + \sum \delta_k Z_{it} \quad (5)$$

where $Bond$ is the indicator of bond market development and structure. We measure the development of bond markets in each economy at different levels, which include the ratios of total bond value to GDP (*TB_GDP*), government bond value to GDP (*GB_GDP*), and corporate bond value to GDP (*CB_GDP*). Bond market structure is measured from different perspectives, including local currency bonds versus foreign currency bonds, government bonds versus corporate bonds, bank-issued corporate bonds outstanding versus nonbank-issued corporate bonds outstanding. Z_{it} is the number of controlling variables that are presented in section II.D.

IV. EMPIRICAL RESULTS

This section presents the empirical results about the impact of bond markets on bank efficiency obtained from the Battese and Coelli (1995) model. Tables 4–7 report the results based on equation (5), noted that the dependent variable is bank profit or cost inefficiency, thus the negative sign of a coefficient will indicate that the variable has a positive impact on bank profit or cost efficiency. The *t* statistics are in parentheses, and ***, **, and * indicate significance levels at 1%, 5%, and 10%, respectively.

A. Effect of the Overall Bond Market Development on Bank Efficiency

We look at the overall development of three bond markets, the aggregate bond market that includes both government bonds and corporate bonds, the government bond market, and the corporate bond market. Tables 4 and 5 show the impact of the overall market development on bank profit and cost efficiency, respectively.

Specifications 1–3 in each table are the results with control of both country-specific and bank-specific variables, while specifications 4–9 report the results by adding additional control for banking industry-specific variables. In general, the development of these three bond markets has a positive effect on bank profit efficiency but a negative one on bank cost efficiency, and this result is robust to the control for country-specific factors, banking industry-specific and bank-level characteristics, and the time trend.

Table 4: Bank Profit (In)efficiency and the Level of Bond Market Development

Model Specification	1	2	3	4	5	6	7	8	9
size	−0.766***	−0.770***	−1.340***	−2.062***	−0.817***	−0.819***	−0.795***	−0.797***	−0.797***
	(−23.674)	(−24.779)	(−12.226)	(−42.232)	(−21.497)	(−21.026)	(−26.137)	(−25.711)	(−26.323)
capital_ratio	0.070	0.074	0.724***	0.526***	−0.003	−0.014	−0.127	−0.111	−0.129
	(0.567)	(0.589)	(4.297)	(3.726)	(−0.025)	(−0.107)	(−0.961)	(−0.834)	(−0.979)
TB_GDP	−0.051*			−0.339***			−0.067**		
	(−1.811)			(−9.809)			(−2.214)		
CB_GDP		−0.227			−0.313*			−0.326	
		(−1.350)			(−1.804)			(−1.491)	
GB_GPD			−0.208***			−0.059*			−0.063*
			(−5.819)			(−1.907)			(−1.920)
fin_open1	−0.064	−0.098	−0.161*	−0.401***	−0.160*	−0.086	−0.242***	−0.314***	−0.226***
	(−0.854)	(−1.215)	(−1.804)	(−4.931)	(−1.891)	(−1.093)	(−2.949)	(−3.038)	(−2.797)
Inv_freedom	0.002**	0.002**	0.008***	0.034***	0.007***	0.007***	0.003**	0.003*	0.003*
	(2.127)	(2.088)	(5.780)	(19.046)	(4.730)	(4.492)	(1.981)	(1.716)	(1.882)
inflat	3.468***	3.421***	7.881***	8.825***	3.084***	3.233***	3.025***	2.919***	3.098***
	(5.481)	(5.758)	(7.538)	(10.247)	(3.938)	(4.134)	(4.485)	(3.789)	(4.448)
RgdpGrowth	−2.909***	−2.701***	−8.038***	−13.357***	−3.139***	−3.453***	−4.163***	−3.942***	−4.106***
	−4.494	−4.560	−6.526	−11.962	−3.506	−3.816	−4.892	−4.348	−4.619
LnRgdp_pc	0.208***	0.217***	0.623***	1.004***	0.259***	0.237***	0.285***	0.315***	0.271***
	(4.567)	(4.776)	(9.016)	(19.804)	(5.386)	(5.348)	(5.111)	(4.836)	(4.996)
act_restrict				0.178***	0.034***	0.033***	0.017	0.020	0.015
				(14.120)	(3.127)	(3.134)	(1.445)	(1.565)	(1.263)
be_req				0.543***	0.125***	0.116***	0.138***	0.165***	0.137***
				(14.175)	(3.643)	(3.411)	(3.530)	(4.167)	(3.246)
sup_ind				−0.115***	−0.017	−0.020	−0.003	−0.001	−0.005
				(−5.350)	(−0.812)	(−0.958)	(−0.138)	(−0.064)	(−0.239)
priv_monitor							−0.025	−0.041*	−0.021
							(−1.281)	(−1.744)	(−1.057)
bc_asset							−0.010***	−0.010***	−0.010***
							(−6.027)	(−5.935)	(−5.888)
fb_ownership							−0.002**	−0.002	−0.002**
							(−2.036)	(−1.566)	(−2.039)
gov_bank							0.000	0.001	0.000
							(0.331)	(0.677)	(0.274)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of banks	926	926	926	880	880	880	783	783	783
No. of observations	6,011	6,011	6,011	5,762	5,762	5,762	5,238	5,238	5,238

Notes: This table reports the results estimated using the Battese and Coeli (1995) model. The dependent variable is bank profit inefficiency. The variables are defined in Table 1. *t* statistics are in parentheses, ***, **, and * indicate significance level at the 1%, 5%, and 15%, respectively.
Source: Authors' calculations.

Table 5: Bank Cost (In)efficiency and the Level of Bond Market Development

Model Specification	1	2	3	4	5	6	7	8	9
size	1.058***	1.057***	1.058***	0.053	1.060***	0.902***	1.078***	1.033***	1.048***
	(81.221)	(88.618)	(99.318)	(0.199)	(72.216)	(115.402)	(89.117)	(109.661)	(79.151)
capital_ratio	−0.100***	−0.102***	−0.099***	−0.112	−0.105***	−0.532***	−0.073*	−0.147***	−0.143***
	(−3.291)	(−2.967)	(−3.249)	(−0.134)	(−3.280)	(−42.682)	(−1.664)	(−4.589)	(−4.091)
TB_GDP	0.037***			0.004			0.036***		
	(6.546)			(0.013)			(6.308)		
CB_GDP		0.079***			0.066***			0.050	
		(3.842)			(3.003)			(1.082)	
GB_GPD			0.039***			0.031***			0.047***
			(5.877)			(6.890)			(6.399)
fin_open1	−0.027**	−0.033***	−0.037***	−0.080	−0.043***	−0.034***	−0.040**	−0.086***	−0.062***
	(−2.433)	(−2.846)	(−4.056)	(−0.095)	(−3.569)	(−2.714)	(−2.401)	(−4.271)	(−3.433)
Inv_freedom	0.000	0.000*	0.000	−0.004	0.000*	0.000**	0.000	0.000	0.000
	(0.900)	(1.748)	(1.130)	(−0.144)	(1.870)	(−2.421)	(−0.907)	(−0.012)	(−1.348)
inflat	0.403***	0.454***	0.378***	−0.002	0.479***	0.440***	0.379*	0.280	0.244
	(3.934)	(2.899)	(3.133)	(−0.002)	(6.407)	(4.365)	(1.692)	(1.593)	(1.295)
RgdpGrowth	−0.306**	−0.227**	−0.302***	0.003	−0.251***	−0.611***	−0.362**	−0.308	−0.315
	(−2.283)	(−2.330)	(−2.879)	(0.003)	(−2.853)	(−6.887)	(−1.926)	(−1.478)	(−1.572)
LnRgdp_pc	−0.037***	−0.040***	−0.032***	−0.016	−0.040***	−0.049***	−0.053***	−0.048***	−0.041***
	(−5.163)	(−5.327)	(−5.241)	(−0.025)	(−5.442)	(−13.005)	(−5.717)	(−3.571)	(−3.246)
act_restrict				0.008	0.003**	0.003***	0.002	0.001	0.004
				(0.060)	(2.090)	(6.205)	(0.832)	(0.515)	(1.596)
be_req				0.022	0.006*	−0.004	0.001	0.008	0.000
				(0.069)	(1.682)	(−0.935)	(0.134)	(0.968)	(0.000)
sup_ind				−0.016	0.002	0.005*	0.003	0.005	0.003
				(−0.054)	(0.805)	(1.881)	(0.641)	(1.098)	(0.894)
priv_monitor							0.003	−0.001	−0.001
							(0.923)	(−0.163)	(−0.159)
bc_deposit							0.000	0.000	0.000
							(−1.178)	(−1.186)	(0.059)
fb_ownership							0.000	0.000	0.000
							(−0.136)	(1.087)	(1.271)
gov_bank							0.000	0.000	0.000
							(−1.438)	(−0.567)	(−1.501)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of banks	926	926	926	880	880	880	783	783	783
No. of observations	6,011	6,011	6,011	5,762	5,762	5,762	5,238	5,238	5,238

Note: this table reports the results estimated using the Battese and Coeli (1995) model. The dependent variable is bank cost inefficiency. the variables are defined in Table 1. T-statistics are in parentheses, ***, **, and * indicate the significance levels at the 1%, 5%, and 15% respectively.
Source: Authors' calculations.

This effect is persistently significant for the aggregate bond market and the government bond market, but not for the corporate bond market. The results indicate that banks are generally more profit efficient, but less cost efficient, in an economy with higher development level of bond markets. This finding confirms our conjecture that bond markets, as an alternative source of finance either for the public or the private sector, may be a potential competitor of bank credit. On one hand, government and the high credit rating companies may choose to obtain finance from bond markets, which will force banks to take more risks and improve the efficiency of asset allocation in order to maintain profitability. On the other hand, banks may obtain a large amount of funds by issuing corporate bonds but with higher cost; furthermore, rather than deposit the funds into banks, institutional investors and wealthy individuals who prefer stable income may be diverted to bond markets and subsequently increases the funding cost of banks. This conjecture may explain the positive (negative) effect of bond market development on bank profit (cost) efficiency. However, as shown in Table 2, the development of bond markets in our sample economies varies significantly, with the aggregate bond value outstanding as high as more than 400% of GDP for Japan, and as low as zero for Cambodia, the Lao People's Democratic Republic, and Tajikistan; some countries have government bond market without corporate bond market, while some others have the opposite. Thus, simply looking at the development of bond markets may not provide a full picture on the impact of bond markets on bank efficiency. In the next sections, we investigate the impact of the bond market structure.

Consistent with relevant literature, our results show that banks are generally more efficient in an economy with higher degree of capital account openness, more constraint on cross-border investment, faster economic growth, lower inflation rate, and higher income.[11] As expected, larger banks are more profit efficient but less cost efficient, and higher capital ratio reduces (increases) bank profit (cost) efficiency. Banking-industry specific characteristics have a mixed effect on bank efficiency. Less stringent banking entry requirements, higher asset concentration, greater supervisory independence and private monitoring power, and greater foreign ownership of banks all help to improve bank profit efficiency, while their impact on bank cost efficiency is trivial.

B. Effect of the Aggregate Bond Market Structure on Bank Efficiency

Panels A and B in Table 6 present the results on the impact of the aggregate bond market structure on bank profit and cost efficiency, respectively, with control for the aggregate bond market development.

We first look at the proportion of government bonds and corporate bonds in a country's aggregate bond market. As shown by specifications 1 and 2 in panel A, both corporate bonds and government bonds have a positive but insignificant effect on bank profit efficiency, while the effect of the aggregate bond market development remains positive, it loses its significance when the proportion of government bonds enters the regression. This result is consistent with the results reported in Table 4, it seems that much of the positive effect of the aggregate bond market development on bank profit efficiency is driven by government bonds.

[11] Noted that this result is inconsistent with Luo, Tanna, and De Vita (2016) who find that financial openness decreases bank profit efficiency. The inconsistency may come from the sample and data: First, they study the sample across 140 economies over the period 1999–2011, while we analyze 35 economies in the Asia and Pacific region over the period 2004–2017. It's likely that the impact of financial openness on bank efficiency may be different across different regions. Second, they use the raw Chinn–Ito index to measure financial openness, while we use the normalized Chinn–Ito index that smooths outliers. When we use the raw Chinn–Ito index, the results are mixed. The model specifications may affect the coefficient of the financial openness as well.

Table 6: Bank (In)efficiency and the Structure of the Aggregate Bond Market

Variables	Profit Inefficiency						Cost Inefficiency					
Model Specification	1	2	3	4	5	6	1	2	3	4	5	6
size	−0.793***	−0.801***	−0.795***	−0.784***	−0.788***	−0.794***	0.886***	1.071***	1.025***	1.061***	0.700	1.062***
	(−25.640)	(−25.089)	(−26.233)	(−25.793)	(−25.459)	−26.331	(73.269)	(107.109)	(47.718)	(92.796)	(1.494)	(91.048)
capital_ratio	−0.119	−0.151	−0.134	−0.100	−0.112	−0.114	−0.215***	−0.064***	−0.839***	−0.095***	−0.157	−0.095***
	(−0.888)	(−1.105)	(−1.007)	(−0.770)	(−0.825)	(−0.853)	(−6.694)	(−3.737)	(−17.018)	(−3.149)	(−0.117)	(−2.930)
TB_GDP	−0.086**	−0.040	−0.058	−0.086**	−0.040	−0.057	0.010	0.043***	0.030***	0.042***	0.022	0.044***
	(−1.966)	(−1.037)	(−1.487)	(−2.040)	(−1.088)	(−1.610)	(1.369)	(7.851)	(2.763)	(5.221)	(0.068)	(4.692)
CB_TB	−0.133						−4.842***					
	(−0.701)						(−2.726)					
GB_TB		−0.164						−0.001				
		(−1.397)						(−0.002)				
LC_TB			−0.052	−0.087					−0.088	−0.008		
			(−0.433)	(−0.709)					(−0.123)	(−0.011)		
LCC-LC				−0.334**						0.007		
				(−2.116)						(0.010)		
FC_TB					0.303	0.359**					0.063	−0.003
					(1.641)	(1.993)					(0.013)	(−0.005)
FCC_FC						0.401***						−0.011
						(4.596)						(−0.016)
Country-level control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank regulation control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of banks	783	783	783	783	783	783	783	783	783	783	783	783
No. of observations	5,238	5,238	5,238	5,238	5,238	5,238	5,238	5,238	5,238	5,238	5,238	5,238

Notes: This table reports the results estimated using the Battese and Coeli (1995) model. The dependent variable is bank profit and cost inefficiency. The variables are defined in Table 1. *t* statistics are in parentheses, ***, **, and * indicate significance level at the 1%, 5%, and 15%, respectively.
Source: Authors' calculations.

We next examine the structure of the aggregate bond market categorized by local currency bonds (specification 3) versus foreign currency bonds (specification 5). While the effect on bank profit efficiency is positive for the local currency bonds and negative for the foreign currency bonds, it's not significant. We then go further to look at the proportion of corporate bonds in each of the currency bonds, and find that the increase of the local currency corporate bonds will significantly improve bank profit efficiency (specification 4), but the effect is opposite for the foreign currency corporate bond (specification 6).

Panel B of Table 6 shows that, except for the significantly positive effect of the proportion of corporate bonds (specification 1), the structure of the aggregate bond market exerts little effect on bank cost efficiency, the coefficient for the aggregate bond market development mostly remains positively significant.

Results from both panels A and B indicate that, given the level of the aggregate bond market development, increasing the proportion of corporate bonds will significantly enhance both bank profit and cost efficiency in a country. However, it's not clear whether this effect is driven by local or foreign currency corporate bonds. In the following subsection, we examine the effect of the corporate bond market structure on bank efficiency.

C. Effect of the Corporate Bond Market Structure on Bank Efficiency

Table 7 presents the results on the effect of the corporate bond market structure on bank efficiency with control of corporate bond market development. Increase of local currency corporate bonds enhances both bank profit and cost efficiency (specification 1), while increase of foreign currency corporate bonds has a significant opposite effect. Since corporate bond market is an important channel for both banks and nonbank companies to raise funds, we next look at the proportion of bank-issued corporate bonds (specifications 3 and 5) versus nonbank-issued corporate bonds (specifications 4 and 6) in local and foreign currency corporate bonds.

As shown in panel A, given the level of corporate bond market development and the proportion of either local or foreign corporate bonds, increasing bank-issued (nonbank-issued) corporate bonds will significantly increase (decrease) bank profit efficiency, and the negative effect of foreign currency corporate bonds on bank profit efficiency seems to be captured by nonbank-issued corporate bonds as the positive significance of its coefficient is taken over by FCNB_FCC in specification 6. In panel B of Table 7, we see a different picture. Increasing bank-issued corporate bonds in either local or foreign currency significantly decreases bank cost efficiency (specifications 3 and 5), and the negative effect of foreign currency corporate bonds on bank cost efficiency seems to be driven by bank-issued foreign currency bonds (specification 5). This result is sensible as obtaining finance by issuing corporate bonds will significantly increase the funding cost relative to bank deposits. Increasing nonbank-issued local currency (foreign currency) corporate bonds will have a significantly negative (positive) impact on bank cost efficiency (specifications 4 and 6).

Although the structure of the corporate bond market has a mixed effect on bank profit and cost efficiency, notably, given the development level of a country's corporate bond market, increasing the proportion of local currency corporate bonds will significantly improve both bank profit and cost efficiency, particularly after taking into account the structure of local currency corporate bonds. This finding has important policy implications for regulators to promote bank efficiency in a country.

Table 7: Bank (In)efficiency and the Structure of the Corporate Bond Market

Variables	Profit Inefficiency						Cost Inefficiency					
Model Specification	1	2	3	4	5	6	1	2	3	4	5	6
size	−0.790***	−0.779***	−0.791***	−0.767***	−0.765***	−0.765***	0.067	1.040***	0.888***	0.936***	0.182***	1.109***
	(−25.791)	(−25.546)	(−25.426)	(−25.874)	(−24.624)	(−24.496)	(0.476)	(81.697)	(79.418)	(90.294)	(16.174)	(73.015)
capital_ratio	−0.116	−0.061	−0.121	−0.025	0.008	0.032	0.009	−0.147***	0.137***	−0.333***	−0.159***	−0.387***
	(−0.962)	(−0.477)	(−0.894)	(−0.190)	(0.064)	(0.232)	(0.024)	(−5.966)	(9.832)	(−11.729)	(−4.977)	(−9.959)
CB_GDP	−0.138	−0.133	−0.288	−0.327	−0.159	−0.478**	0.028	0.130***	0.324***	0.001	0.360***	0.111***
	(−0.581)	(−0.591)	(−1.234)	(−1.348)	(−0.688)	(−2.101)	(0.032)	(4.445)	(11.127)	(0.049)	(7.641)	(4.235)
LCC_CB	−0.150*		−0.268***	−0.501***			−0.018		−0.017**	−0.073***		
	(−1.654)		(−2.708)	(−4.172)			(−0.024)		(−2.325)	(−3.949)		
FCC_CB		0.351***			0.429***	0.057		0.095**			−0.297**	0.406***
		(2.950)			(3.511)	(0.429)		(2.093)			(−2.402)	(9.274)
LCB_LLC			−0.420***						0.107***			
			(−4.410)						(9.370)			
LCNB_LLC				0.574***						0.056***		
				(4.887)						(3.812)		
FCB_FCC					−0.245***						0.086***	
					(−2.589)						(16.586)	
FCNB_FCC						0.272***						−0.089***
						(4.047)						(−6.963)
Country-level control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank regulation control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of banks	783	783	783	783	783	783	783	783	783	783	783	783
No. of observations	5,238	5,238	5,238	5,238	5,238	5,238	5,238	5,238	5,238	5,238	5,238	5,238

Notes: This table reports the results estimated using the Battese and Coeli (1995) model. The dependent variable is bank profit and cost inefficiency. The variables are defined in Table 1. *t* statistics are in parentheses, ***, **, and * indicate significance level at the 1%, 5%, and 15%, respectively.
Source: Authors' calculations.

V. CONCLUSION

Although the determinants of bank efficiency have been extensively examined in the literature, to the best of our knowledge, this research is the first empirical study to comprehensively investigate how bond markets affect bank profit and cost efficiency. By utilizing a large dataset for the Asia and Pacific region over the period 2004–2017, we first examine the effect of the bond market development, we then go further to examine how the structure of each major bond markets affect bank efficiency.

We find that higher development level of the aggregate bond market, corporate bond market, and government bond market generally enhances (decreases) bank profit (cost) efficiency, and this effect is persistently significant for the aggregate bond market and the government bond market development.

We also find that the structure of bond markets matters in affecting bank efficiency. Given the level of the aggregate bond market development, increasing the proportion of corporate bonds will improve both bank profit and cost efficiency; particularly, increasing the portion of local currency (foreign currency) corporate bonds in local currency (foreign currency) bonds will significantly increase (decrease) bank profit efficiency. Given the development level of a country's corporate bond market, increasing the share of local currency corporate bonds has a significantly positive effect on both bank profit and cost efficiency, while increasing foreign currency corporate bonds has an opposite effect. Among the local and foreign currency corporate bonds, increasing bank-issued corporate bonds significantly increase (decrease) bank profit (cost) efficiency.

Although our results show the mixed effect of bond markets on bank profit and cost efficiency, our findings highlight the importance of local currency corporate bonds in improving both bank profit and cost efficiency. The findings of this research have important implications for policy makers and regulators aimed at improving the overall functioning of the banking system, and for bank management to raise funds from the corporate bond market.

Appendix 1

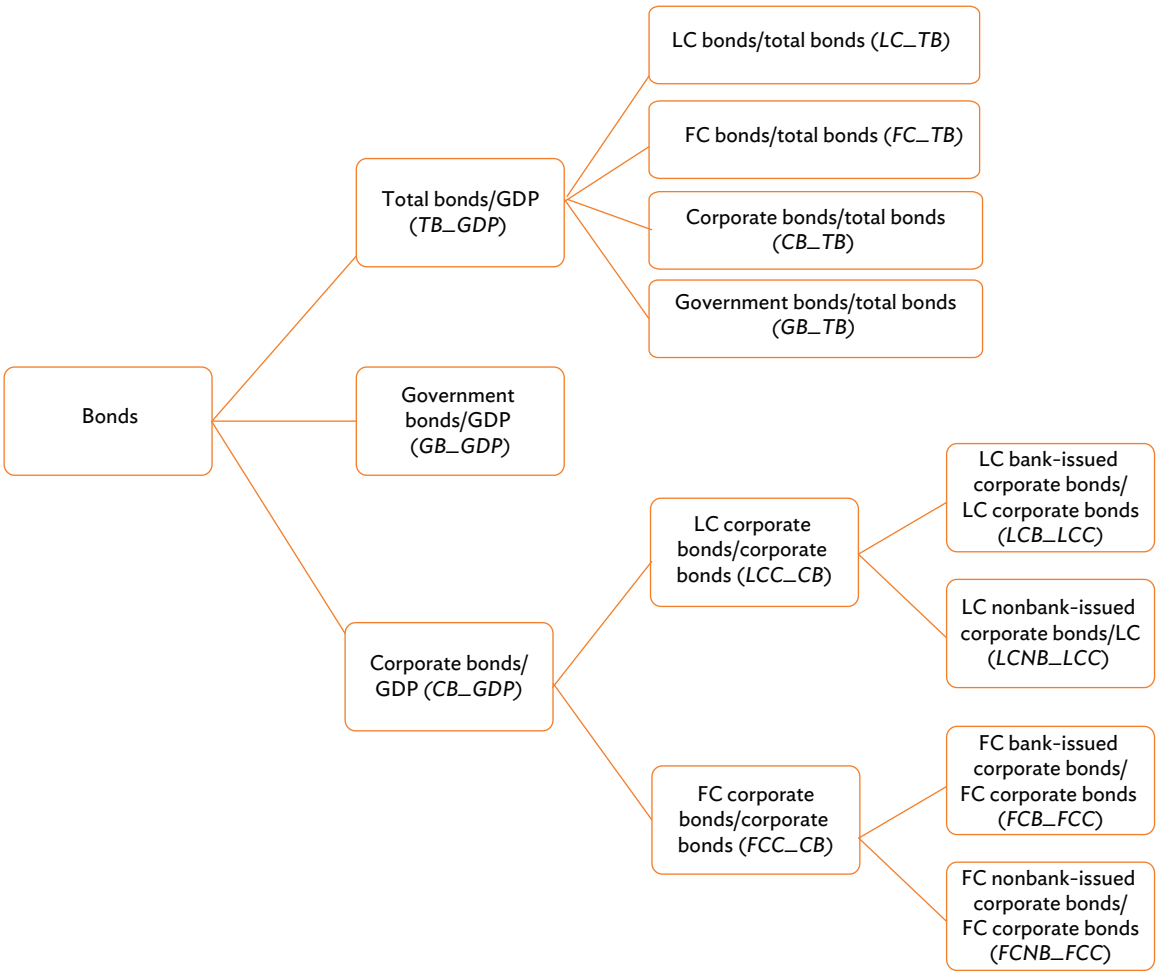
Table A1: Sample Economies and the Number of Banks

Classification	Economy	Code	Number of Banks	Number of Observations
Major advanced economy	Japan	JPN	108	475
Advanced economies	Australia	AUS	24	152
	Hong Kong, China	HKG	21	174
	New Zealand	NZL	10	82
	Singapore	SIN	9	90
	Republic of Korea	KOR	14	80
Developing and emerging economies	Bahrain	BHR	9	73
	Bangladesh	BAN	41	208
	Cambodia	CAM	25	174
	People's Republic of China	PRC	168	1,103
	India	IND	62	483
	Indonesia	INO	104	776
	Kazakhstan	KAZ	32	262
	Lao People's Democratic Republic	LAO	10	44
	Malaysia	MAL	39	230
	Mongolia	MON	9	49
	Myanmar	MYA	8	18
	Nepal	NEP	27	93
	Pakistan	PAK	28	168
	Papua New Guinea	PNG	3	23
	Philippines	PHI	36	298
	Sri Lanka	SRI	21	126
	Tajikistan	TAJ	6	34
	Thailand	THA	24	241
	United Arab Emirates	UAE	20	166
	Uzbekistan	UZB	19	132
	Viet Nam	VIE	49	257
Total			**926**	**6,011**

Source: Authors' compilation.

Appendix 2

Figure A2: Bond Market Development and the Structure of Bond Markets



FC = foreign currency, GDP = gross domestic product, LC = local currency.
Source: Authors' illustration.

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Bank Efficiency and the Bond Markets

Evidence from the Asia and Pacific Region

This study examines the association between bond market development and profit and cost efficiency of commercial banks. Utilizing bank-level data from 27 economies in the Asia and Pacific region, this paper finds that bond market size and structure are relevant to bank efficiency. A larger bond market is generally associated with higher profit efficiency and lower cost efficiency of commercial banks. Given bond market size, a larger share of corporate bonds will enhance both bank profit and cost efficiency. The policy implications of this paper are that balanced and well-developed capital markets will benefit banking sector operations.

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