Impact of the Global Financial Crisis 2008 on Bank Efficiency: An Experience of the Anglo-Saxon Countries

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Dedication

This thesis is dedicated to my parents for teaching me the values of hard and persistent work. I could not able to have this done without endless support, love and personal sacrifices of my wife, Sajida and my kids Zahab, Zartash, and Tooba.

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ABSTRACT

This thesis investigates the differences in the impact of the Global Financial Crisis 2008 (GFC) on the banking sectors of Australia, Canada, New Zealand, UK, and the United States from 2003 to 2015. The selected banking sectors are based on a common Anglo-Saxon banking system and belong to developed economies for which the GFC showed varying degrees of severity. The measures of cost, profit, alternative profit, and shareholder value efficiency are used to assess the impact of the GFC on bank efficiency of the five countries. The aim of this study is achieved with four major objectives: first, the theoretical analysis of the varying impact of the GFC on the banking sectors of the developed and integrated economies is confirmed with econometric analyses; second, the impact of different banking environment variables on bank efficiency is assessed to identify the reasons behind the variation in the impact of the GFC on the efficiency of the selected banking sectors; third, this study compares the results for the U.S. banking sector with other developed economies using a common frontier; fourth, it assesses the change in banking risk, structure, and shareholder value during the study period.

A common frontier is drawn with a one-stage Stochastic Frontier Analysis (SFA) model among the selected group of relatively homogenous economies, and remaining economic variations are controlled with banking environment variables. A group of 29 large and systemically important banks is selected from all five countries for this study. The empirical results confirm the superiority of the Australian and Canadian banking sectors in cost efficiency compared to New Zealand, UK, and U.S. sectors from 2003 to 2015. Profit efficiency of the U.S. and British banks is most negatively impacted by the GFC, and the banking sectors of Australia, Canada, and New Zealand are among the least impacted. A significant impact of the GFC is observed during 2008 and 2009, and the selected banking sectors are not able to achieve pre-GFC efficiency levels in the post-GFC period. Cost-efficient banking is found to be more resilient, and the level of bank liquidity and equity play a vital role in the stability of the banks during the crisis period. The level of risk has declined over the study period, however, the negative influence of the risk on bank efficiency is reported. A higher ratio of lending assets provided earning stability for banks during the crisis period. Bank size, market concentration, and population density of chosen economies are not favorable for bank efficiency. Shareholder value was also impacted by the GFC during the same period and was found to be closely associated with the profit efficiencies of the banks during the study period.

The trend and scores of the selected four efficiency models are consistent over the study period and found to be robust to various alternative tests. The findings of this thesis support the enhanced standards of the bank liquidity and equity, however, we recommend some regulatory initiatives to lower regulatory cost, bank size, and market concentration of selected banking sectors. A few limitations of the thesis are identified, and some guidelines for future research are also provided.

THESIS-RELATED RESEARCH OUTCOME

Research proposal of this study and various drafts of research papers based on the results of this study are presented at several seminars and conferences. The feedback from the participants of the seminars and conferences helped to improve the quality of the thesis. The list of major outcomes presented at various seminars and conferences is as follows:

1. U-Din, Salah, Tripe, David, Kabir, MH. (2018). Market Power and Efficiency in Banking: The Case of USA and Canada. *EFMA Annual Meeting 2018,* Università Cattolica del Sacro Cuore, Jun 27-30, Italy.
2. U-Din, Salah, Tripe, David (2018). The Impact of Global Financial Crisis on Shareholder Value and Operational Efficiency of Banks. *INFINITI 2018,* Poznan University of Economics, Jun 11-12, Poland.
3. U-Din, Salah, Tripe, David, Kabir, MH. (2018). Market Power and Efficiency in Banking: The Case of USA and Canada. *North American Productivity Workshop X,* University of Miami, Jun 12-15, USA.
4. U-Din, Salah, Tripe, David (2018). Shareholder Value and Bank Efficiency; A Post-GFC Assessment. *FEBS 2018,* University of Rome III, Jun 4-6, Italy.
5. U-Din, Salah, Tripe, David, Kabir, MH. (2018). Market Power and Efficiency in Banking: The Case of USA and Canada *22nd New Zealand Finance Colloquium*, February 6-8, 2018. Palmerston North, New Zealand.
6. U-Din, Salah, Tripe, David, Kabir, MH. (2018). Market Structure and Bank Efficiency: An Exploration Based on Australia and New Zealand. *14th WEAI International Conference*, University of Newcastle, Jan.11-14, 2018. Newcastle, Australia.
7. U-Din, Salah, Tripe, David, Kabir, MH. (2017). Market Power and Efficiency in Banking: The Case of USA and Canada. *Research Seminar,* December 06, 2017 Haskayne Business School-University of Calgary, Canada.
8. U-Din, Salah, Tripe, David, Kabir, MH. (2017). Market Power and Efficiency in Banking: The Case of USA and Canada. *Annual CEPA International*

Workshop, The University of Queensland, Nov. 2-3, 2017. Brisbane, Australia.

9. U-Din, Salah, Tripe, David, Malone, Chris (2017). Changing Market Structure and Bank Efficiency; A Case of Australia and New Zealand. *8th Financial Markets and Corporate Governance Conference Ph.D. Symposium*, Victoria University of Wellington, April 19-21, 2017. Wellington, New Zealand.
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LIST OF ACRONYMS

AIG	American International Group
APE	Alternative Profit Efficiency
APRA	Australian Prudential Regulation Authority
BRIC	Brazil Russia India China
CDO	Collateralized Debt Obligations
CE	Cost Efficiency
CIR	Cost to Income Ratio
COLS	Corrected Ordinary Least Squares
CPFF	Commercial Paper Funding Facility
CRS	Constant Returns to Scale
DEA	Data Envelopment Analysis
DFA	Distribution Free Approach
DMU	Decision Making Unit
ECB	European Central Bank
EU	European Union
EVA	Economic Value Added
FDH	Free Disposal Hull
GAAP	Generally Accepted Accounting Principles
GDP	Gross Domestic Product
GFC	Global Financial Crisis
GLS	Generalized least Squares
HHI	Herfindahl-Hirschman Index
IFRS	International Financial Reporting Standards
IMF	International Monetary Fund

LAT	Loans to Assets
LOS	Loan Losses to Assets
MBS	Mortgage Backed Securities
MC	Marginal Cost
ML	Maximum Likelihood
MMIFF	Money Market Investors Funding Facility
NIM	Net Interest Margin
NINJA	No Income No Job or Assets
NOPAT	Net Operating Profit After Tax
NPL	Non-Performing Loans
OECD	Organization of Economic Cooperation and Development
OLS	Ordinary Least Squares
OSFI	Office of the Superintendent of Financial Institutions
OTC	Over-the-counter
OTD	Originate-to-distribute
PBT	Profit Before Tax
PDCF	Primary Dealer Credit Facility
PF	Profit Efficiency
PRA	Prudential Regulation Authority
PTE	Pure Technical Efficiency
QLH	Quiet Life Hypothesis
RBNZ	Reserve Bank of New Zealand
RE	Revenue Efficiency
ROA	Return on Assets
ROE	Return on Equity

SC	Scale Efficiency
SCP	Structure-conduct-performance
SFA	Stochastic Frontier Analysis
SVE	Shareholder Value Efficiency
TAF	Term Auction Facility
TALF	Term Asset-Backed Securities Loan Facility
TBTF	Too-big-to-fail
TC	Total Cost
TE	Technical Efficiency
TOPS	Technically Optimal Productive Scale
TSLF	Term Securities Lending Facility
UK	United Kingdom
USA	United States of America
VAR	Variable Returns to Scale

Chapter 1

INTRODUCTION

1.1 Why Banking Matters

The banking sector plays a vital role in the financial system and the economic development of a country. Financial deregulation over the last few decades has further enhanced the role of the banking sector in the modern-day economy. The multiple forces of financial deregulation, globalization, technological innovations, and new product development have made financial systems more integrated and fragile. The global financial crisis 2008 (GFC) is a recent example of the financial disruption that threatened to totally collapse the global financial system (Greenbaum, Thakor, & Boot, 2016). This study investigates the impact of the GFC on the efficiency of large banks of the United States, UK, Canada, Australia, and New Zealand. The cost, profit, and alternative profit efficiencies are estimated with one-stage Stochastic Frontier Analysis (SFA) for the period of 2003–2015. It also explores the influence of different banking environment variables on bank efficiencies. Furthermore, shareholder value efficiency is estimated to assess the association between bank efficiency and shareholder value. The impact of the GFC on different operational, structural, and environmental aspects of the banking industry in five selected countries is assessed over the study period.

The banking system of a country operates the payment systems, acts as a conduit for monetary policy, and plays an important role in financial intermediation. The importance of the banking system in economic growth and human well-being is widely recognized by economists and policymakers (Beck, Demirgüç-Kunt, & Levine, 2009; Cecchetti & Kharroubi, 2012; Levine, 1997). Every healthy and vibrant economy requires a banking system that moves funds from savers to productive investment opportunities

(Mishkin, 2016; Schumpeter, 1912). The intermediation role of banks helps to transform the size, maturity, and risk of funds for both savers and borrowers under the supervision of government agencies.

Effective financial intermediation plays a key role in societal economic efficiency (Mishkin, 2016). It ensures the availability of funds at a lower cost for domestic and business consumers, which helps to accelerate economic growth and societal well-being. Financial intermediaries also play a vital role in the development of financial markets (Wall, Reichert, & Mohanty, 1993). An inefficient financial intermediary will not necessarily be able to meet the commitments to all stakeholders in the long run, which may result in the failure of the intermediary. The failure of one intermediary may spread by contagion to the rest of the financial sector and the larger economy, which may ultimately lead to a financial crisis (Allen & Gale, 2000). Failure of a bank could cause a reduction in the aggregate supply of funds and an increase in the price of funds in the interbank market, thus reducing the profitability of surviving banks. The higher price of funds and reduction in credit supply also lower economic growth (Acharya, 2009; Wall, 2010). Reduced economic growth mostly leads to higher unemployment, public debt, corporate losses, and lower social well-being.

In recent history, according to Laeven & Valencia (2013), there have been 147 national banking crises, 218 currency crises, 66 sovereign crises, and six major global crises recorded by the International Monetary Fund (IMF). They observed that developed economies suffer larger output losses and an increase in public debts compared to emerging economies. Their study also indicated that past crises mostly came in waves of contagion and were simultaneous in many related countries. Figure 1.1 shows waves of major crises from 1970 to 2010 and their fiscal cost to the world economy. The first major banking crisis during this period was in Latin America from 1980 to 1983, and the last was the Great Recession or Global Financial Crisis (GFC) in 2008. The GFC was the most damaging banking crisis in world history, which cost about 23% of global financial assets in one year and threatened the total collapse of the global banking system (Greenbaum et al., 2016). Although a number of studies have been conducted on the causes of various crises (Summers, 2000), and resulting policy initiatives taken by different countries and institutions are also well-documented (Kaminsky & Reinhart, 1998), the threat of crises remains despite policy reforms after each crisis.

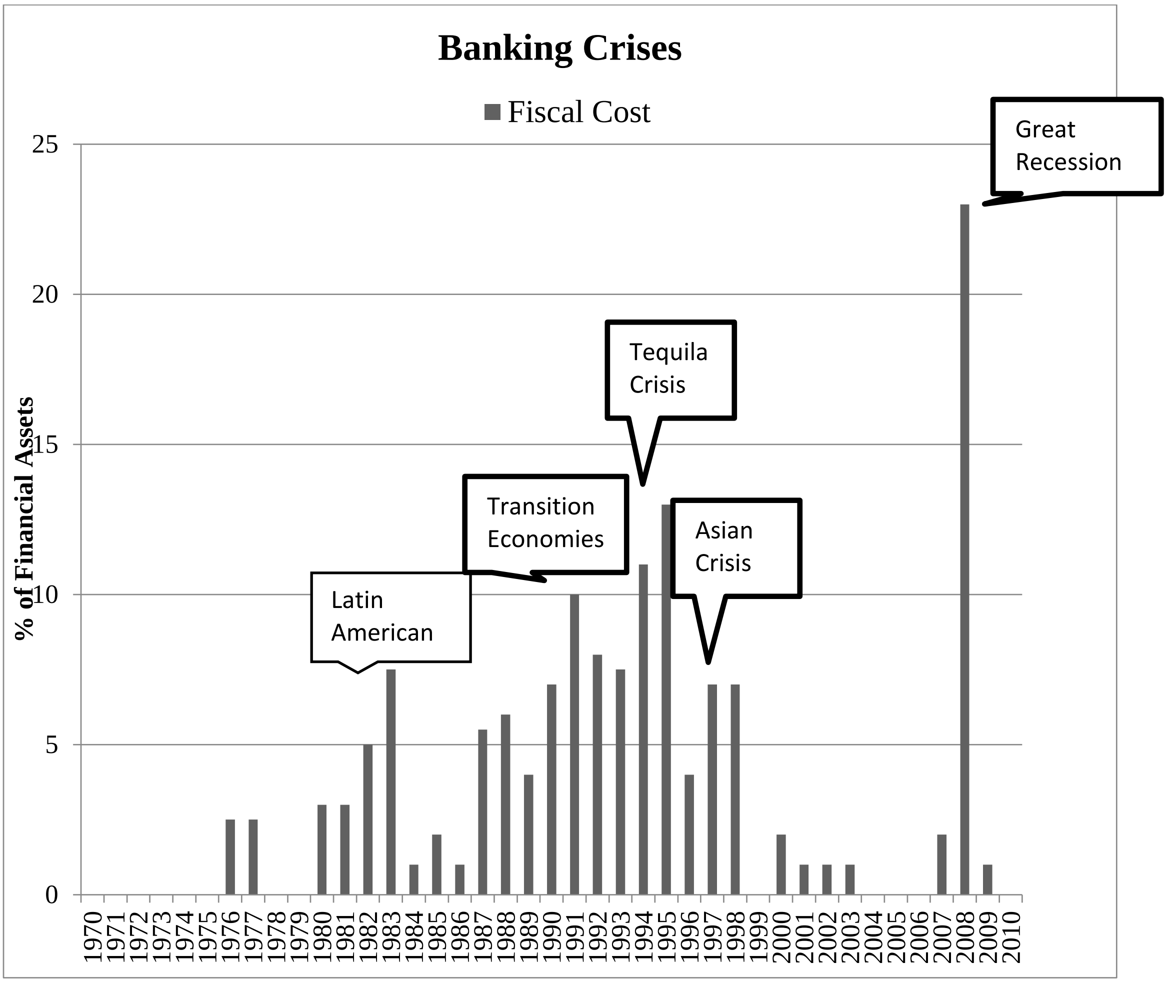


Figure 1.1. Banking Crises (Source: Laeven and Valencia, 2013)

The impacts of the crisis on banking systems were mostly in the form of major declines in the values of financial assets, lower or severely restricted liquidity, and reduced profitability due to higher provisions for loan losses and the higher prices of funds. The lower profitability, higher relative cost, abstracted managerial focus, and reduced scale and scope of services led to lower bank efficiency in many developed and emerging economies. Another regulatory challenge was the shrinkage of available capital and difficulty in raising additional capital to meet minimum regulatory requirements. There were also some general micro- and macroeconomic effects on the impacted economies and financial systems, therefore, research on banking sectors is very important to identify any future shock for world economies.

1.2 The Significance of the Study

A large number of research studies are published every year about various banking sectors of the world. Learnings from these studies help to improve the overall banking systems of the world. Three major lessons emerged from several past structural narratives and econometric analyses of the banking crises (Barth, Caprio, & Levine, 2013; Calomiris & Haber, 2014; Demirgüç-Kunt, Kane, & Laeven, 2008; Laeven & Valencia, 2013). First, all other things being the same, democratic countries are more conducive to banking development than autocracies. Second, all other things being the same, democracies with liberal institutions increase the stability of the banking system and reduce the chances of banking crises. Third, generous government safety nets may lead to inefficient allocation of banking resources, which may give rise to banking crises or destabilization of banking systems. The GFC was one of the big banking crises in recent history and has been thoroughly studied by many researchers. The literature on the GFC is overwhelmed with an extraordinarily long list of contributory causes, however, some of the identified items were symptoms, and many others may have contributed to the crisis but were outcomes in themselves (Calomiris & Haber, 2014; Greenbaum et al., 2016). A recent structural narrative by Calomiris and Haber (2014) analyzed different banking sectors of the world during the GFC and noticed varying impacts of the GFC on many integrated and identical economies.

Calomiris and Haber (2014) examined the data of 117 private banking sectors for the period 1970–2010 and provided a structural narrative about the banking crises. They found the United States in a group of 19 countries having two or more banking crises during the selected period; the World Bank recognizes most of the countries in this group as low-income countries. They also identified a group of “very successful six” crisis-free banking sectors, which were Australia, Canada, Hong Kong, Malta, New Zealand, and Singapore. Three of these were city-states or small islands rather than large countries. The other three countries on the list share two common features: first, they are based on Anglo-Saxon banking models, and second, they are among the world’s most stable democracies. These three countries share both features with the UK, the United States, and Ireland, which are in a group of severely impacted countries. This means there is something else common among the banking sectors of Australia, Canada, and New Zealand that is not found among other Anglo-Saxon countries. As per the three learnings from banking crisis studies, these six countries are democracies with liberal institutions; it may have been differences in the efficiency of their banks that led to the differences in how they fared through the crisis. Therefore, a need exists to assess the efficiency of these banking sectors as they were before, during, and after the GFC.

A few post-GFC studies claim that bank inefficiency in the allocation of available resources was one of the reasons behind the trouble of banks during the GFC (Belke, Haskamp, & Setzer, 2016; Hasannasab, Margaritis, & Staikouras, 2019; Vu & Turnell, 2011). A recent study by Hasannasab et al. (2019) observed that banks underutilized available capital, pushing the implicit required rate of return on equity to a very high level, which led to excessive risk-taking by US banks. This inefficient allocation of funds created a wide gap between the cost of short-term and long-term funds, which created illiquidity in financial markets and led many banking institutions to financial trouble. General theories suggest that human nature is one of the main causes of many banking crises: When human optimism dominates, bank managers expand balance sheets over-ambitiously, supported by excessive leverage, and fail to allocate funds optimally (Kindleberger & Aliber, 1978). The non-optimal utilization of available bank resources is bank inefficiency. Hasannasab et al. (2019) observed similar practices during the years leading to the GFC in the US banking sector. One of the main reasons behind the excessively risky and opportunistic behavior of the US bank managers was generous government safety nets (Calomiris & Haber, 2014).

Some post-GFC studies found that cost-efficient banks were more resilient to the crisis and recovered more quickly (Vu & Turnell, 2011; Xiang, Shamsuddin, & Worthington, 2015). Efficiency may have been the common feature of the Canadian, Australian, and New Zealand banking sectors, but that may not have been the case in the US and UK banking sectors. Therefore, we estimated cost, profit, and shareholder value efficiencies of the United States, UK, Australia, Canada, and New Zealand in this study. Ireland was not included due to complexities with the availability of its banking data. The study of the GFC and bank efficiency based on the Anglo-Saxon countries can help to fill the following research gaps in the prior literature:

i. Varying impacts of the GFC on banks of different countries need to be investigated (Calomiris & Haber, 2014).

ii. Impact of the GFC on bank efficiency, banking market structure, shareholder value, and operational activities needs to be assessed (Berger, Molyneux, & Wilson, 2015; Molyneux, 2018).
iii. More cross-country studies are needed among relatively homogeneous economies on the basis of institutional, regulatory, and market conditions (Belke et al., 2016; Berger & Mester, 1997; Xiang et al., 2015).
iv. Compare efficiency results of the US banks with other developed economies (Berger, 2007; Berger & Humphrey, 1997).

The empirical answers to the research questions of this study have helped fill identified research gaps as well as provide some policy implications. First, the findings of this study identified that the higher level of cost inefficiency before the GFC was one of the reasons behind financial trouble for banks during the crisis. In addition, statistical models have helped identify the reasons behind the varying impacts of the GFC on the selected banking sectors in the periods before, after, and during the crisis. Second, the selection of countries based on the homogeneous Anglo-Saxon banking structure has helped resolve methodological problems related to cross-country bank efficiency studies and have provided results that are more precise. Furthermore, the results for US bank efficiency are compared with those for four other developed economies. Third, the comparison of the five countries on the basis of efficiency score may be useful for regulators, as they may introduce further banking reforms in their jurisdictions to improve bank efficiency and resilience to future crises, especially for the UK and the United States. Moreover, the findings may be useful for existing and potential investors and depositors in the selection of more efficient banks in the future to handle their funds. Fourth, our study period allowed us to investigate efficiency changes over time, which highlighted the impacts of the GFC and post-crisis reforms on bank efficiency.

In addition, the identification of firm-level and macroeconomic variables, which contributed to the resilience or vulnerability of banks to the crisis, can be useful for bankers and regulators to reduce the intensity and frequency of future crises. The analysis of the association between bank efficiency and shareholder value is another distinct feature of this study. Finally, to the author's knowledge, no other study could be found that compared the bank efficiencies of Australian, Canadian, New Zealand, UK, and US banks, especially after the GFC. Another methodological contribution of this study is the first-time inclusion of banking structure variables of the HHI and Lerner Index in a one-stage SFA model, which provided more precise efficiency scores and produced various policy implications.

This study is also extending the work of two recent cross-country studies by Xiang et al. (2015) and Calomiris & Haber (2014). Xiang et al. (2015) compared bank efficiencies of Australia, UK, and Canada, and they further recommended including more Anglo-Saxon countries to increase the sample size for more robust results. Calomiris & Haber (2014) conducted a theoretical analysis of different banking systems during various financial crises. They reported variations in the impact of GFC on the banks of the United States, UK, Canada, Australia, and New Zealand, and recommended building a quantitative model for causal inference of their theoretical narrative. The present study has included two more Anglo-Saxon countries and built quantitative models to investigate the variations in the impact of the GFC on the banks of Australia, Canada, New Zealand, UK, and the United States over the period of 2003–2015.

1.3 Research Questions

The answers to the following questions may help to fill the research gap which is identified by this study and provide some policy implications.

i. How was bank efficiency impacted by the GFC?

This study has assessed the impacts of the GFC on bank efficiency in the selected countries to explore the variation across countries. The results have provided the bank efficiency scores of banks in pre-crisis, crisis, and post-crisis periods, using different efficiency measures.

ii. What is the level of bank efficiency after the GFC in the selected countries?

This study has evaluated the recovery of the surviving banks in selected countries after the GFC. The post-GFC era is studied to explore the following sub-questions:

a. Did the banks in the selected countries achieve the pre-GFC efficiency level in the post-GFC period?
b. How much variation in bank efficiency, if any, has occurred across the selected countries since the GFC?
c. Is the variation in bank efficiency during the GFC statistically significant across countries and among different phases of the study period?

iii. Were efficient banks more resilient to the GFC?

The estimated bank efficiency scores for the crisis period are compared with the pre-crisis period. The role of profit, alternative profit, and cost efficiencies of banks is assessed in building their resilience against the GFC. The relationship of various bank outputs and other characteristics with different efficiency measures is examined later in this section.

iv. What are the determinants of bank efficiency in the selected country?

This study has found the determinants of bank efficiency to explain the reasons behind variation in the impact of the GFC on banks in each selected country. A set of existing and new determinants has been included in chosen econometric models to explore the major determinants of bank efficiency. Some of the macroeconomic and banking sector variables from each country have been used to adjust bank efficiency scores against the country effect. It has helped to decide whether the crisis resilience in a few countries and banks came from firm-level variables or country-specific variables.

v. Investigate the change in the bank risk level in each country before, during, and after the GFC.

At the start of the GFC, US banks carried a large number of problem loans that eroded their capital when the loans defaulted, pushing the banks into insolvency (Greenbaum et al., 2016). It is believed that problem loans have a negative and financial capital positive relationship with bank efficiency and stability (Berger & DeYoung, 1997). Overall, prior literature has noted very high-risk levels in banks before the GFC, and some banks collapsed as a result of this high-risk exposure (Vazquez & Federico, 2015). Several regulatory and supervisory initiatives have been introduced by national and international regulatory bodies to reduce risk levels after the GFC. The risk profiles of banks are assessed and their relationship with bank efficiencies are estimated. It will help to compare bank risk across countries and the study period.

vi. How the GFC impacted the market structure of banking sectors?

Many mergers and acquisitions occurred during the crisis in selected countries (Brown, Davis, & Mayes, 2015; Greenbaum et al., 2016). As a result, the size of banks and banking market concentration have increased significantly in the post-GFC period. The impact that the changes in banking market concentration, competition, and power had on bank efficiency during the study period is explored.

vii. Did bank efficiency contribute to shareholder value and how was it impacted by the GFC?

The association of bank efficiency with shareholder value is assessed. The changes in shareholder value are demonstrated across the study period for all selected banks as well as for each selected country. Association tests among shareholder value, cost, and profit efficiencies are conducted to seek relationships among all these measures of bank performance.

The answers to all these questions have helped to assess the impact of GFC on bank efficiency in a select five countries over the period of 2003–2015. An analysis is conducted on bank efficiency results to report variations across countries and time. The relationship of various firm-level and country-specific determinants with bank efficiency has helped to find the sources of efficiency and inefficiency across banks and countries. The association between shareholder value and different measures of bank efficiency validates the selection of frontier analysis as a comprehensive and sophisticated method for bank performance.

1.4 Limitations of the Study

There are some difficulties and challenges which may limit the research scope of this thesis. First, SFA is based on the restrictive distributional assumption of error terms, which may limit the scope of the resulting efficiency score. This limitation is mitigated by proper statistical tests to find the best fit of data with the assumed distribution of error terms. However, there are also some drawbacks in other available options for bank efficiency estimation. Second, the selected banks from New Zealand are not listed on any share market, meaning that market data for these banks are not available for market-based measures. The accounting data are also collected from annual reports of selected banks because they are not available on DataStream. Third, all firm-level data except New Zealand are obtained from DataStream, which was available in domestic currencies. Data are converted into US dollars for analysis while using a monthly average exchange rate for the bank's financial closing month which is consistent with accounting policies of the banks. However, a major change in the exchange rate of any selected currency in the financial closing month of the bank may affect the reported data. This is applicable to every bank except those in the United States and is beyond the control of the researcher. Fourth, the estimated results are based only on large banks in each country, although these represent more than 50% of selected banking sectors, which is considered to be sufficient to assess the impacts of the GFC. Detail about the selection of 29 larger banks from the previously-mentioned five countries is discussed in the methodology chapter of the thesis. The selected banks of Australia, Canada, New Zealand, and the UK represent more than 80% of their banking sectors. Thus, conclusions need to be drawn with caution in comparing the efficiency scores of the banks in selected countries.

1.5 Thesis Structure

The structure of this thesis consists of six chapters. The next chapter gives an overview of the GFC and banking sector of each country. Chapter 3 reports a review of prior studies related to bank efficiency and its determinants. Chapter 4 presents the research methodology of the study, which includes data collection, measurement techniques of bank efficiency, and potential determinants. Empirical results and analyses are provided in Chapter 5, and the thesis ends with conclusion and policy implications in Chapter 6. References and some appendices are also attached at the end of the thesis.

Chapter 2

THE ANGLO-SAXON BANKING SYSTEM AND THE GFC

2.1 An Overview of the Anglo-Saxon Economic Model

The Anglo-Saxon economic model is based on the concepts of classical economics outlined by Adam Smith and that originated from the UK during the 18th century. It emerged in the 1970s as a "capitalist model" based on neoclassical economic theories of the Chicago School of Economics. The initial Anglo-Saxon model has been further developed under the ideas of Milton Friedman, Ronald Coase, George Stigler, and many other renowned economists. It introduced the self-regulation system, low taxes, private property rights, limited public sector role, contract enforcement, and low barriers to free trade. It is primarily practiced and refined in the UK, the United States, Canada, New Zealand, Australia, and Ireland (Cernat, 2004; Mitchell, Muysken, & Van Veen, 2006). Although the Anglo-Saxon economic model was adopted by many other countries later with some individual variations, it is still available in the above-mentioned six countries with the least variation. There are also a few other economic models that are successfully working in many other countries.

The basic features of Anglo-Saxon and alternative economic models are compared in Table 2.1. Several European countries are using the Continental model with slight customizations as per their economic environment, while the Chinese Model is being used in Mainland China only. The Continental model is based on more employee rights, social participation, government intervention, trade barriers, and higher corporate taxes compared to the Anglo-Saxon model (Cernat, 2004). It is also called the European Social Model, which combines economic growth with high living standards and good working conditions. The Chinese model is very different from the other two models due to higher government involvement in business and corporate governance (Tobin, 2012). Banking sectors play a critical role in all economic models; however, their operating models differ as per government intervention and governance structure.

Table 2.1 Comparison of Economic Models

Feature	Anglo-Saxon Model	Continental Model	Chinese Model
Geographical presence	US, UK, Canada, Australia, New Zealand, Ireland	Most European Countries.	Mainland China
Government Intervention	Minimal	Moderate	High
Influence of employees and social partners	Limited	Extensive and recognized at the national level.	Absent
Ownership Structure	Widely dispersed private ownership; dividend prioritized.	Mainly held by banks and corporate block-holders.	State-Owned Enterprises (SOEs) own the majority of stocks.
Board Structure	One-tier board of directors elected by shareholders.	Two-tier board of directors elected by the shareholder and nominated supervisory board.	The SOEs nominate the board of directors.
Trade Barriers	Low	Moderate	High
Corporate Tax	Low	High	Moderate
Role of Stock Exchange	A strong role in corporate financing.	Moderate	Limited

Source: (Cernat, 2004; Li , Yue, & Zhao, 2009; Tobin, 2012)

The Anglo-Saxon model is considered to be more business-friendly relative to the other two models, due to lower government involvement, taxes, trade barriers, and capital friction. Developed financial markets and well-established banks are the backbones of this model. It is relatively easy in this model to raise business capital through financial markets and the banks. Protection of shareholders' and creditors' rights, deregulation, the autonomous central bank, lower capital requirement, and enhanced management role are the salient features of a banking system under this model. The advocates of this model claim that it encourages entrepreneurship and increases economic activities because it makes conducting business easier due to lower business barriers. The opponents of this model claim that it focuses too much on maximizing short-term profits, and therefore does not place enough emphasis on long-term planning, social well-being, and sustainability. Several research studies found that the Anglo-Saxon model has promoted more competition and flexibility in society through privatization and deregulation since the 1970s (De Bandt & Davis, 2000; Mitchell et al., 2006). The next section of this chapter reviews the banking sectors of each selected Anglo-Saxon country and identifies a few key relevant characteristics.

2.2 Banking in the United States

The history of US banking started with the Bank of Pennsylvania, which was the first state-chartered bank and was founded in 1780. The Bank of North America was the first national-level bank established by the Congress of the Confederation in 1781. The initial federally chartered banks were modeled after the Bank of England but were not able to operate nationwide due to strong legislative opposition. In 1863, during the Civil War, a new system of federally chartered banks called the National Banking System was established, which essentially elevated the successful free banking system in many parts of the United States. Later, a new central banking system was established under the Federal Reserve Act of 1913 called the Federal Reserve System. The role of the newly established central banking system was expanded in response to several financial waves of panic at the start of the 20th century; however, the older state-chartered banking systems were allowed to continue, which gave rise to the dual banking system in the United States. Thus, many small and undiversified banks emerged, which caused the development of a fragmented banking system. The weakness in the US banking system promoted the development of large and efficient financial markets to meet the funding needs of the growing US industrial sector (Bordo, Redish, & Rockoff, 2015). Currently, the banking sector of the United States is chartered and regulated at both federal and state levels. The reforms and deregulation of the last three decades have widened the nationwide role of federally chartered banks, but still, there are thousands of state-level and federally charted banks in the United States, as mentioned in Table 2.2.

Table 2.2 Country Indicators of the United States

Indicator	**2003**	**2015**
Population	290.1 Million	320.9 Million
GDP (US$)	11.51 Trillion	18.04 Trillion
GDP Growth %	2.8	2.6
Human Development Index	0.89	0.92
No. of Deposit-taking Institutions	18,389	12,505
5-Bank Asset Concentration	31	52
Finance and Insurance % of GDP	7.8	7.3

(Source: IMF and the World Bank)

The size of US banks has grown substantially since deregulation and particularly after the GFC. Currently, the "big four" banks of the United States are among the largest 20 banks in the world in terms of assets, and among the top 10 in terms of market capitalization. A large number of financial institutions collapsed in the United States during the GFC and many merged with other banks in the post-GFC period, which significantly reduced the number of deposit-taking institutions in the country. The financial sector of the United States contributes a major portion of GDP every year, which was 7.8% at the start of our study period but had reduced to 7.3% by the end of the study period. There are thousands of banks in the United States, however, 52% of banking assets are held by only five large banks.

2.3 Banking Sector of the UK

The banking system of the UK is one of the oldest in the world, having started in the 17th century. Initially, banking consisted of cash-keeping by goldsmiths. They accepted gold in exchange for a paper receipt, which was transferable to third parties. Those paper receipts were the forerunners to modern banknotes and cheques. A cloth merchant opened the first provincial bank in Nottingham around 1650. The Bank of England was founded in 1694. The widespread trend of joint-stock banks started at the beginning of the 19th century and a large number of small banks were founded in different parts of the UK around that time. The Banking Charter Act was introduced in 1844 to regulate the emerging banking sector. The supervisory role of Bank of England further increased through the Banking Act 1979 to regulate and supervise the expansion of the bank sector. Besides establishing the regime of banking supervision, this act created a two-tier system of banks and other deposit-taking institutions to promote competition (Davies, Richardson, Katinaite, & Manning, 2010). A series of mergers and acquisitions in the mid-20th century led to there being a “Big Five” of banks in the UK, which later became a “Big Four” due to another merger (Davies 2002).

Table 2.3 Country Indicators of the UK

Indicator	**2003**	**2015**
Population	59.65 Million	65.13 Million
GDP (US$)	2.028 Trillion	2.861 Trillion
GDP Growth %	3.5	2.2
Human Development Index	0.88	0.90
No. of Deposit-taking Institutions	410	357
5-Bank Asset Concentration	48	85
Finance and Insurance % of GDP	5.9	7.2

(Source: IMF and the World Bank)

The 21st century brought many regulatory and operational challenges, including the GFC. The banking sector of the UK came under intense pressure beginning with a bank run on Northern Rock in 2007. It was the result of a real estate boom turned to bust, fuelled by a decade of benign financial and macroeconomic conditions (Claessens, Dell'Ariccia, Igan, & Laeven, 2010; Shin, 2009). Several other banks felt similar pressure and were either merged or bailed out by the UK government (Savona, Kirton, & Oldani, 2011). The financial support of the UK government for their troubled financial institutions was higher than any other country but was less effective due to delayed regulatory and supervisory support. The Financial Services Act 2013 called for a paradigmatic shift in regulatory and supervisory strategies of the central bank. The Prudential Regulation Authority (PRA) was established under this act to regulate the banking sector of the UK. During the study period, the number of banks in the UK decreased and concentration increased significantly, especially after the GFC. The contribution of the financial sector has increased in recent years as mentioned in Table 2.3. The post-GFC recovery struggle of the British banking sector is documented in later chapters.

2.4 The Australian Banking Sector

The first renowned Australian deposit-taking institution, the Bank of New South Wales, was established in 1817. The regulatory framework started in the 1840s when the colonial authorities received guidance from Great Britain to develop the banking sector in Australia. The financial system of Australia, based on many other trading and saving banks, building societies, and finance companies, was very active and prosperous until the bank crash of 1893. The practical intervention of government was observed in 1911 after the establishment of the Commonwealth Bank, a portion of which later became the Reserve Bank of Australia. The role of the central bank was further expanded in 1945 and segregated in 1959. The deregulation of Australian banks commenced in the 1980s in response to political pressures, the tremendous growth of non-banking financial institutions, and regulatory challenges (Thomson & Abbott, 2001). As part of deregulation, the governing (or administrative) responsibility was assigned in 1997 to the newly established Australian Prudential Regulation Commission. The current regulatory authority of the financial sector of Australia is the Australian Prudential Regulation Authority (APRA), which was established in 1998 with an enhanced regulatory mandate.

Table 2.4 Country Indicators of Australia

Indicator	**2003**	**2015**
Population	19.9 Million	23.79 Million
GDP ($US)	466.9 Billion	1345 Billion
GDP Growth %	3.1	2.4
Human Development Index	0.91	0.94
No. of Deposit-taking Institutions	244	153
5-Bank Asset Concentration	84	92
Finance and Insurance % of GDP	7.9	9.3

(Source: IMF and the World Bank)

After deregulation, the banking sector of Australia has become more concentrated with every passing year. As per Table 2.4, the number of deposit-taking institutions decreased to 153 by the end of 2015, from 244 in 2003. It was one of the most resilient banking sectors in the GFC. There were no widespread failures or mergers of financial institutions during the GFC, however, Australian banks lost about $8 billion during the crisis (Savona et al., 2011), and a few troubled investment corporations were taken over by major banks. The Australian government strengthened the power of their regulators and introduced deposit insurance and a debt guarantee facility during the GFC. The Australian banking sector was one of the pioneers to implement Basel III recommendations. Currently, more than 80% of banking deposits are held by the four largest banks of Australia (Brown et al., 2015). The contribution of the financial sector to the GDP increased over the study period as the data reported by the Australian Bureau of Statistics show in Table 2.4, and it is one of the highest among OECD countries. The

Australian banking sector is considered as the least affected banking sector by the GFC among all OECD countries (Brown et al., 2015).

2.5 The Banking Sector of New Zealand

The history of New Zealand banking started in the second quarter of the 19^{th} century with trading and savings banks. There was the equally robust growth of trading and trustee savings banks on both islands of the country. Australian trading banks entered the market and expanded their presence through mergers and acquisitions. The Reserve Bank of New Zealand commenced operations as a central bank in 1934 and still plays both roles of regulator and supervisor. The influence of the Australian banks became more apparent following the deregulation of the New Zealand banking sector in the 1980s. As a result, about 87% of banking assets in New Zealand are held by the Australian banks' wholly-owned subsidiaries, which are incorporated in New Zealand but not listed (RBNZ, 2017).

Table 2.5 Country Indicators of New Zealand

Indicator	2003	2015
Population	4.027 Million	4.596 Million
GDP ($US)	88.25 Billion	175.6 Billion
GDP Growth %	4.6	2.4
Human Development Index	0.88	0.91
5-Bank Asset Concentration	70	90
Finance and Insurance % of GDP	6.0	6.3

(Source: IMF and the World Bank)

The Reserve Bank of New Zealand performs the dual role of regulator and supervisor of the New Zealand banking sector. It is one of the most concentrated banking sectors of the world, where 90% of the assets were owned by its five biggest banks at the end of 2015. It is considered to be one of the resilient banking sectors of the world and was among the least-impacted banking sectors by the GFC (Brown et al., 2015). The contribution of the financial and insurance sectors to New Zealand's GDP had improved over the study period.

2.6 The Canadian Banking Sector

A local banking system in Canada came through the colonial overseas banking operations with the founding of the Bank of Montreal in 1817. Later, a few more banks were introduced by colonial governments in different parts of Canada, which used their own local currency. A common currency for Canada was introduced after the Dominion Act 1871. The Bank of Canada was established in 1935 for banking and monetary governance. After deregulation of the Canadian banking sector, the larger banks acquired most of the smaller banks and trust companies to comprise what we now refer to as the "Big Five" banks. The Government of Canada established the Office of the Superintendent of Financial Institutions (OSFI) in 1987 to regulate and supervise the federally registered financial institutions of Canada. The Bank of Canada is responsible for monetary policy. Provincial and territory governments are still allowed to register, regulate, and supervise the provincially registered financial institutions.

The Banking Act 1991 was the major milestone for the incorporation and regulation of federally registered banks. Initially, banking charters were renewed every 10 years after a thorough review of each bank; now the Bank Act is reviewed every four years by the Canadian Parliament (Calomiris & Haber, 2014). The number of registered deposit-taking institutions declined, and asset concentration increased significantly over the study period. The number of federally registered banks has increased, and provincially registered deposit-taking institutions are decreasing over time. The main reason for this decline in the number of deposit-taking institutions is the mergers and acquisitions rather than insolvency.

Table 2.6 Country Indicators of Canada

Indicator	2003	2015
Population	31.68 Million	35.85 Million
GDP ($US)	892.4 Billion	1553 Billion
GDP Growth %	1.8	0.9
Human Development Index	0.87	0.92
Number of Deposit-taking Institutions	1286	761
5-Bank Asset Concentration	69	92
Finance and Insurance % of GDP	6.2	6.8

(Source: IMF and the World Bank)

Historically, several global financial regulatory and rating bodies recognize the strength, resilience, and prudence of the Canadian banking sectors. None of the Canadian banks collapsed during and since the Great Depression of 1930; moreover, it was among the least-impacted banking sectors of the world during the GFC (Mohsni & Otchere, 2018). The Canadian banking system evolved as concentrated, lightly regulated and tightly supervised (Bordo et al., 2015). All major banks have nationwide operations despite the broad (or wide or large) geographical spread of Canada. The Big Five federally chartered banks own 92% of the banking assets of the country (Mohsni & Otchere, 2018), and this concentration increased over the study period. The contribution of the financial services sector to GDP increased over the study period but it is lower than most developed nations.

Despite limited differences between the banking systems of the Anglo-Saxon countries of the United States, the UK, Australia, Canada, and New Zealand, there were substantial variations in the impact of GFC and recovery patterns in the banking sector of each country. Advocates of the Anglo-Saxon banking model used it as a counter-argument to the claim that the Anglo-Saxon economic model caused the GFC. There is an obvious need to look into the various aspects of banks that were impacted by the crisis, the policy responses by different regulators, and the effectiveness of these responses during and after the GFC. A theoretical and empirical renaissance in banking research has started since the GFC to explore all possible dimensions of the post-GFC banking system (Berger et al., 2015), but results are not clear due to time and geographical dynamics. The next section of this study will provide the background of the GFC and the review of the post-GFC banking industry.

2.7 The Global Financial Crisis 2008

The GFC was one of the biggest financial crises in the history of banking. It originated in the United States and severely damaged the whole global banking system (Greenbaum et al., 2016). Many research studies have been conducted in different countries on the GFC to determine its causes and recommend corrective actions for improvement of future banking systems (Beltratti & Stulz, 2012; Berger & Bouwman, 2013; Moradi-Motlagh & Babacan, 2015; Vazquez & Federico, 2015). Symptoms of this crisis started appearing in 2005. Warnings about it came up on different forums and early intervention was recommended to minimize its severity (Roubini, 2006). These warnings were also issued by renowned economists and bankers like Wynne Godley, Raghuram Rajan, and Robert Shiller (Godley, 2000; Rajan, 2006; Shiller, 2007).

2.7.1 Sources of the GFC

The background of the housing bubble in the United States started at the beginning of the 21st century with the political agendas of different US administrations to increase homeownership for minorities and the low-income urban population. Different US administrations introduced legislation to lower the eligibility requirements for home loans and advised lenders to adopt those new relaxed lending guidelines. After some time, lenders complained that they could not continue to take high risk loans on their balance sheets. In response, the government pushed federal mortgage financers, Freddie Mac and Fannie Mae, to increase their purchases of low-income mortgages from lenders. The insurer freed up lenders with the purchase of these risky loans and lenders started issuing more of such loans to earn more fees. The risks to lenders were very low because they immediately sold off those risky loans to the insurer after making profits from service fees. Financial institutions essentially faced only the "pipeline risk" of holding loans for a few months before they passed the risk on to the securities market. The increased securitization led to a decline in credit quality, exacerbated by mortgage originators offering teaser rates, piggy-bank mortgages, and NINJA (no income, no job or assets) loans (Brunnermeier, 2009). This temporary state of low-interest rates and relaxed qualification criteria brought many first-time homebuyers into the market, which put upward pressure on housing prices.

This whole process of mortgage lending was further complicated by innovative securitization products of Mortgage-Backed Securities (MBS) and Collateralized Debt Obligations (CDO) to sell in debt markets. These securities were different from conventional products on the basis of their structures and liabilities, which made it difficult for a credit rating agency to provide adequate ratings. Furthermore, these debt securities were used to back other financial products ranging from insurance to derivatives (Brunnermeier, 2009). The consequences of these innovative products spiraled due to some other fragilities of the US banking system, which are discussed later in this chapter.

In summer 2006, researchers and regulators started issuing warnings about the tenuous future of the US mortgage lending and housing market (Roubini, 2006). The housing bubble eventually reached saturation and burst in the second quarter of 2007. Initially, it appeared to be a normal kind of market adjustment but later it caused a huge fall in the value of houses all over the United States. The increased number of subprime mortgage defaults was noticed, and credit rating agencies downgraded the rating of MBS. Two major subprime mortgage underwriters Ownit Mortgage Solutions and New Century Financial Corporation filed for bankruptcy in the first quarter of 2007. It ultimately turned into a credit crunch in mid-2007 and intensified in the second half of 2007 with the pull-out of Freddie Mac from purchasing risky mortgage loans.

By August 2007, the US and global financial markets were found to be facing a potential financial crisis. Subsequent developments put a question mark on the future of financial institutions holding risky MBS. This was the first and more limited phase of the crisis from August 2007 to August 2008, when the losses of many subprime mortgage lenders disrupted financial markets but real GDP was growing in the United States and forecasters were predicting only a mild recession. The second and more virulent phase of the crisis started in mid-September 2008 when Lehman Brothers filed for bankruptcy on September 15, 2008; AIG collapsed on September 16, 2008, and on the same day the Reserve Primary Fund was run on (Mishkin, 2016). During this period, the stock market fell by 40% and lost about $8 trillion from its peak in October 2007 to November 2008. Meanwhile, the Federal Reserve soon felt the ineffectiveness of traditional central bank tools and the government was facing difficulty getting the Troubled Asset Relief Program passed (Cecchetti, 2009).

These elevated insolvency concerns about financial institutions caused the major withdrawals of funds from banks and short-term financial markets by investors and depositors, which pushed up short-term lending rates and credit spreads. A large amount of asset-backed commercial paper was rolling over with short-term borrowing from money markets. The value of these Mortgage-Backed Securities (MBS) or asset-backed commercial paper fell significantly when their issuers were not able to get funds at an acceptable rate to roll over. As a result, world financial markets declined drastically, which made loans more expensive for banks so many financial institutions pulled back from lending to corporate borrowers and consumer lenders. The non-availability of required funds reduced investment in the real sector, which increased the unemployment rate.

A number of studies have been conducted by the US Government and researchers; there is some agreement on a few causes of crisis and disagreement on a few others. The following are some of the major causes of the GFC that have been identified (Greenbaum et al., 2016):

- ✓ Political will from the US Government to promote leniency in housing loans.
- ✓ The growth of securitization and the originate-to-distribute (OTD) lending model in the United States under self-supervision.
- ✓ Two decades of risky financial innovations.
- ✓ Easy-money monetary policy of the United States.
- ✓ High growth in global economic development without correction.
- ✓ Misaligned incentives in Mortgage-Backed Securities (MBS).
- ✓ The unrealistic rise in house prices in the United States.

- ✓ A substantial increase in consumer lending and consumption.
- ✓ Risky lending by financial institutions with lower standards of underwriting.
- ✓ Liquidity shrinkage in response to insolvency concerns and demand.
- ✓ Reduction in corporate investment and rise in US unemployment.

While this was happening in the United States, much was happening in other parts of the world too. Significant losses were happening in the financial statements of the European banks, which were directly engaged in the sub-prime market through investment in US MBS and indirectly through derivative products based on these securities. However, many of these EU financial institutions were victims of their own vulnerabilities, which could be observed in September 2007 when depositors were waiting in line outside the UK branches of Northern Rock to withdraw their money (Shin, 2009). In Europe, British banks were hard hit and the British government introduced various initiatives to support their banks with government funds. Similar initiatives were introduced later by other European countries. This financial crisis quickly turned out to be a real growth problem for Europe due to the dependence of their industrial sector on the US economy. As the US economy slowed, consumption fell, which depressed production and exports from Europe (Savona et al., 2011).

Most emerging economies escaped from involvement in the GFC due to their reduced integration into the global economy and cautious economic behavior toward their own challenges; however, economic growth dropped significantly due to their dependence on exports to the United States and Europe. Many of these economies were prepared for any economic shock after having a long boom of exports in more than a decade. In most emerging countries, the GFC affected the manufacturing sector first, then spread to other economic sectors, ultimately led to a slow-down of the whole economy.

2.7.2 Effects of the GFC

The GFC is mostly referred to as a crisis of credit markets that centered particularly in the United States, UK, and Europe. Its enormous scope and scale spilled over to many other countries and the severity of impacts depends on their integration with the US economy and internal economic vulnerabilities (Laeven & Valencia, 2013). The problem of MBS brought global debt markets to their bottom in August 2007, however, it affected the stock market by the end of 2007 after having peaked in October 2007 (Krishnamurthy, 2010). During the crisis, financial institutions of many major economies reported losses on a large scale. Some of these institutions failed and others were taken over or rescued with government support. The financial sentiment, consumer confidence, and general economic conditions deteriorated. The lower consumer and government spending led to a decline in economic growth in many major economies.

The impact of the GFC varied across different parts of the world on the basis of their own economic vulnerabilities and challenges. However, the spill-over effect from the United States had several similar consequences in developed countries, which were observed by many international organizations and regulators. The original IMF estimate of 0.5% global economic growth for 2009 ended up being a contraction. The US economy contracted by 2.8%, Canada 2.9%, Germany 5.1%, France 2.2%, Japan 5.2%, Italy 5.0%, Russia 6.1%, Switzerland 2.1%, and UK by 4.9%. The impact of GFC on GDP growth of the five countries in this study is demonstrated in Figure 2.2. Only a few emerging economies like China, India, Brazil, and Argentina grew slightly, along with Australia (IMF, 2011). The impact on other smaller economies from Africa and Asia was not significant for the global economy. Every impacted country responded with fiscal and monetary initiatives to curtail the impact of the crisis and promote economic healing.

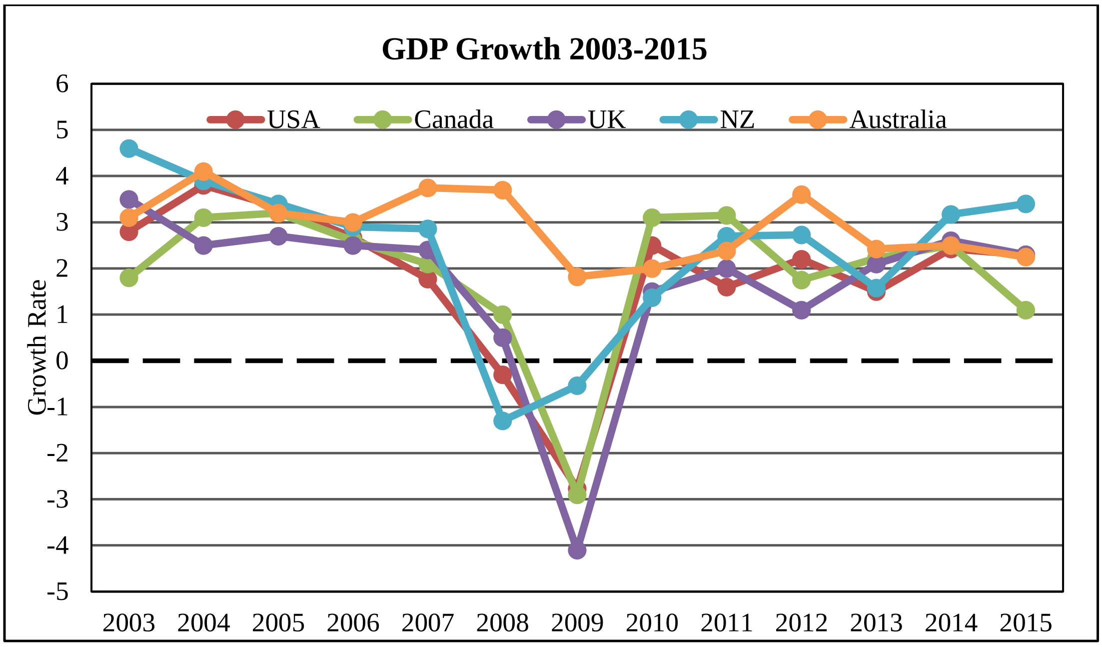


Figure 2.2 Impact of the GFC on GDP Growth

2.7.3 The Response to GFC

As discussed earlier, the US economy was the most affected and was at the epicenter of the GFC. Therefore, a quick and effective response was expected in the United States. Various developed and emerging economies also introduced a variety of measures to deal with the GFC in anticipation of the response to its impact. The IMF identified 153 separate policy actions taken by 13 countries as the response to the GFC, including 49 in the United States alone because the policy response of the United States was critical for the rest of the world (IMF, 2010). The objective of all individuals and some coordinated policy response was minimizing the impact of the GFC and seeking quick recovery for the global economy.

The United States expanded the traditional role of the central bank as the lender of last resort by providing liquidity directly to borrowers and investors in key financial markets along with some other policy initiatives. The Federal Reserve interventions included the discount window, Term Auction Facility (TAF), Primary Dealer Credit Facility (PDCF), and Term Securities Lending Facility (TSLF). It also approved bilateral currency swap agreements with 14 central banks from other countries to help them secure the dollar liquidity positions of banks in their jurisdictions; the ECB was the biggest partner in such an arrangement. Most of these liquidity initiatives were introduced at the end of 2007 and closed by the start of 2010. Another arrangement was to provide liquidity directly to borrowers and investors in key credit markets. These interventions included the Commercial Paper Funding Facility (CPFF), ABCP MMF Liquidity Facility (AMLF), Money Market Investors Funding Facility (MMIFF), and the Term Asset-Backed Securities Loan Facility (TALF). These facilities were established at the end of 2008 and disestablished by mid-2010.

The Federal Reserve also purchased longer-term securities in billions of dollars every month through open market operations to bring down long-term interest rates (Greenbaum et al., 2016). The government took an ownership position in many financial and nonfinancial firms to reduce the risk of insolvency. Most of these responses were targeted and simultaneous to get the maximum benefit and quickest response. Besides introducing many liquidity and stability measures in the market, the US government also reviewed the regulatory environment for financial institutions and markets.

The macroeconomic policy and financial regulatory responses in Europe came very late and were more diverse due to their complex economic structure, therefore, the size of the monetary and fiscal stimulus was relatively larger and less effective compared to other developed economies. On the recommendations of a high-level group formed by the European Commission, a gradual increase in banks' capital, a reduced maximum size of hedge funds and other non-banking financial intermediaries, a re-affirmed role of credit rating, and the standardization of over-the-counter (OTC) transactions were introduced. Two new institutions of the European Systemic Risk Council and the European System of Financial Supervision were also recommended. Overall, many European countries are still working on the after-effects of the GFC due to their late, uncoordinated, and inefficient response (Savona et al., 2011; Schoenmaker, 2017).

The delayed impact of declined demand from developed countries gave time to the emerging economies for mutual coordination. The active state intervention from these economies before the GFC and in the aftermath helped them build momentum in trade between China and other emerging economies. Although it did not substitute for trade with the West, it supplemented the significant portion of their trade that was with the West. As a response to the GFC, many developing countries including BRIC undertook measures to prop up their large financial institutions and financial system. They implemented expansionary monetary policies to reduce interest rates and supplemented this with expansionary fiscal policy. They adjusted their exchange rates, industrial policy, and employment regulations to minimize the microeconomic impact. The huge amount of savings in these countries helped their financial institutions maintain good liquidity levels. The response of each country was different from others on the basis of their balance of payments, foreign reserves, fiscal deficit, and nature of global integration (Chin, 2011).

Overall, many believe that the liquidity support provided by central banks helped to calm financial markets in the initial phase of the crisis. Many developed markets saw interest rate cuts and bank recapitalization as the most promising policy steps to resolve the crisis. Domestic liquidity support didn't help to reduce pressure in interbank markets, but the risk was reduced in interbank markets by foreign exchange (forex) swaps. Many policy announcements had an international spillover effect in restoring investors' confidence and market stability. The unsystematic bailout of financial institutions badly affected market confidence during the crisis due to information asymmetry (Aït-Sahalia, Andritzky, Jobst, Nowak, & Tamirisa, 2012); there was no consensus on proper diagnosis of the real problem, nor corrective actions to restore markets for the long run. The expansionary monetary and fiscal policies helped to bring down the price of funds, which resulted in a reduction in the insolvency rate and better economic growth in the short run.

2.7.4 The Post-GFC Era

Changes in regulation and the economic environment, along with technological changes and financial innovation, have transformed the banking industry. However, the post-GFC reforms of enhanced capital and liquidity requirements, improved supervision, greater supervision of credit rating agencies, better regulation of cross-border banking, and changed accounting disclosure rules have also played a vital role in the transformation of the banking sector (Berger et al., 2015). Some of these reforms are introduced at a national level but most are introduced globally under Basel III.

These banking environment changes and the post-GFC reforms have helped to create very large banking organizations that adopted a universal banking model in many countries. Most of the largest banks have transformed themselves into multiproduct and multi-market financial services conglomerates that offer retail banking, investment solutions, brokerage, insurance, and wealth management services. The over-grown size of banking firms has created various challenges for countries' macroeconomic and financial market stability (Berger et al., 2015). A number of prior studies found that scale economics for large banks disappear and the level of current scale economies is due to too-big-to-fail (TBTF) guarantees instead of true economies (Wheelock & Wilson, 2018). The TBTF banks obtain advantages of implicit government guarantee, lower regulatory cost, technological scale, and endogenous risk-taking which is not possible for smaller banks (Brewer & Jagtiani, 2013; Hughes & Mester, 2013). Banking market concentration has increased, and the number of banks has decreased due to a rapid increase in mergers and acquisitions during the crisis, but the number of mergers has since declined. Smaller and medium financial institutions are preferring to merge with large banks to ride the bandwagon of TBTF that has further increased the size of larger banks (Brewer & Jagtiani, 2013).

The enhanced capital, liquidity, and regulatory requirements have increased the price of capital and restrictions on some capital-intensive activities of banks and may have reduced their profitability (Fu, Lin, & Molyneux, 2014b). These requirements have also created a big shadow banking sector that operates in a less regulated and less supervised environment. Many large banks have partially shifted away from riskier non-traditional banking activities to focus more on retail banking. These banks aim to boost interest rate-, fee-, and commission-related income from low risk and stable banking activities (DeYoung & Torna, 2013). Surviving banks achieved tremendous growth during the post-GFC period in many countries except Europe, where recovery of banks and economies was stalled by the sovereign debt crisis that befell various economies of Europe during 2010 and 2011.

Although, the GFC originated from the US banking sector and was, along with the UK, among the most impacted by the crisis, the Anglo-Saxon banking system cannot be blamed for this. The banking systems of Australia, Canada, and New Zealand, based on the Anglo-Saxon banking model, were among the least impacted developed countries of the world (Calomiris & Haber, 2014; Xiang et al., 2015). The banking sectors of Australia, Canada, New Zealand, and the United States have grown tremendously since the GFC. The banks of the UK are in the process of recovery, but their pace of recovery is very slow. Many banks of Australia, Canada, and New Zealand are among the safest banks in the world. An enormous variation in the impact of the GFC on the selected five countries is reported in several studies, and an analysis of several variables that may have played a role in this variation is recommended (Calomiris & Haber, 2014; Savona et al., 2011). The banking sector of each country has significantly changed during the study period, which provides further incentive to explore the impact of the GFC during and after the crisis. Many studies have been conducted on the impacts of the GFC on bank efficiency, although various aspects and geographies are identified to be further explored.

Chapter 3

LITERATURE REVIEW

The previous chapter provided an overview of the Anglo-Saxon banking model and the banking system of each selected country. A review of the GFC is also provided with its origin, background, and impacts in different parts of the world. The purpose of this chapter is to review the literature on performance evaluation and efficiency of the financial institutions before, during, and after the GFC. Section 1 reviews the different measurements to evaluate the performance of financial institutions and the importance of efficiency measurements. Section 2 discusses the role of the macroeconomic environment in bank efficiency. Section 3 presents the relationship of risk with bank efficiency in prior studies. The relationship of bank efficiency with the banking market structure is reviewed in Section 4. Section 5 surveys the prior literature on the relationship between shareholder value and bank efficiency. This chapter concludes with a summary of selected prior studies on bank efficiency and its determinants.

3.1 Bank Efficiency Studies

Research on the banking sector is as old as modern-day banking: most of the initial studies were on banking operations, regulatory framework, and the role of banks in the economy (Davies 2002; Doukas, Murinde, & Wihlborg, 1998; North & Thomas, 1973). Later studies were focused on product development, financial management, performance, structure, and governance of the banks (Anderloni, Llewellyn, & Schmidt, 2009; Freixas & Rochet, 2008). Most of the recent studies are focused on the role of technology in banking, customer service, financial innovation, risk management, globalization, competition, and bank performance (Berger et al., 2015; Greenbaum et al., 2016). The performance analysis is the core of every banking assessment and is vital for the survival of a bank.

Various stakeholders conduct periodic reviews of bank performance for several reasons. The bank regulators seek to identify problematic banks and their compliance with the regulatory framework. The results of the performance review help them to recommend remedial solutions for vulnerable banks. Shareholders need to determine their returns on investment and stability of banks, so they can decide on buying or selling stocks of certain banks. Investment analysts review bank performance to recommend best performing banks to their prospective investors. Researchers explore bank performance to provide future policy guidelines and feedback on past initiatives to bank management and regulators. Banks also evaluate their own performance over time to determine outcomes of their previous management actions so that decisions can be made about future resource allocation, a performance comparison of various sub-units or departments, the reward for the workforce, and setting future expectations. The existence of problems cannot be identified without persistent monitoring of performance, and such problems may lead to financial failure in the future (Madura, 2015). The evaluation and analysis of banks using the most accurate and modern techniques are essential to ensure a healthy financial system together with an efficient economy.

Performance review tables based on several accounting ratios are an integral part of banks’ annual reports in most countries, and ratio analysis is an essential part of their regulatory requirements as well. Efficiency, liquidity, and profitability ratios are compared in these tables over a period of many years. The most popular and commonly used ratios are Return on Equity (ROE) and Return on Assets (ROA). The ROE can be found in many studies analyzing the performance of banks, reports of concerned analysts, and financial reports of companies. In the banking sector, ROE and ROA measures largely correlate with each other, and both of them provide the same indications of the tendency in financial performance (Karr, 2005). Performance measurements of ROA, ROE, and net interest margin (NIM) have been used with a stability measure of Z-score in some recent studies to compare the performance of different banking business models (Mergaerts & Vander Vennet, 2016). Similarly, many studies have used ROA, ROE, Tobin's q, and cost to income ratio (CIR) as substitutes for each other or to supplement their results from other techniques (Berger & Mester, 2003). Other banking-specific ratios have also been used to evaluate bank performance including loan losses to total loans, interest income, interest expenses, deposits, etc.

Some other studies concentrate on the use of the set of ratios or entire systems of accounting measures. The multi-criteria systems of ratio analysis include the Analytical Hierarchy Process (AHP), CAMEL model, and Du Pont System. Most of these systems are created with minor adjustments and replacements of existing financial ratios. Another multi-criterion system is based on indices developed by researchers over time, which include Treynor's index, Jensen's index, and Sharpe index. The use of these multi-criteria systems increases the ability to confirm an overall view of bank performance, convenience to collect data and make calculations and combine the advantage of many measures together (Stankevičienė & Mencaitė, 2012). Many central banks use the CAMEL model with the combination of a few additional ratios to monitor their regulated financial institutions.

Although these measures are in use for a long time in many organizations, they have been criticized and significant shortcomings have been identified by different analysts and researchers. These ratios or combinations of ratios may well serve their purpose of informing bank shareholders about their company; however, they don't tell about the optimal utilization of inputs to produce the best output relative to other industry players. Their reliance on comparable norms and standards is the most significant shortcoming and does not allow a composite overall score on the entire bank's soundness. Moreover, these ratios mainly reflect short-term performance, whereas efficiency analyses are more focused on long-term performance (Berger & Humphrey, 1997; Sherman & Gold, 1985).

As a result of this criticism, researchers initiated work on more sophisticated econometric and mathematical models of bank performance assessments that were being used in other industrial sectors. One option for the researchers to assess bank performance was to use a frontier production function, which was being used in the industrial and agriculture sector to measure production efficiency (Cobb & Douglas, 1928; Farrell, 1957). The initial study by Farrell (1957) used the frontier production function for estimating the efficiency of the agriculture sector, which drew upon the work of Debreu (1951) and Koopmans (1951). He defined efficient production function as the output that a perfectly efficient firm could obtain from any given combination of inputs, then compared the observed performance of each firm with it to estimate their inefficiency. Further work was noticed in a pivotal paper of Aigner, Lovell, & Schmidt (1977), where a stochastic frontier production function model was used to measure the efficiency of the metal industry in the United States from 1957 to 1958. In the same year, another paper used a stochastic frontier production function with a composed error model on data from the 1962 French Census of Manufacturing Industries and proved that the results were better than previous studies on the same data due to the introduction of an error term (Meeusen & Van den Broeck, 1977). Later, the seminal paper of CCR (Charnes, Cooper, & Rhodes, 1978) used the linear programming technique of Data Envelopment Analysis

(DEA) for estimating efficiency scores for the general research. All these studies helped to formulate economic inferences of the production function in the form of cost and profit functions (Debreu, 1959; Shepherd, 1953), which proved to be a better option to assess bank performance. Further detail of production, cost, and profit functions is provided in the next chapter.

The estimation of minimizing cost and maximizing profit functions was found to be very close to the objectives of the bank owners. As a result, frontier production functions came into use to analyze the performance of financial institutions. The widespread use of frontier analysis models in economics and management sciences was noticed by Bauer (1990), who identified three reasons for their popularity. First, he found the notion of frontier consistent with the underlying economic theory of optimizing behavior. Second, the deviation from a frontier has a natural interpretation as a measure of efficiency for units to pursue their behavioral objectives. Finally, information about the structure of the frontier and the relative efficiency of economic units has many policy applications (Bauer, 1990). Now there is the widespread use of both parametric and non-parametric frontier analysis approaches to measuring efficiency in economics and management sciences.

The use of frontier efficiency models in banking was introduced in the early 1980s to measure the performance of US commercial banks (Benston, Hanweck, & Humphrey, 1982; Berger, Hanweck, & Humphrey, 1987; Sherman & Gold, 1985). The famous survey conducted by Berger and Humphrey (1997) was a major contribution to improving the usage of frontier approaches in the banking industry. They summarized the theoretical analysis of 130 bank efficiency studies from the literature based in 21 countries. They provided a summary of prominent studies, a critique on the use of different frontier approaches to measuring bank efficiency, and directions for future research. They concluded that frontier analysis was the most sophisticated approach to benchmark-relative performance (Berger & Humphrey, 1997). They identified two major benefits of frontier analysis: first, its outcome can be easily understood by any person with little institutional knowledge because it gives a single economic value; second, it helps management teams to identify their areas of best practice, which can help to improve operations.

As per the Berger and Humphrey (1997) survey, DEA and Free Disposal Hull (FDH) are the most commonly used non-parametric approaches in past studies. Berger and Humphrey noticed some major drawbacks with non-parametric approaches: these approaches assume no measurement error, no accounting inaccuracies, and no luck or change that may temporarily increase a firm's short-term efficiency (Berger & Humphrey, 1997; Farrell, 1957). If any of these errors are present in the data of a firm, it may affect efficiency scores of all units being compared. The SFA is referred to as an econometric frontier approach and is found to be the most commonly used parametric frontier approach for efficiency measurement in literature. It specifies a functional form for the cost, profit, or production relationship among inputs, outputs, and environmental factors and allows for random errors. The drawback of the SFA is that it pre-assumes a symmetric shape of the frontier (Førsund, Lovell, & Schmidt, 1980). The recommended solution is to use more flexible functional forms (Berger & Humphrey, 1997). Some regression models have also been tried as an alternative to the frontier analysis, but they did not get much acceptability because they too have limitations. Two major limitations are the requirement of a larger sample size and a smaller number of study variables (McAllister & McManus, 1993). In addition, the outcome of regression analysis is not as comprehensive and concise as that of a frontier analysis.

Most of the initial bank efficiency studies were based on either the branches of a single bank or the banks of a single country, but later the trend of cross-country studies started. Researchers began applying frontier analysis in banks to compare the efficiency of branches within banks, similar to the comparison of production units (Berger, Leusner, & Mingo, 1997; Parkan, 1987; Sherman & Gold, 1985). All these studies used different parametric and non-parametric approaches, economic concepts, functional forms, and production variables. A large dispersion in average results of efficiency among all these studies was noticed. This variation in the results was due to a small number of branches, non-availability of branch data for some financial institutions, and extreme variation in inputs and outputs because of varying branch sizes. Most of the studies have found a high level of inefficiency among branches of banks because of the small size of branches and a small network of branches. They have recommended that bigger branches and branch networks can help improve efficiency with scale economies (Berger, Hunter, & Timme, 1993).

In the early 1990s, many researchers worked on their methodologies to draw efficiency frontiers among different banks of a country to overcome the problems of branch studies (Bauer, Berger, & Humphrey, 1993; Berger, 1993; Wheelock & Wilson, 1994). These studies reported an improved efficiency in the banking sector and narrowed the variation among results of the studies using different methodologies. In this regard, a US study by Berger and Mester (1997) played a vital role in exploring the differences in efficiency concepts, measurement methods, and the potential correlates of bank efficiency. They estimated cost, profit, and alternative profit efficiencies of 6,000 US commercial banks for the period of 1990 to 1995. From their empirical analysis, they found that the measurement of each efficiency concept does add some independent information value about banks. They identified several correlates of cost, profit, and alternative profit efficiencies and found that each efficiency measure was estimating a different kind of optimization for the same organization. They concluded that despite significant research on the efficiency of financial institutions over the previous few decades, little information and no consensus has been gained on the source of the substantial variation in efficiencies measured from different techniques. Many later studies worked to finalize one best approach to measure bank efficiency, but it is still a work in progress, with each frontier approach and economic concept having its pros and cons (Coelli, Rao, O'Donnell, & Battese, 2005; Greene, 2008; Kumbhakar & Lovell, 2003; Simar & Wilson, 2007; Wang & Schmidt, 2002).

The trend of cross-country studies started at the end of the 20th century, following the future research guidelines of the famous survey study by Berger and Humphrey (1997), who gave three major considerations for the future direction of efficiency research. First, there is a trend to regress the efficiency value with the variables of interest, which may produce misleading information if the robustness of the efficiency value is not tested with other available techniques. Second, more cross-country comparative studies are recommended in order to explore whether the US market results carry over to other nations with different overall concentrations and products. Third, there is a considerable lack of information on efficiency determinants. Many later studies have explored the application of frontier analysis approaches across different countries and the impacts of different environmental variables on bank efficiency (Carbó-Valverde, Humphrey, & del Paso, 2007; Chaffai, Dietsch, & Lozano-Vivas, 2001; Mergaerts & Vander Vennet, 2016; Xiang et al., 2015). These studies have compared the bank efficiency of several countries and found consistency in the results of different frontier approaches.

Carbó-Valverde et al. (2007) conducted a cross-country study on 153 large banks from 10 European countries for the period of 1996–2002 to compare their relative efficiency and its determinants. They used the two-stage DFA approach to separate the influence of internal variables from external variables of banks in efficiency estimation. Their results showed identical average efficiency for all large banks of the 10 countries. Owing to the integration of the European market, not much difference exists in the business environment and productivity across these countries. After a comparison of the top one-third of the most efficient banks with the least efficient ones, they found that banks of each efficiency group are the same in almost every country after controlling the business environment. They reported the influence of the business environment on bank efficiency and recommended studying firm-specific variables to assess their contribution to bank inefficiency.

The impact of different business environment variables on bank efficiency was also explored by Xiang et al. (2015), who compared bank efficiency among Australia, UK, and Canada after the GFC. They used a two-stage mixed SFA approach for the data of 23 large banks from the three countries. They claimed that the financial systems of all three countries share a common "Anglo-Saxon" inheritance of banking operations, structure, and regulations (Xiang et al., 2015). Their results showed, on average, a high level of profit efficiency, moderate level of technical efficiency, and low level of cost efficiency in all three countries. Overall, Australian banks showed a superior profit, cost, and technical efficiency. Xiang et al. found a significant impact of different banking environment and firm-level variables on the efficiency of banks, consistent with many other bank efficiency studies (Beck, De Jonghe, & Schepens, 2013; Belke et al., 2016; Schaeck & Cihák, 2014).

Many comparative and individual country studies have been conducted in Eastern European countries, Brazil, China, India, Malaysia, and other Asian countries. The importance of research on bank efficiency is felt all over the world; therefore, studies are conducted in most major economies. All studies have made some contribution to the information about bank efficiency; however, a lack of comparative cross-country studies is noted in some prominent studies. The reasons behind the lack of cross-country studies are methodological challenges, selection of appropriate countries, and difficulties in getting the required data. Despite these challenges, the need for cross-country studies is there. Over time, tremendous improvements have been made in estimation approaches, functional forms, selection of appropriate variables, and analysis methods.

Every year, several bank efficiency studies are conducted to improve the methodology and economic implications of the frontier analysis. Methodological advances in the frontier analysis have made it possible to include banking environment variables in efficiency estimation models. Many banking environment variables have been used in various prior studies to control cross-country differences and to identify the determinants of bank efficiency. Although a large number of efficiency determinants are identified in several prior studies, as discussed in the next section, a limited number of variables can be included in each estimation model because of the statistical limitations of the econometric models (Wooldridge, 2013).

3.2 Determinants of Bank Efficiency

The inclusion of banking environment variables in estimation models can help identify their contributions to bank inefficiency, control cross-country differences in the banking environment, and individual heterogeneity of banks. These potential determinants of bank inefficiency might provide important implications for public policies, research, and bank management (Berger & Humphrey, 1997; Bikker & Bos, 2008). A large number of banking environment variables are included in various prior studies as per their research objectives and data; however, only a limited number of variables can be included in each estimation model because of the statistical limitations of the econometric models. Several important prior studies and determinants of bank efficiency are reviewed in this section. Based on prior studies, research objectives, and banking environments of the chosen countries, a set of 10 carefully selected banking environment, and one GFC dummy variables are included in each estimation model of this study. Even though banking systems of the five selected countries are based on a common Anglo-Saxon model, some differences in the macroeconomic and regulatory environment have developed over time, as per the individual needs of each country. It is believed that the production technology of commercial banks is well known, homogeneous, and smoothly dispersed across most of the developed countries (Berger, 2007; Greene, 2008). The difference in the scale, structure, or macroeconomic environment can impact the efficiency or inefficiency instead of the production technology. Therefore, the same stochastic frontier is used for all selected banks, and all banking environment variables are included in the inefficiency equation of each model.

The banking environment variables or potential determinants of bank efficiency are further divided into three broad groups on the basis of various research hypotheses used in the past studies, but all are included together in each estimation model. These three groups are the macroeconomic, bank risk, and banking market structure variables.

3.2.1 Macroeconomic Environment and Bank Efficiency

A consensus exists among prior studies that almost all developed economies and major emerging economies experienced a high level of financial stress and reduced economic activity as a result of the GFC, but the magnitude and time of the impact differed greatly (Claessens, Dell'Ariccia, et al., 2010). The impact of the GFC on the selected economies of this study was also different in terms of time and extent. Many studies have tried to explore the sources of resilience or vulnerability among these countries. Some studies gave credit to a better economic environment and others to better management of individual banks (Mohsni & Otchere, 2018; Xiang et al., 2015). Various aspects of the economic environment and individual banks need to be explored. This study has a dual challenge in this regard: First, segregating the roles of the economic environment and prudent bank management in the resilience or vulnerability of the selected banking sectors is difficult. Second, the comparison of efficiencies among different countries using a common frontier may be problematic due to the different economic environments. A number of prior studies have worked to provide a solution to these challenges and various methodological advances have been developed.

Banking technology is based on a set of specific methods that banks use to convert their physical and financial inputs into services and products. These methods are more or less the same in large industrialized countries (Dietsch & Lozano-Vivas, 2000). Moreover, the similarity in these methods is greater among the countries that follow some common economic or banking models. Dietsch and Lozano-Vivas (2000) used a DFA to investigate the influence of the banking environment on the cost efficiency of French and Spanish banks. Results from their parametric model without environmental variables found cost efficiency to be much lower for Spanish banks than for French banks. However, the difference in cost efficiency scores was reduced substantially when environmental variables of population density, per capita income, deposit density, the HHI, capital ratio, and branch density were included in the estimation model. The economic environment variables of per capita income, interest rate, average net interest margin, capital adequacy, concentration, deposit density, and branch density have been used by many other studies to minimize the banking environment variations and to assess their impact on estimates of bank efficiency (Belke et al., 2016; Casu & Ferrari, 2015; Fiordelisi, Marques-Ibanez, & Molyneux, 2011; Fitzpatrick & McQuinn, 2008; Huang, Chiang, & Tsai, 2015).

A similar practice was observed in the survey by Berger (2007), who reviewed 100 cross-country bank efficiency studies from different parts of the world. He concluded that studies using common frontiers have progressed significantly by controlling the difference in banking environments through econometric methods, selection of economies with similar environments, and methodological improvement. The methods of choosing economies with almost homogeneous environments and using a set of environmental control variables have minimized the cross-country variations but are not sufficient to eliminate them (Berger, 2007). An exhaustive set of control variables is required to eliminate cross-country variations, but the limitations of the econometric models may not allow a large enough number of variables. A careful selection of environmental variables is the optimal solution to control cross-country variations. A recent cross-country bank efficiency study by Xiang et al. (2015) selected countries with almost homogeneous banking models and used five economic environment variables to control economic variations. They selected Australia, UK, and Canada to compare over the period of 1988–2008 and used the variables of per capita income, concentration, capital adequacy ratio, average profit margin, and deposit density in a one-stage SFA model to control the variations in the banking environment.

The present study has used a methodology that has taken care of the methodological challenges of cross-country studies identified by prior studies. First, five almost-homogeneous banking sectors based on the Anglo-Saxon model are selected. Second, a set of potential bank-level and banking environment variables are used as determinants of bank efficiency. The three macroeconomic environment variables are the nominal interest rate, GDP per capita, and population density. These variables help control cross-country macroeconomic variations and their possible relationship with bank efficiency can help policymakers to create a banking sector that supports business operations in the broader economy.

Nominal Interest Rate

The level of the interest rate might affect both the costs and profit margins of the banks. Rising interest rates increase bank profits under general conditions and are more beneficial for commercial banks than for saving banks (Bikker & Vervliet, 2018; Hancock, 1985). Prior studies suggest that an environment with low-interest rates brings down the net bank margin and information asymmetries, and as a result, banks react by lowering their lending standards to search for high yields (Bikker & Vervliet, 2018; Delis & Kouretas, 2011). The search for a high yield may lead to a higher level of risky assets, credit expansion, and intensifying of competition (Dell'Ariccia & Marquez, 2006), which may result in reduced bank efficiency. However, a high level of interest rates might raise bank profits if a bank maintains an excess of floating-rate assets over floating-rate liabilities, and it would increase bank costs and decrease bank profits in the reverse situation. The positive impact of low interest rates on investment income of banks is also apparent in prior studies (Claessens, Coleman, & Donnelly, 2017). In any case, an impact of interest rate differences between countries is expected on bank efficiencies. The five-year bond yield is taken as the nominal interest rate of each country to control the impact of interest rate differences and explore its relationship with efficiency.

GDP Per Capita

The GDP per capita is a proxy for the income level or economic growth of a country. It affects numerous factors related to the demand and supply of banking services. Countries with higher per capita income are expected to have more deposits and higher loan assets. Also, higher demand for loans and deposits may result in more competitive interest rates and profit margins (Delis & Tsionas, 2009; Dietsch & Lozano-Vivas, 2000). Income level and bank efficiency are expected to have a positive relationship (Xiang et al., 2015). GDP per capita varies over time and among selected countries; therefore, it is used to control cross-country variations and their impact on bank efficiency.

Population Density

This is measured by the number of people per square kilometer. Greater population density should make the retail distribution of bank services less costly, which should improve bank efficiency (Lozano-Vivas, Pastor, & Pastor, 2002). A less densely populated country may be expected to need more branches and ATMs per unit of the population to deliver convenient services to customers (Carbó-Valverde et al., 2007). Although the introduction of fintech has helped reduce the cost of bank coverage, the initial cost of fintech is very high. The impact of fintech depends on the scope and scale economies of the adopted technology. Most previous studies have reported a positive relationship between population density and bank efficiency; however, we may expect different relationships in this study because of the recent fast growth of fintech. The countries selected for this study have widely different population densities, from the lowest 3 persons per square kilometer in Australia to the highest 271 persons in the UK. The inclusion of this variable will control cross-country variations in population density over time.

3.2.2 Bank Risk and Efficiency

As discussed in the previous chapter, risk-taking activities of banks were among the major reasons for the GFC (Greenbaum et al., 2016). The failure of many prominent banks during the GFC cast doubt on the quality of risk management practices in the banking sectors of various countries. After a thorough review, many regulatory and supervisory initiatives were introduced globally, which included enhanced standards of liquidity, capital, and supervision (Vazquez & Federico, 2015). A number of studies have been conducted in various parts of the world to assess the pre- and post-GFC risk levels of banks. Furthermore, the impact of risk management on bank efficiency and stability has also been explored in a few economies.

In an earlier study on the relationship between bank risk and cost efficiency, Berger and DeYoung (1997) found that most banks approaching failure have a high ratio of problem loans, low asset quality, and lower cost efficiency. They estimated cost efficiency with the SFA model and used the Granger-causality technique to seek its association with problem loans and bank capital. They suggested that the intertemporal relationships between problem loans and cost efficiency ran in both directions for the US commercial banks for the period of 1985–1994. A high level of nonperforming loans would incur high costs of loan monitoring; alternately, low expenditure on underwriting and monitoring would expand the nonperforming loans in the long run. In the latter case, there can be a positive relationship between loan losses and bank efficiency, which is called the “skimping” hypothesis (Berger & DeYoung, 1997). They further conclude that low bank capital precedes an increase in loan losses, and high loan losses lead to decreased bank efficiency. It is believed that thinly capitalized banks may respond to moral hazard incentives by taking increased portfolio risks, which may lead to bank failure (Altunbas, Carbo, Gardener, & Molyneux, 2007; Berger & DeYoung, 1997; Fiordelisi et al., 2011). Overall results of prior studies are ambiguous about the relationship between the levels of bank capital and risk (Anginer & Demirguc-Kunt, 2014a; Koehn & Santomero, 1980).

Altunbas et al. (2007) investigated the relationship between cost efficiency, capital, and risk variables of more than 20,000 European banks from 1992 to 2000. They found a positive relationship between the levels of bank capital and cost efficiency; however, different results were obtained for various types of banks. The level of loan losses, the ratio of net loans to assets, and the ratio of liquid assets to deposits were found to be negatively associated with cost efficiency. They found a positive influence of capital level, bank size, interest rate, and liquid-assets-to-total-assets ratio on cost efficiency. In another study on European commercial banks, Fiordelisi et al. (2011) investigated the intertemporal relationship between bank efficiency, capital, and risk. They found a positive impact of higher capital level on the cost and profit efficiency of banks for the period of 1995–2007 (Fiordelisi et al., 2011). However, higher bank risk impacted cost efficiency negatively and profit efficiency positively. Their study concluded that efficient banks eventually become better capitalized, and a higher capital lowers the risk, which leads to a better level of efficiency. The results of their study also underline the importance of long-term bank efficiency for achieving financial stability objectives.

In a recent study, Vazquez and Federico (2015) selected data for EU and US banks to review the roles of different risk variables in failed banks during the GFC. They used the variables of net stable funding ratio, the ratio of equity to total assets, and Z-score to measure the risk levels of banks in the pre-crisis and crisis periods. The results showed that banks with weaker liquidity, lower Z-score, and higher leverage before the GFC were more vulnerable to subsequent failure (Mohsni & Otchere, 2018; Vazquez & Federico, 2015). They also found systematic differences across bank types. The large global banks were susceptible to failure owing to their insufficient capital buffer, and the smaller banks were prone to fail because of their liquidity problems (Laeven, Ratnovski, & Tong, 2014; Vazquez & Federico, 2015).

In a later study, Xiang et al. (2015) investigated the impact of the GFC on major banks of Australia, Canada, and the UK. They reported results similar to those of the earlier studies, with loan losses and financial leverage negatively impacting bank efficiency. However, some of their results were different from those of previous studies: bank size was found to be negatively and loans-to-assets ratio positively related to cost and profit efficiencies of banks. Furthermore, they found a negative impact of financial leverage on technical efficiency but a positive impact on cost and profit efficiencies. Although financial leverage may increase the profit efficiency of a bank, it may also increase its risk level. As mentioned earlier, a higher risk level or a lower Z-score can negatively affect the efficiency of the bank over a long period. In their study, Mohsni and Otchere (2017) reported that a higher Z-score was one of the main reasons for the less severe impact of the GFC in Canada than in the US banking sector.

The relationship between a bank's risk level and efficiency has been investigated in prior studies for a couple of decades. The relationship of risk variables with bank efficiency has changed over time because of the changes in the market structure and characteristics, economic environment, and regulatory framework of the banks. As discussed earlier, the GFC was one of the major events in the history of banking and it has changed the structure and environment of banking sectors in various countries. The post-GFC initiatives have created a dual challenge for banks. First, higher capital, liquidity, and supervision levels have increased the cost of banking. Second, the restraints on banks from capital-intensive activities may further reduce their profitability. The impact of these initiatives on bank efficiency needs to be assessed. Although a negative impact of some risk-reduction initiatives is expected in the short run, it might help banks improve their efficiency in the long run (Fiordelisi et al., 2011; Mohsni & Otchere, 2018). For this study, the author has decided to investigate the relationship between bank risk rates and efficiency and compare the results among selected economies across the time period. The variables of the Z-score, the ratio of loan losses to total loans, the ratio of loans to total assets, and the level of equity are selected to proxy the different aspects of bank risk.

Z-Score

The Z-score relates a bank's capital level to the variability in its returns. The variability in returns is typically measured by the standard deviation of ROA as the denominator and the ratio of equity capital to assets added to the ROA as the numerator. The banks with lower risk will have higher Z-scores and those with higher risk will have lower Z-scores. In other words, Z-score measures the distance of a bank from insolvency (Beck et al., 2013; Boyd & Graham, 1986). It is typically calculated by the following formula:

$$Z-score = \frac{\mathrm{ROA} + \left(\frac{\mathrm{Equity}}{\mathrm{Asset}}\right)}{\sigma(\mathrm{ROA})} \qquad (3.1)$$

Here ROA and the equity-to-asset ratio are calculated for each bank in each financial year. The standard deviation of ROA is computed over either a rolling time window or the whole sample period; each selected method will have a different impact on the results of the Z-score (Li, Tripe, & Malone, 2017). In this study, the standard deviation of ROA is computed by using a rolling window of four years, which makes sense because the lending pattern and risk profile may change over time (Delis, Tran, & Tsionas, 2012). The relationship of bank risk with efficiency depends on various features of the bank, however, a positive relationship is expected between Z-score and efficiency, which means that banks with lower risk should have better operational efficiency.

Loan Losses

This is a measure of a bank's credit risk, which is the ratio of loan loss expenses to total loans in each financial year. A bank with a higher ratio of loan loss expenses to total loans is considered to be more at risk, which in turn might affect the efficiency of the bank. An increased amount of NPLs can increase bank costs related to monitoring, collection, write-offs, or the selling of bad loans that may negatively affect the cost efficiency of the bank (Altunbas, Carbó-Valverde, Gardener, & Molyneux, 2007; Berger & DeYoung, 1997). Higher loan loss expenses can affect the profit efficiency of a bank while lowering net income. But the skimping hypothesis has proposed a positive relationship between loan losses and cost efficiency in the short run. Here, the critical decision for the bank lies in the trade-off between short-term operating costs and future loan losses. A bank may choose to reduce costs on the resources devoted to underwriting and monitoring of loans in order to maximize profits, and it may bear the consequences of higher loan losses in the future (Berger & DeYoung, 1997). A positive relationship between loan losses and profit efficiency can be found in the existence of the "moral hazard" hypothesis. In this case, banks with relatively low capital, high profitability, or low market share respond by lowering their underwriting standards to increase their lending portfolio. This may result in higher loan losses but may be less than the benefit of growth in the lending portfolio and its contribution to interest revenue (Berger &

DeYoung, 1997; Bikker & Vervliet, 2018). Overall, a negative relationship between loan losses and bank efficiency is expected in this study.

Loans-to-Assets Ratio

The ratio of total loans to assets can be considered a proxy for liquidity as well as earnings stability. A high ratio of total loans to total assets means a low liquid position for a bank because loans are among the most illiquid assets (Xiang et al., 2015). Low liquidity might have a dual impact on a bank: first, an illiquid bank might face emergency borrowing at a higher interest rate to meet its obligations, and second, it might face bank runs, forcing it to fail even though it might be solvent. Loans are a source of stable revenue and higher returns compared to liquid assets for a bank. The maintenance cost of loans is lower relative to investments once underwritten, so it can be a major source of profit for the bank (Dietsch & Lozano-Vivas, 2000). Moreover, the value of loans is not highly fluctuating, so it stabilizes the balance sheet of a bank. The relationship of this ratio with bank efficiency depends on the role of loans on the balance sheet of the bank, whether as a source of illiquidity or revenue.

Equity Ratio

This is the ratio of equity capital to total assets, which is the proxy for the financial insolvency risk of a bank. It is argued that insolvency risk influences the cost and profits of banks through the higher risk premium that must be paid by banks to borrow, and through the costs involved with risk management activities. In other words, the equity ratio should have a positive effect on bank cost and profit efficiencies; however, the effect of the equity ratio may turn negative because the cost of raising equity capital is higher than debt. Moreover, a higher level of equity can increase agency costs and lower the performance of banks (Berger & Di Patti, 2006; Cummings & Wright, 2016; Dietrich &

Wanzenried, 2011). Therefore, the relationship between equity ratio and bank efficiency is difficult to predict. It is also being tested for the enhanced level of equity capital for banks under Basel III. However, most prior studies have found a positive relationship between equity ratio and bank efficiency (Altunbas et al., 2007; Pessarossi & Weill, 2015; Vu & Turnell, 2011).

3.2.3 Banking Market Structure and Bank Efficiency

The role of the banking market structure in the performance or efficiency of an individual bank or the banking sector is well recognized in prior studies (Berger, 1995; Casu & Girardone, 2009; Goetz, 2018). Studies on the relationship between banking market structure and efficiency are based on theories that explain the relationship between market concentration, power, and bank efficiency or performance (Maudos & de Guevara, 2007). Banking structures of many countries have changed significantly since the GFC, especially in the countries selected for this study (Berger et al., 2015; Brown et al., 2015; Wheelock & Wilson, 2018). Therefore, it is very important to review various banking market structure theories and include some banking market structure variables in this study according to the banking environment of the chosen countries.

The background of the banking market structure comes from industrial organization literature, which has reported a positive impact of market competition on fostering efficiency, service quality, innovation, and international competitiveness (Claessens & Laeven, 2004). The widespread positive impact of market competition on industrial organizations persuaded the governments of many developed and developing countries to introduce reforms in their financial sectors for promoting greater competition. A more competitive banking market structure is expected to lead to reduced costs, enhanced efficiency, higher service quality, and heterogeneous products (Claessens &

Laeven, 2004). All these outcomes of a competitive banking market structure would result in better financial performance and stability for banks. However, recent research has indicated that the relationship between market competition and performance is more complex and ambiguous in the financial sector than in other sectors (Atkins, Li, Ng, & Rusticus, 2016). Prior studies have tested and developed numerous hypotheses to investigate the relationships between market structure variables and bank performance or efficiency. The key study hypotheses are structure-conduct-performance (SCP) hypothesis (Bain, 1951), quiet life hypothesis (QLH) (Hicks, 1935), relative-market-power (RMP) hypothesis (Clark, 1988), and the efficient-structure (ES) hypothesis (Demsetz 1973).

The traditional SCP hypothesis asserts that increasing concentration may result in imperfect competition in a market because of the absence of effective market supervision, and this may give banks power to increase the prices of their products and services (Berger, 1995; Färe, Grosskopf, Maudos, & Tortosa-Ausina, 2015). It is evident from the prior studies that higher concentration may result in lower deposit rates and higher lending rates. Therefore, it is believed that the existence of imperfect competition may not be beneficial for banks, consumers, and the economy over the long run. Bank managers in concentrated markets increase the prices of their outputs as well as their spending, which may result in higher costs as well as higher prices for bank outputs (Berger & Hannan, 1998).

An increase in the output prices above the competitive level and greater spending on non-productive activities may result in a negative relationship between market power and bank efficiency. This negative relationship is called QLH (Hicks, 1935). One reason for this negative relationship may be insufficient efforts by managers to control costs. The second can be the unnecessary benefits for managers as rewards for increasing the bank revenues. Third, a decrease in market competition may tempt managers to engage in more non-profit-maximizing activities than under conditions of perfect competition. Fourth, managers may use available resources to maintain and obtain additional market power such as lobbying or entry and exit barriers. Fifth, imperfect competition and higher bank power may allow managerial incompetence to persist without any willful effort to improve firm efficiency, allowing such managers to enjoy a "quiet life" (Berger & Hannan, 1998; Färe et al., 2015; Koetter, Kolari, & Spierdijk, 2012).

The RMP hypothesis is based on the concept of scale economies (Clark, 1988). It is applicable to banks with large market shares and equally good management and technology. These banks will be able to lower their unit costs while charging market prices, which may result in higher unit profits. These banks stand in a better competitive position relative to other market players; as a result, their market shares increase and the market becomes more concentrated (Berger, 1995). In this case, there will be a positive relationship between market concentration and bank efficiency, but it will be applicable only to high market share banks; otherwise, it may show a very weak relationship (Berger, Demirguc-Kunt, Levine, & Haubrich, 2004).

The ES hypothesis postulates that a positive relationship between bank performance and concentration is due to better X-efficiency (Leibenstein, 1966). The better efficiency of banks is achieved through superior management, better production technology, and product innovation, which combined may lead to further market concentration and bank power (Berger, 1995). This hypothesis predicts a reverse causality between market competition and bank efficiency (Demsetz 1973). The best-managed firms have the lowest costs and consequently the largest market share, which leads to a higher level of market concentration. There are two possible reasons for this better efficiency: First, competition persuades managers to exert more effort to improve firm performance; otherwise, their firm will not able to survive in the market. In the case of improved firm performance, managers get better incentives; thus, they are motivated for better incentives and to secure their jobs. Second, shareholders evaluate the performance of their firms relative to others in competitive markets. Therefore, they provide the best production technology to the firm so they can better assess managerial performance and make changes in management if necessary (Pruteanu-Podpiera, Weill, & Schobert, 2008). During this reverse causality, inefficient banks will disappear, and the market will be taken over by efficient banks, which should be beneficial for both the banking sector and the economy.

Many important papers have tested the relationship between market structure and bank efficiency, but it is difficult to draw a decisive conclusion from a review of recent literature because of the varying results of these studies. The reasons behind the variation in results are identified as their different methodologies, time frames, and geographies (Beck et al., 2013). Most of the initial studies on the relationship between market structure and bank performance faced three challenges: the first was the selection of appropriate variables to define the market structure and evaluate bank performance; the second was the selection of a valid model to assess the relationship between the selected variables; the third was to find a suitable explanation of the relationship between the selected variables (Berger et al., 2004). Explaining the negative relationship between market concentration and bank performance is relatively easy, however, the positive relationship may fall under any of the given hypotheses. Many recent studies have overcome these challenges by introducing additional measures of market competition, bank power, bank performance, and non-traditional estimation models such as frontier analysis.

In one of the pioneer studies on bank efficiency and market structure, Berger (1995) used the variables of market share, concentration, and X-efficiency in three regression models to test the existence of four different hypotheses on market conduct and performance. He used extensive data of 12,000 US financial institutions to estimate cost efficiency, profitability, market concentration, and deposit growth, covering the ten years of the 1980s. He found limited support for the ES and RMP hypotheses but found a positive relationship between market concentration and cost efficiency.

Later studies by Maudos & de Guevara (2007), Casu & Girardone (2009), and Koetter et al. (2012) reported a positive relationship between bank market power and cost efficiency. These studies used the Lerner Index as a measure of market power and HHI as a measure of market concentration or competition. They estimated the relationship among these variables in different regression models, in the presence of some bank-level and macroeconomic variables. Results were estimated for a large sample of EU and US commercial banks. Similar results were reported by later studies that included banks in both developed and developing countries (Färe et al., 2015; Kasman & Carvallo, 2014; Schaeck & Cihák, 2014; Weill, 2013). One such study by Schaeck and Cihák (2014) concluded that competition incentivizes banks to improve efficiency as it reallocates profits from inefficient banks to efficient ones, and this, in turn, may increase market concentration and power.

Conversely, many studies have supported the earlier results of Berger and Hannan (1998), which were consistent with the QLH, with a negative relationship between cost efficiency and market concentration (Atkins et al., 2016; Fu, Lin, & Molyneux, 2014a; Pruteanu-Podpiera et al., 2008; Restrepo-Tobón & Kumbhakar, 2014). These studies have also reported a negative impact of market concentration and power on banks' financial stability. Atkins et al. (2016) found that banks facing less competition are more likely to engage in risky activities, face more regulatory interventions, have higher loan losses, and fail. Fu et al. (2014a) studied 14 Asia-Pacific economies from 2003 to 2010 and found that greater market concentration fosters financial fragility and lesser bank power, which encourages banks to take more risk. Restrepo-Tobón and Kumbhakar (2014) estimated the Lerner Index and HHI of US commercial banks for the period of 1976 to 2007. They used both market structure variables in alternative profit and cost efficiency frontier models and found that cost efficiency has a negative relationship with the Lerner index but a positive one with HHI; however, they found a positive relationship between the Lerner index, HHI, and alternative profit efficiency. They suggested this was due to the QLH, according to which bank managers spend more in concentrated markets with less competition and make a profit by setting higher prices of outputs.

Although Färe et al. (2015) found a positive relationship between market power and bank efficiency, their results were not consistent for different estimation models and study samples. They concluded that the relationship between market power and efficiency is not linear, which indicates that the impact of market power on efficiency varies for each firm. Similar heterogeneity in the impact of market competition on bank performance and stability has been reported by a few other studies (Beck et al., 2013; Martinez-Miera & Repullo, 2010). Beck et al. (2013) suggested that understanding the market, bank characteristics, and the regulatory and institutional frameworks are critical in gauging the effect of competition on bank performance and stability. Many prior studies have also discussed the role of bank size or share in shaping the relationship between market power or competition and bank efficiency (Beck et al., 2013; Berger, Klapper, & Turk-Ariss, 2009; Xiang et al., 2015). The RMP hypothesis implies that bigger banks have relatively more market power and scale economies, which can help them become more efficient

(Wheelock & Wilson, 2018). These prior studies have concluded that the relationship between bank size and efficiency may vary for different bank sizes, time periods, and countries.

As discussed earlier, several indicators such as HHI, Panzar-Rosse Statistic, Lerner index, Tobin's q, and the Boone Indicator have been used in prior studies to measure the banking market structure. Each of these has its own strengths and weaknesses: some are more inclined toward measuring market competition and others toward market power; some are direct measures and others are indirect. This study has included three well-recognized variables of market structure in its estimation models. The Lerner index is used to measure bank market power, HHI to measure market concentration, and total assets to measure bank size. A substantial impact of the GFC is expected on all three variables because of the merger and acquisition activities in selected countries during and after the GFC. Moreover, a significant relationship is expected between market structure variables and bank efficiency.

Lerner Index

The Lerner index represents the markup of price over the marginal cost that a bank may set for its customers, which is the indicator of its market power. It is calculated as follows:

$$Lerner_{it} = (P_{TAit} – MC_{TAit})/P_{TAit} \qquad (3.2)$$

Here P_{TAit} is the price of total assets proxies by the ratio of total revenue to total assets for bank *i* at time *t*, and MC_{TAit} is the marginal cost of the total assets for bank *i* at time *t*. The resulting $Lerner_{it}$ has averaged over the study period for each bank *i*. The MC_{TAit} is derived from the following translog cost function:

$$\ln TC_{it} = \beta_0 + \beta_1 \ln Q_{it} + \beta_2 \frac{1}{2} \ln Q^2_{it} + \sum_{j=1}^{2} \alpha_{jt} \ln w_{jit} + \frac{1}{2} \sum_{k=1}^{2} \sum_{j=1}^{2} \alpha_{kj} \ln w_{kit} \ln w_{jit} + \sum_{j=1}^{2} \delta_j \ln Q_{it} \ln w_{jit} + \gamma_t t + \varepsilon_{it} \quad (3.3)$$

Here Q_{it} is a proxy for bank output or total assets for bank *i* at time *t*, and w_{jit} is a vector of three input costs that indicate the price of labour, borrowed funds, and fixed assets respectively. The price of labour is the ratio of total personnel expenses to total number of employees; the cost of borrowed funds is the ratio of total interest expenses to total liabilities, and price of fixed assets is the ratio of operating expenses except personnel expenses to net fixed assets. The time trend *t* is included to capture the influence of technological changes leading to shifts in the cost function over time. The variables of the total cost *(TC)*, total assets *(Q)*, and two inputs (w_1, w_2) are normalized by the price of funds (w_3) to impose a linear homogeneity on the model. Furthermore, *TC, Q*, and all inputs are normalized with total equity to reduce the bias from differing bank sizes.

The marginal cost *(MC)* is then computed using the following equation:

$$MC_{TAit} = Cost_{it}/Q_{it} \left[\beta_1 + \beta_2 \ln Q_{it} + \sum_{j=1}^{2} \delta_j \ln w_{jit}\right] \quad (3.4)$$

The outcome of equation 3.4 is used in equation 3.2 to calculate the Lerner index for each year *t* of all banks, which is then used in the one-stage SFA model to test its association with bank efficiency. A higher value of the Lerner index indicates higher market power for the bank to set prices of its products and services, which is likely to reflect lower competition in the given banking industry of the country.

Although the annual Lerner index is estimated for each bank, it cannot be used in the estimation model if the estimated value is negative. The estimation model for this study required logged values of each variable, and the natural log of negative values cannot be taken. Therefore, the average annual Lerner index is calculated for each country over the study period. The MC and efficiency scores are estimated with similar translog equations, which may give rise to the problem of simultaneity (Koetter et al., 2012). Although variables, estimation models, and estimation processes are different for both the outcomes, there are chances of a simultaneity problem because of the similar functional forms and the similarity in some variables. Another option is to use World Bank data of the Lerner indices for each country, which is partially available for Australia, New Zealand, and the UK, and fully available for Canada and the United States. The World Bank data for the Lerner index for Canada and the United States is substituted in estimation models for robustness, and consistent results are obtained. Another alternative measure is Tobin's q (Keeley, 1990), but this cannot be estimated for New Zealand's unlisted banks.

Herfindahl-Hirschman Index

The HHI is the sum of the squared market share of each bank in the system and applies to the system as a whole. This study has calculated the market share of each selected bank in a given country on the basis of the assets held at the end of its financial year. A lower HHI score represents low concentration in the given banking industry and a higher HHI is a sign of higher market concentration. It accounts for the relative market share of each bank and market concentration, which makes it superior to the traditional concentration ratio. Banks operating in a more concentrated market are expected to generate more profits because of lower competition, and to form a positive relationship with bank efficiency (Demsetz 1973). On the other hand, this relationship may turn to the negative with bank efficiency if bank management spends more on staff and other non-productive activities (Berger & Hannan, 1998). The possible implications of the analysis results of this study are discussed with reference to prior literature in the next chapter.

Bank Size

Bank size is measured by taking the logarithm of total bank assets measured in millions of US dollars to account for a possible non-linear relationship between bank inefficiency and bank size. Although a positive relationship between bank size and efficiency is expected, it may turn negative. A positive relationship implies that larger banks are able to attract cheaper capital, to grow into different business ventures, to attract and retain better managers, and to achieve economies of scale (Berger et al., 2015). A negative relationship means that larger banks have higher overhead costs, loan losses, and more moral hazard cost of management, which is consistent with diseconomies of scale.

The size of banks has increased very rapidly in the past couple of decades, owing to deregulation in many countries (Berger, DeYoung, Genay, & Udell, 2000; Wheelock & Wilson, 2012). Initial literature generally did not find scale economies in financial institutions, but later studies have found economies of scale in many financial institutions (Berger & Mester, 1997, 2003). On one side, the growing size of banks was providing scale economies. On the other side, there were concerns for researchers and policymakers because of the potential cost to the economy in the form of TBTF banks and reduced competition in the market (Berger et al., 2015; Boot, 2017). Most recent studies have pointed out the exhaustion in scale economies for large US banks in the post-GFC period (Wheelock & Wilson, 2018). The relationship between bank efficiency and total assets is explored in this study, while using recent data sets to comment on the consequences of the growing bank size and its role in the varying impacts of the GFC.

3.3 Bank Efficiency and Shareholder Value

During the last half-century, the global banking industry has been transformed by financial technology developments, product innovations, prudential regulations, internationalization, and changes in corporate behavior (Fu et al., 2014b). Currently, most stocks of financial institutions are held by sophisticated and institutional investors. A competitive market and shareholder pressure have progressively driven banks to strategically focus on the shareholders' value maximization. The GFC further accelerated these pressures, and banks were expected to practice better risk-management and asset-utilization besides performing well. In the post-GFC period, regulators have forced banks to raise more capital, hold more liquidity, and refrain from capital-costly activities (Fu et al., 2014b). This phenomenon has created a dual challenge for banks in maximizing shareholder value. First, higher capital and liquidity levels have increased banks' costs. Second, the restraint of banks from capital-costly activities such as lending, and investment banking has reduced their profitability. Although many studies have investigated the relationship between bank efficiency and shareholder value before the GFC (Beccalli, Casu, & Girardone, 2006; Chu & Lim, 1998; Fiordelisi, 2007; Fiordelisi & Molyneux, 2010; Kirkwood & Nahm, 2006), only one has investigated the post-GFC period (Fu et al., 2014b), to the best knowledge of the researcher.

There are numerous prior studies on bank efficiency as well as on shareholder value, however, the literature on both aspects has been developed separately for a long time. Most initial bank efficiency studies were focused on the improvement of methodology, comparison of estimation approaches, and sources of bank inefficiency (Berger & Humphrey, 1997; Berger, Hunter, & Timme, 1993; Dietsch & Lozano-Vivas, 2000; Kumbhakar, Lozano-Vivas, Lovell, & Hasan, 2001; Resti, 1997). These studies introduced bank efficiency as a comprehensive and sophisticated measure of bank performance (Berger & Humphrey, 1997). On the other hand, studies on shareholder value were focused on the development and comparison of new measures of shareholder value, relationship between the market and accounting-based value measures, and determinants of shareholder value or firm performance (Barth, Beaver, & Landsman, 2001; Liu & Ohlson, 2000; O'Hanlon & Peasnell, 1998). Meanwhile, a question was raised through a few studies about the superiority of bank efficiency as a measure of performance and its relationship with shareholder value or stock performance of banks (Beccalli et al., 2006; Chu & Lim, 1998; Fiordelisi, 2007).

A study by Chu and Lim (1998) claimed to be the first one to link bank efficiency with market returns. Chu and Lim used the DEA approach to estimate the cost and profit efficiencies of 220 banks operating in Singapore over the period of 1992 to 1996. Next, they regressed these efficiency scores with the annual change in the share price of banks and also explored correlations among both estimates. They were motivated by the earlier studies that had claimed that stock prices incorporate all relevant publicly available information in informationally efficient stock markets, and efficiency scores are estimated with published accounting data. Therefore, a good bank efficiency estimate should be relevant to the stock price in any informationally efficient stock market. Chu and Lim (1998) reported that change in profit efficiency reflects the change in the share price of a bank, but they found no relation between cost efficiency and share price (Chu & Lim, 1998). Many later studies also supported their conclusion that shareholders are more interested in bank profit as a source of more dividends (Beccalli et al., 2006; Fu et al., 2014b; Pasiouras, Liadaki, & Zopounidis, 2008).

The study by Becalli et al. (2006) focused on similar objectives but concluded that the stocks of cost-efficient banks outperform those of their inefficient counterparts. They regressed the stock performance with a change in cost efficiency, estimated with parametric and non-parametric approaches, as well as with accounting ratios. The study was based on publicly listed banks of major European countries for the years 1999 and

2000. They concluded that both parametric and non-parametric efficiency estimates were positively related to the stock performance of banks, but the selected accounting ratios were not able to significantly explain stock returns. Moreover, the stochastic frontier efficiency estimates were more accurate in explaining the moment of stock price returns (Beccalli et al., 2006).

Meanwhile, efficiency estimation approaches were further improved, and Fiordelisi (2007) introduced the concept of shareholder value efficiency. He first used a parametric approach to estimate cost, profit, and shareholder value efficiency for listed banks of four major EU economies over the period of 1997 to 2002. In the second step, he explored the correlation between traditional bank efficiency estimates and shareholder value efficiency. The results showed no significant relationship between cost, profit, and shareholder efficiencies, however, all efficiency estimates found a positive and significant association with other measures of shareholder value (Fiordelisi, 2007). A later study by Fiordelisi and Molyneux (2010) extended the literature on the relationship between bank efficiency and shareholder value using similar efficiency measures. They explored potential determinants of shareholder value and bank efficiency besides seeking the association between these bank performance measures. The relationship between bank performance measures and its determinants was explored with the help of correlation, regression, and Granger-causality tests. They found a positive and significant relationship between bank efficiency and shareholder value, with the variables of loan losses, financial leverage, bank size, and liquidity identified as major determinants of the shareholder value (Fiordelisi & Molyneux, 2010).

In a more recent study, Fu et al. (2014b) investigated the relationship between the shareholder value and bank efficiency for 274 commercial banks of 14 Asia-Pacific economies between 2003 and 2010. This study investigated the impact of the GFC on the relationship of bank efficiency with accounting- and market-based shareholder value measures. The authors of this study observed a significant impact of the post-GFC regulatory and economic reforms on the banking environment; therefore, they expected a change in the relationship between shareholder value and bank efficiency in the selected economies. They regressed accounting and market-based shareholder value measures with cost and profit efficiencies in the presence of some control variables. The results indicated a positive relationship between profit efficiency and stock returns, however, cost efficiency was found to take more time to be reflected in the shareholder value, consistent with earlier studies (Beccalli et al., 2006; Fiordelisi & Molyneux, 2010; Fu et al., 2014b).

It may be concluded from prior literature that shareholder value has a strong relationship with profit efficiency but its relationship with cost efficiency is based on "time dynamics." As mentioned earlier, the literature on the relationship between bank efficiency and shareholder value is relatively sparse and new. As a result, there is a need to further investigate this relationship in different banking markets with improved measurement approaches to capture time and location dynamics. Most prior studies have used two- or three-stage approaches to measure bank efficiency and its determinants, which is widely criticized by some later studies (McDonald, 2009; Simar & Wilson, 2007; Wang & Schmidt, 2002). The changes in the banking environment of many developed countries have been recognized after the GFC (Fu et al., 2014b; Wheelock & Wilson, 2018), and only one study investigated the relationship between bank efficiency and shareholder value, based on 14 Asia-Pacific economies. Therefore, this study uses more appropriate econometric models to explore the relationship between bank efficiency and shareholder value in five developed economies of the world in the post-GFC period.

Details of the selected models and variables are discussed in the next chapter. It is expected that the findings of this study will further extend the literature on the relationship between bank efficiency and shareholder value.

3.4 Summary and Conclusion

Using accurate and modern techniques for the assessment of banks is essential to ensure a healthy financial system together with an efficient economy. It is concluded in this chapter that frontier analysis is one of the most sophisticated and comprehensive approaches to benchmark relative performances of the banks (Berger & Humphrey, 1997). There are two major benefits of a frontier analysis: First, its outcomes are understandable for any person with little institutional knowledge because it gives one economic value. Second, it helps the management team identify their areas of best practice, which can help improve operations. The use of frontier analysis in banking literature started in the early 1980s to measure the performance of commercial US banks (Berger et al., 1993). Widespread use of frontier analysis models in economics and management sciences was noticed by Bauer (1990), who identified three main reasons for their popularity. First, he found that the frontier analysis is consistent with the underlying economic theory of optimizing behavior. Second, the deviation from a frontier has a natural interpretation as a measure of efficiency for units to pursue their behavioral objectives. Finally, information about the structure of the frontier and the relative efficiency of economic units has many policy implications (Bauer, 1990). There is now widespread use of both parametric and non-parametric frontier analysis approaches to measuring efficiency in economics and management sciences.

Most of the initial bank efficiency studies were based either on branches of a single bank or on banks of a single country, however, a trend of cross-country studies started in later years. The importance of research on bank efficiency is recognized all over the world, and therefore studies have been conducted on most of the major economies. All studies have made some contribution to the information about bank efficiency, however, some prominent studies have identified a lack of cross-country studies (Berger & Humphrey, 1997; Xiang et al., 2015). The reasons behind this lack are methodological challenges, selection of appropriate countries, and difficulties with getting the required data. Despite these challenges, the need for cross-country studies exists. Moreover, the need to assess bank efficiency has become obligatory after economic shocks such as the GFC. Although the GFC originated in the United States, its impacts were felt by most of the developed and emerging economies; however, the impact was asymmetrical among many close-knit developed economies (Calomiris & Haber, 2014; Claessens, Dell'Ariccia, et al., 2010).

Over time, tremendous improvements have been made in the frontier analysis estimation approaches, functional forms, selection of appropriate variables, and analysis methods. A review of prior literature has identified a need for cross-country bank efficiency studies while using improved frontier analysis methods. Furthermore, a set of banking environment variables need to be explored to assess the impact of the GFC on bank efficiency. The present study uses an improved methodology and some new banking environment variables to assess the impact of the GFC on bank efficiency in five developed economies. Details of the selected frontier analysis models and estimation techniques are provided in the next chapter.

Chapter 4

RESEARCH METHODOLOGY

This chapter explains the theoretical framework of frontier analysis, its different measurement and estimation techniques, and the selected bank efficiency models. It also describes the data used to estimate bank efficiency and the selection of inputs, outputs, and potential determinants of bank efficiency. The remainder of this chapter is divided into four major sections: section 4.1 briefly discusses the theoretical framework of a frontier analysis and its measurement techniques; section 4.2 explains different models of the SFA approach and introduces the SFA models to estimate cost, alternative profit, profit, and shareholder value efficiency for panel data in this study; section 4.3 provides the description and sources of data being used to estimate efficiency and its determinants; the last section summarises the research methodology of this study.

4.1 Frontier Analysis

Performance analysis of production units is vital for the stakeholders and the future of those units. The economic performance of units is commonly described as being more or less "efficient" or "productive." The terms productivity and efficiency are often used interchangeably in media, but they are not the same things. The productivity of a unit means the ratio of its outputs to inputs. It is easier to calculate this ratio for a unit that produces single output from a single input than for a unit that produces several outputs from several inputs. In the latter case, the outputs and inputs must be aggregated in some economically sensible manner such that the measure of productivity remains the ratio of two scalars (Fried, Lovell, & Schmidt, 2008; Kumbhakar & Lovell, 2000). The difference between the output growth and input growth is called productivity growth, which may vary across producers and time. This variation in productivity is characterized as ignorance of the producer or residual (Abramovitz, 1956). In principle, the residual can be attributed to the differences in the scale of operations, production technology, operating efficiency, and the business environment of units (Fried et al., 2008). The business environment of a unit is not under the control of the producer, but the other three are controllable and can optimally be used to reduce productivity variations or increase efficiency.

The measure of efficiency compares the observed and optimal values of the outputs and inputs. An initial measure of technical efficiency was introduced by Farrell (1957), which drew upon the work of Debreu (1951) and Koopmans (1951). These studies defined a firm's efficiency as the radial distance of its real performance to a frontier of the best possible performances (Debreu, 1951; Koopmans, 1951); however, some non-radial measures of efficiency have also been developed for various purposes (Chambers, Chung, & Färe, 1996; Charnes, Cooper, Golany, Seiford, & Stutz, 1985; Färe & Lovell, 1978).

Efficiency can be measured by comparing the observed output to the maximum potential output obtainable from a given input, or by comparing the observed input to the minimum potential input required to produce a given output, or by some combination of the two (Farrell, 1957; Fried et al., 2008). In these comparisons, the optimum can be defined according to the behavioral goals of the producer, and if the optimum is expressed in terms of the value, then it is called economic efficiency (Greene, 2008). Allocative and technical efficiencies combine to provide an overall economic efficiency measure. The allocative efficiency reflects the ability of a firm to use the inputs in optimal proportions in light of the prevailing prices and production technology (Coelli et al., 2005). The technical efficiency refers to the ability to avoid waste, either by producing as much output as allowed by the technology and input usage, or by using as little input as required by technology and output production (Fried et al., 2008). Thus, an analysis of the technical efficiency can have either an output maximization or an input minimization orientation. Therefore, defining and measuring economic efficiency requires the specification of an economic objective and information of relevant prices.

The concepts of allocative, technical, and economic efficiencies are explained with Farrell’s (1957) input-oriented perspective of efficiency in Figure 4.1. A firm is considered here, which uses two inputs, X_1 and X_2, to produce a given output q, under the assumption of constant returns to scale (CRS). The curve SS' in Figure 4.1 represents various combinations of inputs X_1 and X_2 by which an efficient firm can produce a given output q. This isoquant is based on the points of minimum utilization of both inputs to produce a fixed output. Therefore, a firm can be considered technically efficient if it uses the combination of inputs located on the curve SS' to produce a given output. The firms that are above the curve are considered inefficient, which means they are using more inputs to produce the given output. The distance QP for a firm at point P is its technical inefficiency on the ray OP. This technical inefficiency can be expressed by the ratio QP/OP, which refers to the percentage by which all inputs need to be reduced in order to reach the technically efficient point Q for this firm. The value of this ratio lies between 0 and 1, with the value 1 for a technically efficient firm at any point on the efficiency frontier isoquant SS´. The value will get closer to 0 the further it moves away from the curve SS´(Coelli et al., 2005).

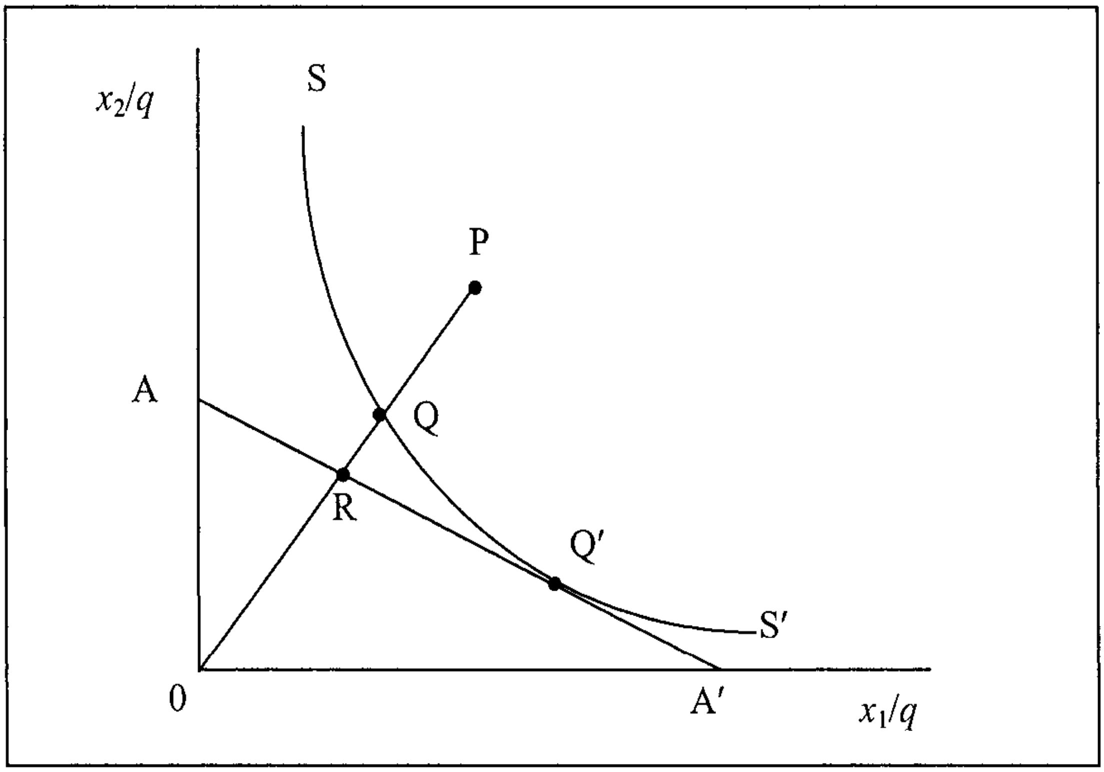


Figure 4.1 Technical and Allocative Efficiencies (Input-oriented)

The allocative efficiency (AE) is illustrated in Figure 4.1 by line AA´. It represents the cost-minimizing line, and its slope represents the input price ratio. The distance RQ is the allocative inefficiency and the ratio of OR/OQ is AE. A firm needs to reduce its production costs by RQ to move from a technically but not allocatively efficient point Q to point Q´, a technically and allocatively efficient point. The measures of TE and AE can be estimated as follows:

$$AE = \frac{W'X''}{W'X'} = \frac{OR}{OQ} \qquad TE = \frac{W'X'}{W'X} = \frac{OQ}{OP} = 1/d_i(x,q) \qquad (4.1)$$

Here, W is the vector of input costs and X is the vector of inputs associated with point P. The input vectors of x´ and x´´ are associated with the technically efficient Q and cost-minimizing Q´, respectively. The input-oriented measure of TE may also be expressed in terms of input-distance function $d_i(x, q)$. Now we may calculate the economic efficiency once we have the price information of inputs. The measure of cost efficiency (CE) can be estimated from the ratio of the input costs associated with points P and Q, which may be expressed as follows:

$$CE = \frac{W'X''}{W'X} = \frac{OR}{OP} \qquad (4.2)$$

As discussed earlier, the combination of TE and AE is called the total economic efficiency. The total CE may be obtained as a product of TE and AE, as follows:

$$CE = TE \text{ x } AE = \frac{OQ}{OP}\, X\, \frac{OR}{OQ} = \frac{OR}{OP} \qquad (4.3)$$

CE is the production of a certain output level with the minimum input cost, and this too takes a value between 0 and 1. The firm with CE value 1 will be considered fully cost-efficient. Further details of cost efficiency are discussed in the later sections of this chapter.

The other perspective of efficiency is the maximization of the output with the given amount of inputs, which is called the output-oriented efficiency. The difference between the output- and input-oriented efficiency measures is illustrated in Figure 4.2, which is based on a case where two outputs (q_1 and q_2) are produced from a single input (x) under the assumption of CRS. The unit production curve DD´ represents the maximum combinations of q_1 and q_2 that can be produced using given input amounts. Every technically efficient firm must be on curve DD´, and all firms below this curve should be considered technically inefficient. In Figure 4.2, a firm at point A is using the same amount of inputs as a firm at point B, but it is producing a lower output. The distance of

AB is the level of TE for the firm at point A, which is the amount of output that could be increased without requiring extra input.

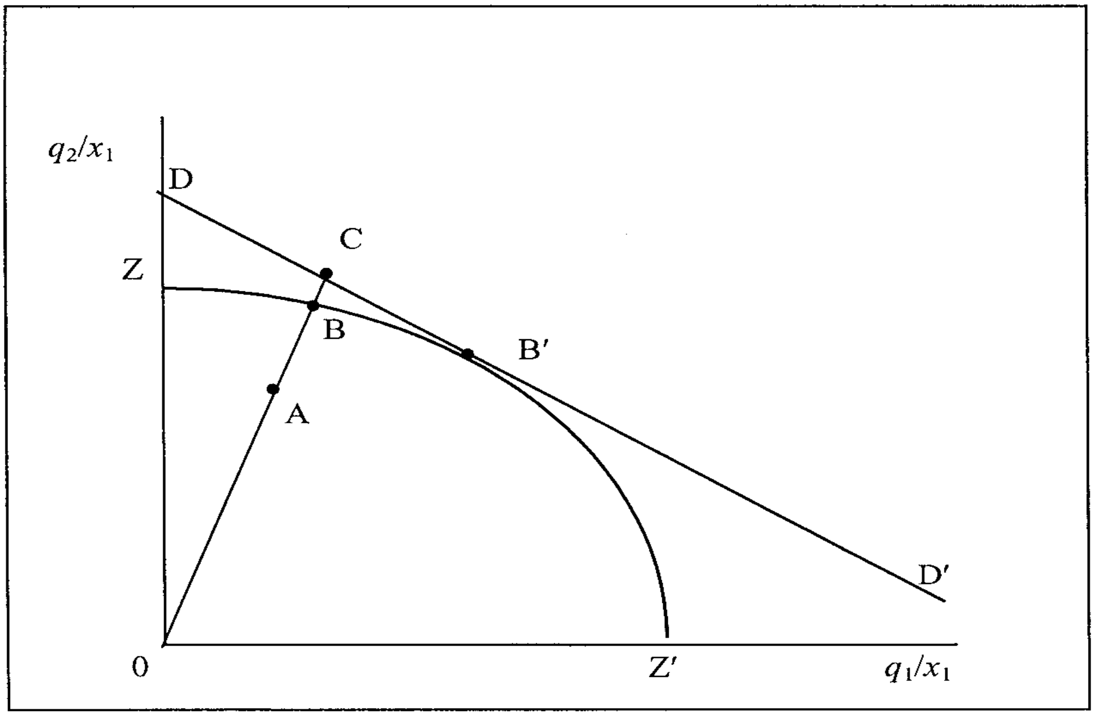


Figure 4.2 Technical and Allocative Efficiencies (Output-oriented)

The ratio of output-oriented TE can be expressed as follows:

$$TE = \frac{OA}{OB} = d_o(x,q) \qquad (4.4)$$

An iso-revenue DD′ is drawn in Figure 4.2 in the presence of output prices, which is necessary to calculate the AE ratio of OB/OC. Farrell's efficiency measures of TE and AE can be expressed as follows in the presence of output prices:

$$AE = \frac{p'q'}{p'q''} = \frac{OB}{OC} \qquad TE = \frac{p'q}{p'q'} = \frac{OA}{OB} = d_o(x,q) \qquad (4.5)$$

Here, *p* represents the output prices and *q*, *q*′, and *q*′′ represent output vectors of the firms associated with point A, B, and B′ respectively. This information may also be used to estimate revenue efficiency (RE) as follows:

$$RE = \frac{p'q}{p'q''} = \frac{OA}{OC} \qquad (4.6)$$

Equation 4.6 can also be expressed as the product of TE and AE to estimate total RE as follows (Coelli et al., 2005):

$$RE = TE \text{ x } AE = \frac{OA}{OB} \, X \, \frac{OB}{OC} = \frac{OA}{OC} \qquad (4.7)$$

Profit efficiency (PF) can now be calculated by combining equations 4.7 and 4.3, considering both cost and revenue efficiencies. A profit-efficient firm produces the maximum revenue from the given input and output prices while maintaining the production process at the lowest cost level. In profit efficiency, a firm has some given input and output prices and it needs to achieve an optimal level of production that can give it the maximum profit. Further details of profit efficiency are discussed in the later sections of this chapter.

A technically and allocatively efficient firm may not have an optimal scale of operations that can be the source of scale inefficiency. The input-oriented and output-oriented concepts of technical and allocative efficiencies are shown in Figures 4.1 and 4.2 with the assumption of constant-returns-to-scale (CRS), which may not always hold. The issue of scale efficiency is not applicable in the case of CRS, however, it is applicable for the firms using a variable-returns-to-scale (VRS) technology. In the case of VRS technology, the firm involved may be too small in its scale of operations and might fall within the increasing returns-to-scale part of the production function. Conversely, a too-large firm may operate within the decreasing returns-to-scale part of the production function. In both of these cases, the efficiency of a firm might be improved by changing the firm's scale of operations while keeping the same input mix. The level of scale economies may also differ for producing two or more products jointly relative to producing the same products separately (Debreu, 1959; Panzar & Willig, 1977).

The concept of efficiency or productivity is based on the production theory of neoclassical economics, which can be estimated with econometric as well as mathematical techniques. An econometric approach can be used to estimate the economic frontier and measure the efficiency relative to that frontier. Various modifications have been introduced and implemented in conventional econometric techniques during the last three decades to improve the efficiency estimation (Fried et al., 2008). In sharp contrast to the econometric techniques, mathematical programming techniques are inherently enveloping techniques, so they require little or no modification to be used in efficiency estimation (Charnes et al., 1978; Førsund & Sarafoglou, 2002).

A mathematical programming technique is nonparametric, which does not require restrictive assumptions about the functional form of the underlying production frontier. A key drawback of this approach, among many others, is that it generally assumes that there is no random error, which means no measurement error in constructing the frontier, no inaccuracies created by accounting, and no luck that temporarily gives a decision-making unit (DMU) better- or worse-measured performance in any particular year (Bauer, 1990; Dyson et al., 2001). Such errors in the data or the estimation process may lead to errors in the resultant inefficiency. Moreover, errors in one unit may affect CE scores of all other units (Greene, 1993). Therefore, the existence of any of these errors may produce biased efficiency scores if the random error is not separated from the estimated score.

Many nonparametric approaches have been developed over time to improve the accuracy and reliability of this technique. The two main and frequently used nonparametric approaches are DEA (Data Envelopment Analysis) and the FDH (Free

Disposal Hull). DEA is a mathematical programming technique, which generates a comparative ratio of weighted outputs to inputs for each DMU. This technique was initially developed by Charnes, Cooper, and Rhodes (1978). It envelops data by constructing a piecewise linear convex production possibility set, and estimates the efficiency score of each DMU relative to best-practice production possibilities set (Charnes et al., 1978). The strength of this approach is that it does not force one to make limiting assumptions about the relationships between the variables examined (Charnes et al., 1985). FDH is a special case of DEA, where the production possibilities set is composed of DEA vertices, and the free disposal hull points are interior to these vertices. Therefore, it produces greater average efficiency scores than DEA efficiency scores. It is less restrictive in respect of the convexity assumption in defining the production possibilities set from the observations. However, it is sensitive to both the number and the distribution of the data set, and the number of input and output dimensions (Deprins, Simar, & Tulkens, 1984; Tulkens, 1993). Both of these approaches are well-recognized by prior studies, but DEA is much more popular and widely used in bank efficiency studies.

Unlike nonparametric approaches, parametric approaches employ econometric techniques to estimate efficiency scores. Parametric frontier approaches are more sophisticated than nonparametric ones and require functional forms and assumptions to construct a stochastic optimal frontier to measure efficiency. They allow for possible random errors, which is a major advantage of these approaches (Aigner, Lovell, & Schmidt, 1977). The efficiency score from these approaches is expected to be more precise after random errors are separated out; however, they also impose structure on the frontier by using a functional form of technology, which is a drawback of these approaches (Førsund et al., 1980). The misspecification of the assumed functional form may produce inaccurate efficiency scores. Many parametric approaches have been introduced over time to overcome the drawback of this method and to make it more robust. Two of the most widely used parametric approaches are SFA (Stochastic Frontier Analysis) and DFA (Distribution Free Approach).

The econometric approach is stochastic, which allows it to distinguish the effects of noise from those of inefficiency, thereby providing the basis for statistical inference. As discussed in the previous chapter, the most widely used parametric approach is SFA, which employs a composite error where inefficiencies are assumed to follow an asymmetric distribution, while random errors are assumed to follow a symmetric distribution (Kumbhakar & Lovell, 2000). It was independently developed by Aigner et al. (1977) and Meeusen and Van Den Broeck (1977). Typically, the inefficiency errors are assumed to be non-negative half-normally distributed, and the random errors are assumed to be the normally distributed. The other recommended distributions for inefficiency errors are exponential, truncated normal, and gamma (Aigner et al., 1977; Greene, 1990; Kumbhakar & Lovell, 2003; Meeusen & Van den Broeck, 1977). The other commonly used parametric approaches are DFA and thick frontier approach (TFA).

Each of the above approaches has its own strengths and weaknesses. The present lack of consensus among researchers regarding a preferred frontier model leads to a difference of opinions regarding the lesser of evils. The use of any frontier model depends on the suitability of the data and research objectives of the study. Overall, frontier analysis is recognized as one of the most sophisticated and comprehensive approaches to benchmark-relative performances of banks (Berger & Humphrey, 1997) because it is consistent with the underlying economic theory of optimizing behavior. Furthermore, the deviation from a frontier has a natural interpretation as a measure of efficiency for units to pursue their behavioral objectives. Finally, information about the structure of the frontier and about the relative efficiency of economic units has many policy applications (Bauer, 1990). Currently, these operations research techniques are used widely to measure efficiency in economic and management sciences (Assaf, Berger, Roman, & Tsionas, 2019; Fethi & Pasiouras, 2010). SFA is the most widely used parametric and DEA the nonparametric approach to estimate bank efficiency (Badunenko, Henderson, & Kumbhakar, 2012; Berger & Humphrey, 1997). The advantages of both approaches were discussed earlier, however, SFA is found to be more suitable to achieve the research objectives of this study. Explanations for this suitability are discussed in the next section.

4.2 Bank Efficiency and SFA Models

As discussed earlier, several prior studies have recognized the frontier analysis as the most sophisticated method to compare relative performances of banks (Bauer, 1990; Berger & Humphrey, 1997; Davies & Tracey, 2014), and many have used it to compare the performance of banks over time and across the industry and countries (Fu et al., 2014b; Lozano-Vivas et al., 2002; Matousek, Rughoo, Sarantis, & Assaf, 2015). Similarly, frontier analysis can help in this study to compare the efficiency of banks before, during, and after the GFC across the selected countries. The frontier analysis may be used to compare efficiency among branches of one bank or among banks of one nation or among banks of different nations. The frontier drawn to compare branches of one bank is termed “bank-specific frontier,” the one for banks of one nation is called “nation-specific frontier,” and the one for banks of different nations is called “common frontier” (Berger, 2007). Bank-specific frontiers cannot be used for cross-country studies, but nation-specific and common frontiers have been used in prior cross-country studies. The use of nation-specific frontiers for comparisons of efficiencies in different nations may serve several purposes, but it cannot be used to draw any conclusion about whether banks in one nation are more efficient than those in other nations, because they are measured against different frontiers. Also, these comparisons cannot be used to suggest policies for the international banking sector (Berger, 2007).

The use of a common frontier may also be problematic because it is almost impossible to control the differences in the economic environments of the selected countries. Differences in regulations, legal systems, financial market development, competition conditions, cultures, and demographics may have important effects on the distance from the common frontier. The solution is to account for the differences in the environment for the common frontier through control variables and to choose nations with almost similar economic and cultural environments (Berger, 2007; Xiang et al., 2015). Therefore, in this study, a common frontier is drawn for banks from Australia, Canada, New Zealand, UK, and the United States with the SFA approach. The banking systems of all the selected developed countries are based on the Anglo-Saxon economic model (Mitchell et al., 2006), and they share a common inheritance in their banking operations, structure, and regulations (Xiang et al., 2015). The remaining variations in their banking environment are controlled by using country-specific environmental variables in the measurement model. Moreover, a comparison between national frontiers and the common frontier is conducted for robustness and results are found to be consistent.

Three main SFA methodologies have been used in prior studies to estimate bank efficiency and identify its determinants (Berger & Humphrey, 1997; Vu & Turnell, 2011; Xiang et al., 2015). These are the two-stage model, two-stage mixed model, and the one-stage model. The problems of correlation, biased estimators, and data-generating process with the two-stage methodologies are well documented in the literature (McDonald, 2009; Simar & Wilson, 2007; Wang & Schmidt, 2002). There are three benefits of including potential efficiency determinants in the one-stage SFA approach: first, this will give us more precise efficiency scores in the presence of potential determinants; second, it will solve the statistical problems (Wang & Schmidt, 2002) of the two-stage approach; third, it will estimate the relationship of selected determinants with inefficiency. This study has used the one-stage SFA panel data model of Battese & Coelli (1995) to estimate cost, profit, alternative profit, and shareholder value efficiencies.

Although some other SFA models are also available for panel data (Coelli et al., 2005; Greene, 2005; Kumbhakar & Lovell, 2000), the Battese & Coelli (1995) model is most suitable for this study because of three considerations. The first consideration in the selection of a panel data frontier model is whether or not we assume inefficiency to be varying with time. This study has selected the model of time-varying inefficiency because of the nature of banking operations and the longer time period of the study (Coelli et al., 2005; Greene, 2008). The second consideration is whether to select a fixed-effect model with minimal distribution assumptions, or a random-effect model that makes specific distribution assumptions. The random-effect model is selected in this study on the basis of the Hausman test; moreover, it is not possible to include a large number of fixed-effect dummies in the model because of the size of the data set. The third consideration is selecting a distribution assumption. Prior studies have obtained a very strong correlation among estimates of inefficiency from different distributions, however, the half-normal and truncated normal were found to have higher correlations than other distributions (Greene, 2008; Kumbhakar & Lovell, 2000; Ritter & Simar, 1997). This shows that the assumption about the distribution of inefficiency will not noticeably change the estimators, but the half-normal and truncated normal distributions may report better results. Therefore, this study has selected a frontier model with a truncated normal distribution assumption. On the basis of these three considerations, the random-effect, time-varying, inefficiency effect model of Battese and Coelli (1995) is selected for this study. This model has a few shortcomings similar to the other available models, but it is a most frequently used one-stage SFA model for panel data in prior studies for robust results (Alqahtani, Mayes, & Brown, 2017; Fitzpatrick & McQuinn, 2008; Xiang et al., 2015).

Data for three banking inputs, three banking outputs, ten banking environment variables, and one dummy variable are used in the selected efficiency estimation models. Details of the banking environment variables are provided in the previous chapter while banking inputs and outputs are discussed in the next section. Technical details of selected efficiency models are provided in later sections of this chapter.

4.2.1 Selection of Bank Inputs and Outputs

As discussed in the previous chapter, the frontier analysis approach was initially used by industrial sectors to estimate their efficiency. Identifying the inputs and outputs of any production process is relatively easy and straightforward in an industrial sector, whereas in the banking sector this selection is a big challenge. Mostly, proxies of bank inputs and outputs are directly calculated from the accounting statements without considering the economic implications of market prices (Hasannasab et al., 2019; Mountain & Thomas, 1999). On the other hand, estimation of input and output prices through econometric techniques may also give poor measurement because of a poor selection of variables and the construction of estimation models (Greene, 1993; Koetter, 2006). Past studies are not able to build a consensus on the selection of bank inputs and outputs, however, the following three are the main approaches being used in prior studies.

i. *Production Approach:* This approach considers financial institutions to be the producer of services for their customers while using labour and capital (Berger & Humphrey, 1997). In this case, the financial institutions are expected to perform account transactions and process documents for customers, which includes loan applications, credit reports, payment instruments, insurance claims, account openings, financial planning, etc. The best measure of output, in this case, should be the number of documents and transactions processed over a given period. However, the transaction flow data is typically proprietary and not generally disclosed to the public. In addition, the size and the processing cost of the transactions may vary. Therefore, Benston (1965) introduced a classification of expenses as interest expenses, personnel expenses, and operating expenses, and used them as inputs to the banking production process (Benston, 1965). The objective of banking production is to earn income for a bank, so the output is defined as interest income and non-interest income (Favero & Papi, 1995).

ii. *Intermediation Approach:* The second approach to defining inputs and outputs of banking was introduced by Sealey and Lindley (1977), who noted that financial firms are involved in the transformation process of borrowing funds from surplus spending units and lending those funds to deficit spending units. They called this "the financial intermediation or asset approach" (Sealey & Lindley, 1977). They defined financial institutions as profit-maximizing producers, and economic inputs and outputs were more important for them than technical ones. In this case, it is assumed that banks produce loans and investments while using labour, fixed assets, and available funds. Therefore, the identified economic inputs are cost of deposits/borrowed funds, operating expenses, and personnel expenses, and the outputs are different types of loans and investments; some later studies have included non-interest income as the outcome of off-balance-sheet activities of banks (Davies & Tracey, 2014; Xiang et al., 2015).

iii. *Value-added Approach:* The output set under this approach are those balance-sheet categories that contribute to bank value addition. These categories are deposits, loans, and other earning assets (Hancock, 1985; Lozano-Vivas et al., 2002). Deposits are a major market segment of banking, and the fees paid by depositors is a relevant share of the net profits of financial institutions. Therefore, deposits can be considered as an output of banks (Resti, 1997). The price of labour, capital, and funds are usually specified as inputs. Some prior studies have also used a modified form of these approaches under different arguments and input or output variables. Overall, the use of input and output approaches depends on the research objectives and functions of the selected banks (Holod & Lewis, 2011). Some studies are more focused on the banks' macroeconomic functions, and others are associated with their internal functions (Favero & Papi, 1995).

This study has selected the "intermediation approach" of Sealey and Lindley (1977) to choose bank inputs and outputs. This approach has been widely used in past studies and has provided very robust results (Berger & Humphrey, 1997; Tsionas, Malikov, & Kumbhakar, 2018; Xiang et al., 2015). It has been argued in prior studies that this approach might be more appropriate for evaluating the efficiencies of entire financial institutions compared to other approaches, which are more suitable for evaluating the efficiency of branches of financial institutions (Berger & Humphrey, 1997). The input, output, dependent and banking environment variables used in the selected efficiency models are summarised in Table 4.1. The sources of data used to calculate these variables are discussed later in this chapter.

Table 4.1: Summary of Selected Variables

Dependent Variables	
TC	Total cost includes interest expenses and operating expenses. It is used to calculate cost efficiency.
PBT	It is profit before tax plus a constant Θ. The constant is the minimum profit of a bank over the profit of all banks plus 1. It is done to make all values of dependent variables positive for the natural log. This variable is used in the calculation of profit and alternative profit efficiency.
EVA	Economic value added, which is replaced as the dependent variable in the equation of alternate profit efficiency to measure the shareholder value efficiency. Details are discussed later in this chapter.
Input Prices	
w_1	Price of labour is personnel expenses per employee.
w_2	Price of physical capital is the operating expenses minus the personal and administrative expenses divided by the value of the fixed assets.
w_3	Price of funds is interest expenses divided by total borrowed funds, including deposits and other borrowings.
Output Quantities	
Y_1	The total amount of loans, advances, and other receivables.
Y_2	All investments in assets and securities.
Y_3	Total non-interest income, including commissions and fees.
Output Prices	
P_1	Price of the loan is the interest income divided by total loans, advances, and receivables.
P_2	Price of other assets is the non-interest income divided by other assets. Other assets are total assets minus total loans.
Banking Environment Variables	
GDC(z_1)	GDP per capita in each country in a given year, which is a measure of the market size available to the banks and the level of income in each country.
IR(z_2)	The five-year bond rate in each country in year t, which is a measure of the potential profitability in a given banking system.
PD (z_3)	The population density in each country, measured by the number of people per square kilometer.
LAT(z_4)	The ratio of loans to total assets shows the dependence of the bank on the lending portfolio.
EQ (z_5)	The ratio of total equity to total assets of each bank for a given year.
LOSS(z_6)	The ratio of loan loss expenses to total loans of each bank for each year.
Z-Score(z_7)	Z-score of each bank as a measure of bank stability. The Z-score is calculated with the following formula: $\frac{\text{ROA} + \left(\frac{\text{Equity}}{\text{Asset}}\right)}{\sigma(\text{ROA})}$ where ROA and the equity-to-asset ratio are calculated for each bank in each financial year, but the standard deviation of ROA is computed using a rolling window of four years.
TA(z_8)	Total book value of assets, used to measure bank size.
HHI (z_9)	The Herfindahl-Hirschman Index is calculated on the basis of bank assets and is a proxy for concentration.
Lerner(z_{10})	Lerner index is a measure of the market power of banks in each country in a given year and is a measure of market competition.
DGFC(z_{11})	Dummy variables for the years 2008 and 2009, which are the years most impacted by the GFC.

4.2.2 Cost Efficiency Model

Cost efficiency is an overall economic efficiency that combines both technical and allocative efficiencies (Coelli et al., 2005; Greene, 2008). It measures the minimization of input costs or expenditures to produce a given output, as discussed earlier in association with Figure 4.2. Cost efficiency can be decomposed into technical and allocative efficiencies to give more useful information, in some cases using Simultaneous-Equation Frontier Models (Kumbhakar & Lovell, 2000). Several other approaches to measure allocative inefficiency on the basis of cost function and demand system have also been suggested. To the author's knowledge, unfortunately, there is no method for panel data in the mainstream which allows a convenient analysis of this type of inefficiency in the context of the fully integrated or one-stage frontier model, reflecting econometric problems (Greene, 2008; Kumbhakar, Wang, & Horncastle, 2015). Some non-parametric and multi-stage parametric models are also available, which are beyond the scope of this study.

Cost efficiency measures show how close a bank's cost is to the best-practice cost frontier for producing the same bundle of outputs. This study uses panel data of 29 commercial banks from Australia, Canada, New Zealand, UK, and the United States for the period of 2003–2015; therefore, the panel data random-effect time-varying inefficiency effect cost-frontier model of Battese and Coelli (1995) was selected to estimate cost efficiency (Battese & Coelli, 1995). Panel data models have various advantages over cross-sectional or time-series data models. They can generate a more efficient and accurate estimation owing to reduced collinearity and greater degrees of freedom. They also help make statistical inferences and computations easier in terms of measuring error (Wooldridge, 2013). The selection of the proposed model was already discussed in this chapter; the selection of banks is discussed later, along with data description.

The selected model has been used by prior studies in the following three functional forms: Cobb-Douglas, translog, and Fourier-Flexible (Berger et al., 1987; Berger & Humphrey, 1997; Greene, 2008; Meeusen & Van den Broeck, 1977). This study has used a panel data model in the translog form, which is more flexible and less strict in imposing functional form for the cost and profit functions compared to the Cobb-Douglas functional form. It is one of the most widely used functional forms in bank efficiency studies. Although the Fourier-Flexible is less strict and more flexible than the translog form, it cannot be used in the present study owing to the limited size of the data set. However, both functional forms generate similar efficiency results and the difference in the estimated mean efficiency between the two forms is insignificant, which means that both forms are substantially equivalent from an economic point of view (Berger & Mester, 1997; McAllister & McManus, 1993).

The equation of the SFA cost function of Battese and Coelli (1995) model in the translog form can be specified as follows:

$$\ln TC_{it} = \alpha_o + \sum_{n=1}^{3} \alpha_n \, lny_{nit} + \frac{1}{2} \sum_{n=1}^{3} \sum_{k=1}^{3} \alpha_{nk} \, lny_{nit} lny_{kit} + \sum_{j=1}^{2} \beta_j \, lnw_{jit} + \frac{1}{2} \sum_{j=1}^{2} \sum_{m=1}^{2} \beta_{jm} \, lnw_{jit} lnw_{mit} + \sum_{n=1}^{3} \sum_{j=1}^{2} \omega_{nj} \, lny_{nit} lnw_{jit} + \lambda t + \kappa t^2 + v_{it} + \mu_{it} \quad (4.8)$$

$$\mu_{it} = \delta z_{it} + \varepsilon_{it} \quad (4.9)$$

The cost function equation (4.8) has to be linearly homogenous in input prices and for the second-order parameters to be symmetric, so the following restrictions must be imposed.

$$\alpha_{nk} = \alpha_{kn}, \ \beta_{jm} = \beta_{mj}, \ \sum_{j}^{3} \beta_j = 1, \ \sum_{j=1}^{3} \beta_{jm} = 0, \ \sum_{n=1}^{3} \omega_{nj} = 0 \quad (4.10)$$

In equation (4.8), TC_{it} is the total cost (interest and non-interest expenses) of the *i*-th bank in each year t, y_{it} is a vector of three outputs values (loans, investments, non-interest income), and w_{it} is a vector of three input prices (the price of labour, price of funds, price of fixed assets). The time variable *t* is included in the stochastic frontier for technological change, but it is not included in inefficiency because it is not expected to be a determinant of inefficiency. Equation 4.8 will simultaneously estimate the α, β, ω, ƛ, and κ, the vectors of unknown parameters. To impose linear input cost homogeneity as per the model's requirements, total cost and input prices are normalized by the third input: the price of funds. Furthermore, TC, all input prices, and outputs are normalized with total equity to control potential scale bias. Potential scale bias was expected because of the large variation in size among the banks in our study. v_{it} are normally distributed random error terms, which are identical in distribution and independent of inefficiency error terms and regressors. μ_{it} are truncated normal non-negative inefficiency error terms, which are identical in distribution and independent of random error terms and regressors. Details of the selected input, output, and dependent variables are given in Table 4.1.

According to the Battese and Coelli (1995) model, inefficiency is assumed to be a function of a set of banking environment variables z_{it} and a vector of unknown parameter δ, to be estimated as specified in equation (4.9). All banking environment variables are included in the inefficiency equation together, in each estimation model, where ε_{it} is the truncation of the normal distribution with 0 mean and variance σ^2, such that the point of truncation is $- \delta z_{it}$, meaning that $\varepsilon_{it} \geq - \delta z_{it}$. Therefore, the non-negative inefficiency component follows a truncated normal distribution; μ_{it} is $N(\delta z_{it}, \sigma^2_{\mu})$. In this model, the composed error term is equal to $\nu_{it} + \mu_{it}$ and total variance is $\sigma^2 = \sigma^2_{\nu} + \sigma^2_{\mu}$.

An estimate of μ_{it} is obtained by generalizing the estimation of Jondrow et al. (1982) as proposed in Battese and Coelli (1993) for panel data. Cost efficiency is measured by substituting the estimation of inefficiency term μ_{it} in the equation $CE_{it} = \exp(-\mu_{it})$. Equation 4.9 will contribute to Equation 4.8 to estimate CE as well as provide the relationship of CE with the banking environment variables or other potential determinants. This is the methodological advantage of using the Battese and Coelli (1995) one-stage SFA model. It helps control for environmental differences across countries and analyzes the effects of these variables on estimated efficiency scores. The one-stage SFA model is the simultaneous estimation of the cost frontier and its parameters, which are solved using the method of maximum likelihood (ML). All frontier models in this study are solved using the ML technique on the FRONTIER 4.1 software developed by Coelli (2005). The technical details of this software are provided in Coelli et al. (2005) and also in the manual of software. This software is used because of its availability and ease of use; however, its results are found to be consistent with other software such as LIMDEP. Although FRONTIER 4.1 is available in “R” and “Stata” software, we used the original version, which fully supports the estimation of Battese and Coelli (1995) for panel data.

4.2.3 Profit Efficiency Model

The measure of profit efficiency of banks can be a better source of information for bank management in terms of evaluating overall bank performance than cost efficiency alone. Profit efficiency is the outcome of both minimization of the production cost and maximization of the revenue. Profit efficiency is more aligned with the goals of shareholders and managers, and superior to cost efficiency (Berger & Mester, 1997). Therefore, profit efficiency is also measured along with cost efficiency in this study to achieve a complete assessment of bank performance. The estimation model used for cost efficiency can also be applied to profit efficiency with few changes. Profit efficiency measures how close a bank's profit is to a best-practice bank's profit while utilizing the same input bundle. It is based on a maximization function, which is the ratio of the actual profit to the maximum feasible profit that can be achieved by the best-practice banks.

The equation for the SFA profit function of Battese and Coelli (1995) in translog form can be specified as follows:

$$\ln PBT_{it} = \alpha_o + \sum_{s=1}^{2} \alpha_s lnp_{sit} + \frac{1}{2} \sum_{k=1}^{2} \sum_{s=1}^{2} \alpha_{ks} \ lnp_{kit} lnp_{sit} + \sum_{j=1}^{2} \beta_j \ lnw_{jit} + \frac{1}{2} \sum_{j=1}^{2} \sum_{m=1}^{2} \beta_{jm} \, lnw_{jit} lnw_{mit} + \sum_{s=1}^{2} \sum_{j=1}^{2} \omega_{sj} \ lnp_{sit} lnw_{jit} + \lambda t + \kappa t^2 + v_{it} - \mu_{it} \quad (4.11)$$

Subject to

$$\alpha_{ks} = \alpha_{sk}, \ \beta_{jm} = \beta_{mj}, \ \sum_{j}^{3} \beta_j = 1, \ \sum_{j=1}^{3} \beta_{jm} = 0, \ \sum_{s=1}^{2} \omega_{sj} = 0 \qquad (4.12)$$

Where

$$\mu_{it} = \delta z_{it} + \varepsilon_{it} \qquad (4.13)$$

Equation 4.11 is the profit-maximizing function and most of its variables are similar to those of Equation 4.8, except the dependent variable, which is the amount of profit before tax of each bank plus Θ. The output amounts are replaced with output prices (p_{it}), and the inefficiency term has a negative sign. Here Θ is the absolute value of minimum normalized profit before tax over all banks in the sample plus 1, so as to ensure that we take the logarithm of positive numbers. As per Table 4.1, the output prices are the price of loans (p_1) and the price of other assets (p_2). The positive sign of inefficiency error terms is changed to negative because inefficient banks obtain less profit than the most efficient banks and they deviate negatively from the profit frontier. In other words, banks with higher μ_{it} can be found further from the profit frontier and are less profit-efficient. The properties of symmetry and linear homogeneity are imposed on profit function with Equation 4.12. Therefore, the profit before tax and input prices are normalized by the third input of the price of borrowed funds. Furthermore, profit before tax *(PBT),* all input prices, and all output prices are normalized with total equity to control potential scale bias. The rest of the process of this analysis is similar to the cost efficiency analysis process.

4.2.4 Alternative Profit Efficiency Model

The standard profit efficiency measures how close a bank is in producing the maximum possible profit for a given level of input costs and output prices. In other words, the standard profit function assumes that the output markets are perfectly competitive so that banks are output price takers. In contrast, the alternative profit function measures how close a bank is to producing maximum feasible profits given a particular level of input prices and output quantities. Thus, the alternative profit function assumes that banks have some market power in determining their output prices, which means that the perfectly competitive output markets assumption cannot hold (Berger & Mester, 1997). The alternative profit efficiency may provide useful information when one or more of the following conditions prevail in the given banking sector: (1) when banking services and products are not of the same quality; (2) when the market of outputs is not perfectly competitive and banks have the power to set the prices of their products and services; and (3) when it is difficult to measure the prices of outputs accurately. Since our study sample is based on the countries where banks have higher market power and concentration and different qualities of services, the alternative profit efficiency is also estimated. It may also be viewed as a robustness check on standard profit efficiency estimates (Berger & Mester, 1997). It is also based on a maximization function, which is the ratio of the actual profit to the maximum feasible profit that can be achieved by the best-practice banks.

The equation for the SFA alternative profit function in the translog form can be specified as follows:

$$\ln PBT_{it} = \alpha_o + \sum_{n=1}^{3} \alpha_n \, lny_{nit} + \frac{1}{2} \sum_{n=1}^{3} \sum_{k=1}^{3} \alpha_{nk} \, lny_{nit} lny_{kit} + \sum_{j=1}^{2} \beta_j \, lnw_{jit} + \frac{1}{2} \sum_{j=1}^{2} \sum_{m=1}^{2} \beta_{jm} \, lnw_{jit} lnw_{mit} + \sum_{n=1}^{3} \sum_{j=1}^{2} \omega_{nj} \, lny_{nit} lnw_{jit} + \lambda t + \kappa t^2 + v_{it} - \mu_{it} \quad (4.14)$$

Subject to

$$\alpha_{nk} = \alpha_{kn}, \ \beta_{jm} = \beta_{mj}, \ \sum_{j}^{3} \beta_j = 1, \ \sum_{j=1}^{3} \beta_{jm} = 0, \ \sum_{n=1}^{3} \omega_{nj} = 0 \qquad (4.15)$$

Where

$$\mu_{it} = \delta z_{it} + \varepsilon_{it} \qquad (4.16)$$

The equation for APE is similar to that for CE for explanatory variables, except that the sign of μ_{it} is changed to negative and the dependent variable is PBT of each bank plus constant of Θ. In standard profit efficiency, the price of output is given, so a bank changes the quantities of output and input to get optimal revenue for maximum profit. However, when estimating alternative profit efficiency, the quantity of output is given so a bank can set different prices to get optimal revenue for maximum profit (Berger & Mester, 1997). The inefficiency errors are similar to those for Equation 4.8 with a negative sign. Equation 4.15 has imposed the restrictions of symmetry and linear homogeneity on this model. The normalization of variables is done for linear homogeneity and scale bias similar to the standard profit efficiency model.

4.2.5 Shareholder Value Efficiency Model

As discussed in the previous chapter, a need has been identified to assess the relationship between the operational efficiency of bank and shareholder value creation. A few prior studies have reported that profit efficiency has a strong relationship with shareholder value but the relationship with cost efficiency is based on “time dynamics.” As mentioned earlier, the literature on the relationship between bank efficiency and shareholder value is limited and relatively new. As a result, there is a need to further investigate this relationship in different banking markets with better measurement approaches to capture “time and location dynamics.” Most prior studies have used two- or three-stage approaches to measure bank efficiency and its determinants, which are widely criticized by some later studies (McDonald, 2009; Simar & Wilson, 2007; Wang & Schmidt, 2002). The changes in the banking environment of many developed countries have been recognized after the GFC (Fu et al., 2014b), but only one study has investigated the relationship between bank efficiency and shareholder value, with that based on only a few Asia-Pacific economies. Therefore, for the present study more suitable econometric models are used to explore the relationship between bank efficiency and shareholder value in four big, developed economies, covering the post-GFC period. New Zealand banks are incorporated in the country but not listed; therefore, market price data for their parent bank is taken to estimate the shareholder value of each bank.

The model for the estimation of shareholder value efficiency (SVE) is very similar to the APE model. In this case, the dependent variable is replaced with the variable of economic value added (EVA); the rest of the features of this model are the same as alternative profit efficiency model. The variable of EVA includes economic value addition (EVAD) plus the constant of φ, which is the absolute value of minimum normalized EVAD plus 1. The method for calculating the EVAD is given below. Furthermore, the amount of EVAD, all input prices, and all output amounts are normalized with total equity to control potential scale bias. The amount of EVA and input costs are normalized by w_3 to comply with the linear homogeneity condition of the model.

$$\ln EVA_{it} = \alpha_o + \sum_{n=1}^{3} \alpha_n \, lny_{nit} + \frac{1}{2} \sum_{n=1}^{3} \sum_{k=1}^{3} \alpha_{nk} \, lny_{nit} lny_{kit} + \sum_{j=1}^{2} \beta_j \, lnw_{jit} + \frac{1}{2} \sum_{j=1}^{2} \sum_{m=1}^{2} \beta_{jm} \, lnw_{jit} lnw_{mit} + \sum_{j=1}^{2} \sum_{n=1}^{3} \omega_{nj} \, lny_{nit} lnw_{jit} + \lambda t + \kappa t^2 + v_{it} - \mu_{it} \quad (4.17)$$

Subject to

$$\alpha_{nk} = \alpha_{kn}, \beta_{jm} = \beta_{mj}, \sum_{j}^{3} \beta_j = 1, \sum_{j=1}^{3} \beta_{jm} = 0, \sum_{n=1}^{3} \omega_{nj} = 0 \quad (4.18)$$

Where

$$\mu_{it} = \delta z_{it} + \varepsilon_{it} \quad (4.19)$$

The rest of the detail, description, and assumptions of these equations are already discussed with the models of cost efficiency and alternative profit efficiency in earlier sections.

Annual EVAD is calculated for each bank with the help of the formula being used by Fiordelisi (2007), which is as follows:

$$EVAD_{it} = NOPAT_t - (CI_{t-1} * K^e_{t-1}) \quad (4.20)$$

Where NOPAT is net operating profit after tax, CI is shareholder's equity, and K^e is the estimated cost of equity. EVAD is the amount of profit a bank earns in excess of the returns the shareholders require on the contributed equity to the bank—in other words, the bank's price of capital.

Various methods of estimating the price of capital are discussed in prior studies (Damodaran, 2007; Fiordelisi, 2007; Maccario, Sironi, & Zazzara, 2002). It is argued that historical realized returns are good indicators of expected returns and can, therefore, be used as proxies for the cost of equity (Maccario et al., 2002). Either the ROE for year *t*-1 or an average ROE for past years can be used as the cost of equity. ROE of the banks mostly stays steady under stable conditions, but fluctuates significantly during economic shocks; it is better, therefore, to take ROE of year *t*-1, as the minimum expectation of shareholders for the following year. The amount of equity invested is also taken from year *t*-1 because shareholders are expecting returns on their capital, which is already invested in the bank. Although this is not an ideal method for estimating the cost of equity, it is selected due to data limitations. Market data and beta, which are required for other methods of the price of capital estimation, are not available for New Zealand banks.

4.3 Data Description

As discussed in the introduction, the objective of this study is to assess the varying impacts of the GFC on the banking sectors of Australia, Canada, New Zealand, UK, and the United States. This objective is further divided into two sub-objectives: first, to assess the impact of the GFC on the efficiency of banks, and second, to explore the determinants of this varying impact. A sample of 29 large commercial banks from five countries is taken for the period of 2003–2015. The selected period is very important because it includes the pre-GFC, GFC, and post-GFC years. The study period starts from 2003 to avoid overlap with the tech crisis of 2002 and goes up to 2015, which allows observing the impact of the post-GFC national and international reforms in each banking sector.

The sample is based on listed banks that survived through the GFC. Banks are selected on the basis of their asset size and together they represent more than 50% of the banking sector assets in each country. Coverage of more than 50% of the banking sector is assumed to be sufficient to observe the impact of the GFC. An adequate number of banks are selected from each country to maintain a sufficient number of observations for the proposed estimation techniques. The selected Australian banks hold about 90% of the country’s banking assets, Canadian banks 92%, New Zealand banks 90%, UK banks 85%, and US banks 58%. The list of selected banks is given in Table 4.2. The sample is based on Anglo-Saxon economies (Mitchell et al., 2006) with a shared inheritance in banking operations, structure, and regulations. The remaining variation in their economic environments is controlled by including control variables in the measurement model.

Table 4.2 List of Selected Banks

Sr.	Name of Bank	Country
1.	Commonwealth Bank of Australia	Australia
2.	Westpac Bank Australia	Australia
3.	NAB Australia	Australia
4.	ANZ Australia	Australia
5.	Bendigo and Adelaide Bank Ltd.	Australia
6.	Bank of Queensland Ltd.	Australia
7.	TD Canada Trust	Canada
8.	Royal Bank of Canada	Canada
9.	Bank of Nova Scotia	Canada
10.	Canadian Imperial Bank of Commerce	Canada
11.	Bank of Montreal	Canada
12.	National Bank of Canada	Canada
13.	ANZ Bank NZ	NZ
14.	Westpac Bank NZ	NZ
15.	Bank of New Zealand (BNZ)	NZ
16.	ASB NZ	NZ
17.	HSBC Bank UK	UK
18.	Barclays Bank UK	UK
19.	Royal Bank of Scotland UK	UK
20.	Lloyds Bank UK	UK
21.	Standard Chartered Bank UK	UK
22.	J.P. Morgan Chase	United States
23.	Bank of America	United States
24.	Wells Fargo	United States
25.	Citigroup	United States
26.	US Bancorp	United States
27.	PNC Financial Services	United States
28.	SunTrust Bank	United States
29.	BB & T	United States

The consolidated accounting data of input, output, and other firm-level variables were collected from DataStream. Data for macroeconomic and industry-level variables were collected from the IMF's International Financial Statistics, central banks, and World Bank reports. None of the selected banks for New Zealand are listed on the stock exchange in their own right, and therefore data for those banks were collected from their annual reports. The data for the Australian banks excluded their New Zealand subsidiaries. Data of both countries were converted into US dollars before subtracting the data of New Zealand subsidiaries from their Australian parent banks. Although some other banks in the study operate globally, the share in income and assets of their global operation was not significant relative to their domestic operations, and management strategy was conveyed from the home country. All firm-level data was collected in domestic currencies and later converted into US dollars using the average monthly exchange rate for the financial closing month of the bank. The average monthly exchange rate of the closing month was selected as per the accounting policies of banks for reporting the annual data. Data were not corrected for inflation because when data of both sides of equations are adjusted for inflation, it will not significantly change the results. Some of the selected banks moved from GAAP accounting standards to IFRS during the study period, which may impact the reported amount and names of a few selected variables. The results were therefore tested with a dummy of the changing year for the possible effect of this change, and to get consistent results.

The descriptive statistics are given in Tables 4.3 and 4.4 for each variable. They include three dependent variables, three input prices, three output quantities, two output prices, and ten banking environment variables for the different estimation models. There is substantial variation in the values of each variable across time and countries. Some variation in data was due to the different sizes of banks in each country, and the rest was due to changes in the banking environment over the study period. The impact of the size bias is controlled by normalizing the data. Results of correlation among banking environment variables are reported in Appendix 2. There is not a high level of correlation among selected variables, however, a medium level of correlation exists among total assets, total loans to assets ratio (LAT), and loan losses to total loans ratio (LOS). The reason behind these correlations is the significance of total loans in total assets of banks and the use of total loans as denominators of two later ratios. Estimation results do not change significantly after excluding the variables of LAT and LOS. Detail of each selected variable and data processing was discussed earlier in this chapter.

Table 4.3 Descriptive Statistics

	Mean	Max	Min	SD
Dependent Variable (US$M)				
Total Cost (TC)	26,265	157,045	50	31,141
Profit Before Tax (PBT)	5,376	37,014	−60,492	8,749
Economic Value Added (EVA)	766	12,570	−54,060	5,730
Input Variables (US$M)				
Price of Labour (w_1)	0.083	0.154	0.017	0.024
Price of Funds (w_2)	0.024	0.069	0.002	0.015
Price of Physical Capital (w_3)	2.56	17.23	0.53	1.89
Output Variables (US$M)				
Net Loans (y_1)	313,133	2,211,669	318	322,225
Total Investment (y_2)	265,016	2,211,865	125	396,900
Non-interest Income (y_3)	11,280	65,356	−35,532	15,021
Price of Loans (p_1)	0.069	0.163	0.020	0.021
Price of Other Assets (p_2)	0.049	0.259	0.000	0.029
Environment Variables				
Nominal Interest Rate (z_1)	3.42	6.86	0.72	1.60
GDP per Capita (z_2)	43,662	67,524	21,712	10,053
Population Density (z_3)	55.86	269.20	2.59	91.03
Z-Score (z_4)	39.84	140.45	1.59	27.53
Loan Losses (z_5)	3,134	37,390	0.00	5,643
Equity Ratio (z_6)	0.067	0.134	0.016	0.025
Loan to Assets (z_7)	0.61	0.90	0.25	0.16
Total Assets (z_8)	652,616	3,929,498	489	764,916
HHI (z_9)	1266	2516	252	538
Lerner Index (z_{10})	0.27	0.56	0.03	0.13

Table 4.4 Descriptive Statistics (by country)

	Sample	USA	UK	CAD	AU	NZ
Dependent Variable (Average US$M)						
Total Cost (TC)	26,265	43,278	53,596	14,350	12,718	2,264
Profit Before Tax (PBT)	5,376	10,304	6,135	4,038	3,474	615
Input Variables (Average US$M)						
Price of Labour (w_1)	0.083	0.092	0.082	0.09	0.086	0.058
Price of Funds (w_2)	0.024	0.014	0.013	0.017	0.036	0.043
Price of Physical Capital (w_3)	2.56	1.66	2.65	2.20	3.40	2.34
Output Variables (Average US$M)						
Net Loans (y_1)	313,133	388,080	728,995	210,726	200,807	35,036
Total Investment (y_2)	265,016	390,643	690,871	168,265	57,457	3,328
Non-interest Income (y_3)	11,280	20,198	23,565	6,769	2,772	349
Price of Loans (p_1)	0.069	0.08	0.052	0.064	0.071	0.075
Price of Other Assets (p_2)	0.049	0.053	0.059	0.034	0.040	0.061
Environment Variables (Average)						
Nominal Interest Rate (z_1)	3.42	2.56	3.01	2.73	4.36	4.89
GDP per Capita (z_2)	43,662	49,038	41,321	43,331	48,043	32,565
Population Density (z_3)	55.86	33.45	257.51	3.71	2.83	16.32
Z-Score (z_4)	39.84	44.47	30.69	38.02	46.81	35.32
Loan Losses (z_5)	3,134	6,733	6,093	876	679	75
Equity Ratio (z_6)	0.067	0.10	0.05	0.05	0.06	0.06
Loan to Assets (z_7)	0.61	0.52	0.52	0.51	0.74	0.81
Total Assets (z_8)	652,616	918,463	1,551,535	818,313	295,556	44,094
HHI (z_9)	1266	586	1458	1596	1121	1944
Lerner Index (z_{10})	0.27	0.22	0.29	0.45	0.25	0.17

4.4 Summary

This chapter started with an explanation of various methods to measure bank performance and of the reason for selecting frontier analysis as a preferred method to assess the performance of banks. Theoretical framework and different approaches of frontier analysis and efficiency concepts were given in detail. The Battese and Coelli (1995) one-stage SFA model is selected to estimate the cost, profit, alternative profit, and shareholder value efficiencies of banks on the common frontier. The specifications of selected models in a translog functional form for panel data of 29 selected banks are given. The intermediation approach is used to choose three inputs and three outputs for bank efficiency models. The balanced panel data for the period of 2003–2015 is based on 377 observations, which are sufficient to apply the proposed estimation models. Although data and research methodology are very important for any study, the policy implications depend on the analysis of the results, which are provided in the next chapter of this study.

Chapter 5

EMPIRICAL RESULTS AND ANALYSIS

This chapter analyses the outcomes of the selected SFA estimation models generated from the data of 29 large Australian, Canadian, New Zealand, UK, and US banks for the period of 2003–2015. Efficiency scores of cost, profit, alternative profit, and shareholder value models are compared among the five countries across the study period. Efficiency scores were estimated using common frontiers across all banks. Although the use of a common frontier across all banks is justified in the previous chapter with reference to prior studies, a few country-specific frontier results were also estimated for robustness purposes. The impact of the GFC is assessed on all efficiency scores and banking environment variables during the study period. The relationship of various efficiency determinants is investigated and analyzed. Association of shareholder value creation with various bank efficiency measures is assessed toward the end of this chapter. A few robustness tests were also conducted to increase the reliability of the estimated results.

The remainder of the chapter proceeds as follows: The next section reports the ML parameter estimates and a comparison among efficiency scores for all estimation models. It also provides a comparison among selected countries and assesses the impact of the GFC on efficiency scores. Section 5.2 discusses the relationship of banking environment variables with cost, profit, alternative profit, and SVE. Section 5.3 explores the association between shareholder value creation and various measures of bank efficiency. Section 5.4 provides the outcomes of various robustness and diagnostic tests to increase the reliability of the estimated results. Result outcomes are summarised at the end of the chapter.

5.1 The Global Financial Crisis and Bank Efficiency

The varying impacts of the GFC on economically homogeneous and interconnected countries was one of the major concerns for policymakers after the crisis (Calomiris & Haber, 2014; Greenbaum et al., 2016). Moreover, there was great variation in the impacts of this crisis on banks within and across the countries. Several studies have been conducted on the impacts of the GFC on various banking sectors (Aït-Sahalia et al., 2012; Beck, de Haan, & DeYoung, 2014; Schoenmaker, 2017). Most of the initial studies on the GFC and bank performance were conducted on the US banking sector owing to its significant role in the origin of this crisis. Later, several country-specific and a few cross-country studies were conducted on the GFC and bank efficiency. These studies concluded that cost-efficient banks were more resilient and less likely to fail during the crisis (Claessens, Kose, & Terrones, 2010; Vu & Turnell, 2011; Xiang et al., 2015). Therefore, this study has estimated cost, profit, alternative profit, and shareholder efficiencies of five asymmetrically impacted banking sectors. A comparison is conducted among these sectors and the impact of the GFC is assessed on each.

5.1.1 Cost Efficiency

Cost efficiency measures the performance of a unit in minimizing input costs to produce given outputs (Førsund et al., 1980; Shepherd, 1953). One-stage SFA was used in this study to estimate the cost efficiency of 29 large banks from Australia, Canada, New Zealand, UK, and the United States over the period of 2003–2015. The selection of the study sample and details of the estimation model are already discussed in the Research Methodology and Literature Review chapters. Table 5.1 summarises the ML parameters of all input, output, and time variables along with some cost efficiency model statistics. Results of 10 banking environment and GFC dummy variables are discussed later in this chapter.

Table 5.1 Parameter Estimates of Cost Efficiency Model

Variables	Parameters	Coefficients	t-ratio
Constant	α_0	−1.54***	−3.14
lnY1 (Total Loans)	α_1	1.43***	6.33
lnY2 (Total Investment)	α_2	0.44***	3.30
lnY3 (Non-interest Income)	α_3	0.08	0.13
0.5lnY1lnY1	α_{11}	−0.09	−1.15
0.5lnY2lnY2	α_{22}	0.19***	4.98
0.5lnY3lnY3	α_{33}	−0.99***	−3.29
lnY1lnY2	α_{12}	−0.04	−0.85
lnY1lnY3	α_{13}	0.21	1.11
lnY2lnY3	α_{23}	−0.98***	−8.96
ln W1/W3 (Price of Labour)	β_1	0.62***	3.87
ln W2/W3 (Price of Physical Capital)	β_2	0.50***	3.39
0.5ln (W1/W3)ln(W1/W3)	β_{11}	0.03	0.47
ln (W1/W3)ln(W2/W3)	β_{12}	0.04	1.12
0.5ln (W2/W3)ln(W2/W3)	β_{22}	−0.06**	−2.07
lnY1 ln (W1/W3)	ω_{11}	−0.13**	−2.19
lnY2 ln (W1/W3)	ω_{21}	−0.13***	−3.86
lnY3 ln (W1/W3)	ω_{31}	0.12	0.71
lnY1 ln (W2/W3)	ω_{12}	−0.12***	−3.01
lnY2 ln (W2/W3)	ω_{22}	0.09	0.37
lnY3 ln (W2/W3)	ω_{32}	0.46***	4.74
t	λ	−0.05***	−7.10
t^2	κ	0.03***	3.22
Sigma-squared	σ^2	0.09***	9.68
Gamma	γ	0.88***	14.61
Log-Likelihood Function		396	
LR test		400	
Observations		377	

Note: *** and **indicate 1% and 5% significance levels respectively. Software Frontier 4.1 is used to estimate these parameters based on a common frontier for all five countries.

$$\ln TC_{it} = \alpha_0 + \sum_{n=1}^{3} \alpha_n \, lny_{nit} + \frac{1}{2}\sum_{n=1}^{3}\sum_{k=1}^{3} \alpha_{nk} \, lny_{nit} lny_{kit} + \sum_{j=1}^{2} \beta_j \, lnw_{jit} + \frac{1}{2}\sum_{j=1}^{2}\sum_{m=1}^{2} \beta_{jm} \, lnw_{jit} lnw_{mit} + \sum_{n=1}^{3}\sum_{j=1}^{2} \omega_{nj} \, lny_{nit} lnw_{jit} + \lambda t + \kappa t^2 + v_{it} + \mu_{it}$$

Most parameters and LR test in Table 5.1 are significant at 1 % level, which shows a good statistical fit of the model with the data. It is mentioned in prior literature that $\gamma = \sigma^2_{\mu} / (\sigma^2_{v} + \sigma^2_{\mu})$, which indicates the proportion of the inefficiency error terms in the total noise of the estimation model (Aigner et al., 1977; Coelli et al., 2005). The significant value of sigma-squared proves the existence of noise in the model, and the 0.88 value of gamma suggests that the majority of residual noise in the cost frontier model is due to inefficiency effect. In other words, diagnostic tests clearly indicate the presence of inefficiency-related deviation from the estimated common frontier. Significant values of sigma-squared and gamma justified the use of the one-stage SFA model, consistent with the argument in the prior literature that one-stage SFA is more suitable for relative benchmarking of bank performance than other models (Belke et al., 2016; Wang & Schmidt, 2002). Reported outcomes of gamma and likelihood ratio tests in Tables 5.4, 5.7, and 5.10 are consistent and justify the use of the one-stage SFA alternative profit, profit, and shareholder value efficiency models respectively.

Although all parameter coefficients reported in Table 5.1 are important however the most important and consistent with the research objectives of this study is time or technological change. A negative and significant association of total cost with t and a positive association with t^2 showed a non-linear relationship between time or technological change and total cost. This indicates that banks' total costs declined in the initial years and increased in the later period. In other words, the impact of technological changes was positive initially and became negative after some time. The relationship of technological change with the cost is consistent with a few other recent studies, which reported that adoption of new banking technology isn't cost-efficient for banks due to its sub-optimal utilization and competition from FinTech companies (Boot & Thakor, 2018; Xue, Hitt, & Chen, 2011). The relationship of input and output variables with bank cost is very complex (Weill, 2013; Daglish, Robertson, Tripe, & Weill, 2015) and beyond the research objectives of this study however the association between cost efficiency and its determinants is discussed later in this chapter.

Table 5.2 Mean Cost Efficiency Scores (Common Frontier)

Year	Cost Efficiency	Australia	Canada	New Zealand	USA	UK
2003	0.83	0.94	0.94	0.82	0.75	0.71
2004	0.84	0.90	0.91	0.85	0.79	0.75
2005	0.84	0.94	0.93	0.82	0.82	0.70
2006	0.85	0.90	0.95	0.79	0.83	0.74
2007	0.85	0.93	0.96	0.80	0.80	0.76
2008	0.77	0.90	0.88	0.78	0.65	0.68
2009	0.73	0.90	0.85	0.72	0.59	0.62
2010	0.72	0.92	0.83	0.71	0.56	0.63
2011	0.74	0.94	0.85	0.75	0.59	0.64
2012	0.74	0.92	0.83	0.72	0.62	0.63
2013	0.75	0.92	0.82	0.74	0.66	0.62
2014	0.76	0.91	0.80	0.77	0.69	0.63
2015	0.73	0.87	0.74	0.71	0.72	0.57
Mean	**0.78**	**0.91**	**0.87**	**0.77**	**0.70**	**0.67**
Ranking		**1**	**2**	**3**	**4**	**5**
SD	**0.05**	**0.02**	**0.06**	**0.05**	**0.09**	**0.06**

This table presents the annual average CE scores from the one-stage SFA for the entire sample (N = 377), estimated with equations 4.8, using FRONTIER 4.1 software.

Average annual CE scores from the common frontier and ranking of all banks are reported in Table 5.2, along with mean efficiency scores of each country based on the same frontier. On average a 22% inefficiency level is reported over the study period and the level of inefficiency has increased during this period. The Australian and Canadian banking sectors were the most cost-efficient among the selected countries at the start of the study period, and they retained this rank at the end of the period. Banks of the United States and the UK were among the least efficient banks at the start of the study period and were at the bottom of the ranking at the end of this period. Although the ranking of banking sectors is done on the basis of their mean CE scores, it persists persisted in most of the study years. This means that more cost-efficient banking sectors in the pre-crisis period stayed resilient during the crisis and are relatively more efficient even after the crisis.

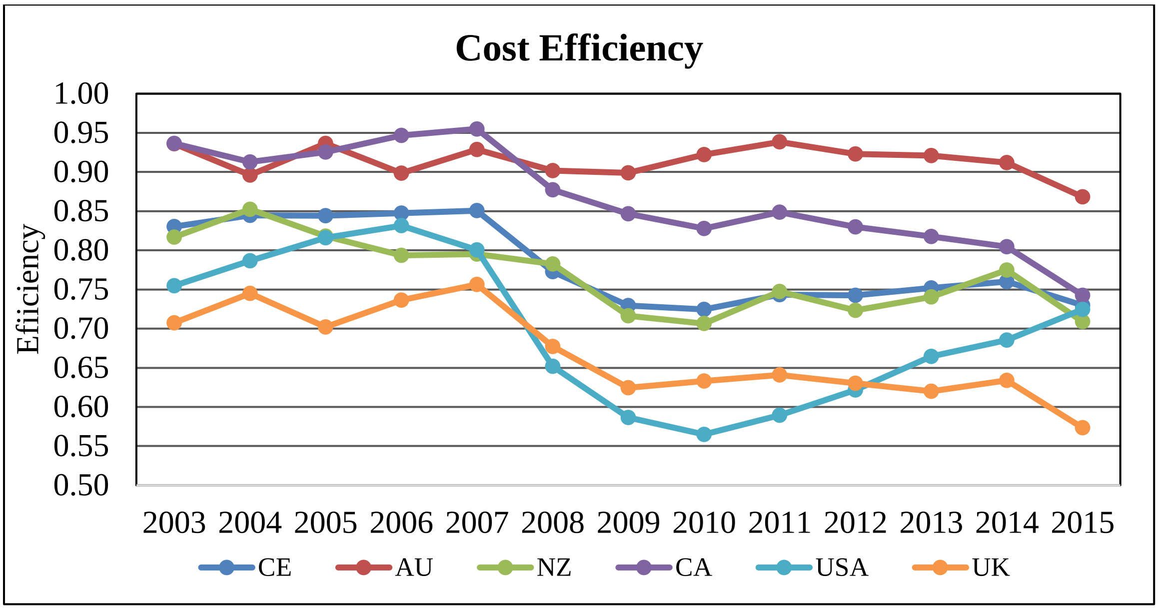


Figure 5.1 presents the annual average cost efficiency scores (CE) from the one-stage SFA for the entire sample (N = 377), estimated with equations 4.8, using FRONTIER 4.1 software. AU are results for Australian banks, NZ for New Zealand, CA for Canada, USA for the United States of America, and UK for the United Kingdom.

The level of cost efficiency has declined over the study period in all the chosen banking sectors. The impact of the GFC is visible in Table 5.2 and Figure 5.1, which was noticed in 2008 on the banks of all countries. However, some impact of the GFC was felt on the cost efficiency of the US banks in 2007. Among selected countries, the banks of Australia and Canada were the least impacted and the US and UK banks were most impacted by the GFC. The level of the cost efficiency kept declining until 2010, and recovery was noticed during 2011 in each country except Australia, where banks started improving in 2010. A dummy variable was also included in the estimation model for the GFC years, and it showed a significant and negative relationship with cost efficiency.

The levels of cost efficiency for the pre-crisis, crisis and post-crisis periods are compared for each country in Figure 5.2. On average, the banks of our selected countries were not able to achieve their pre-crisis cost efficiency levels during the post-crisis period. Average efficiency scores from the same common frontier were also compared for each country. Only the Australian banks were able to achieve the pre-crisis cost-efficiency level in the post-crisis period. None of the other country's banks were able to achieve their pre-crisis CE scores.

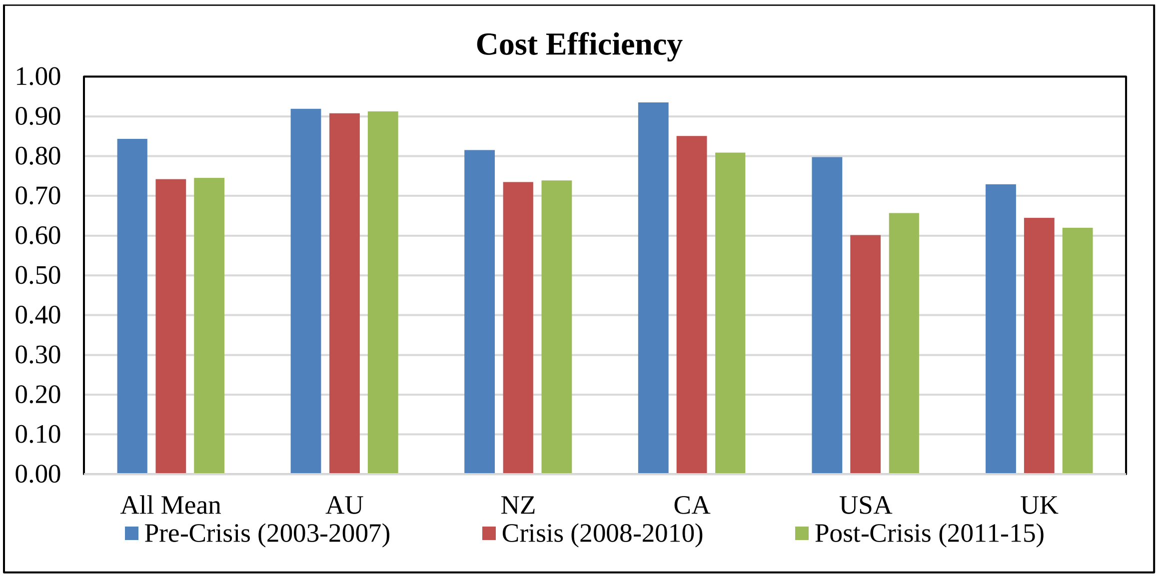


Figure 5.2: Pre- and Post-GFC CE Scores of each country

The advantages and disadvantages of using a common frontier for cross-country studies are well documented in prior studies. Similarly, the pros and cons of using a separate frontier for each country are also discussed. The major drawback of the common frontier is that cross-country differences are not completely controllable and separate frontiers may not be suitable for comparison among different nations (Berger, 2007; Xiang et al., 2015). This study followed the recommendations in Berger (2007), which suggested choosing nations with a relatively homogenous economic environment and control the remaining differences in the banking environment through econometric methods. However, we have also estimated the CE scores with separate frontiers for a few countries for robustness purposes. A comparison of CE scores from common and separate frontiers is shown in Figures 5.3 and 5.4.

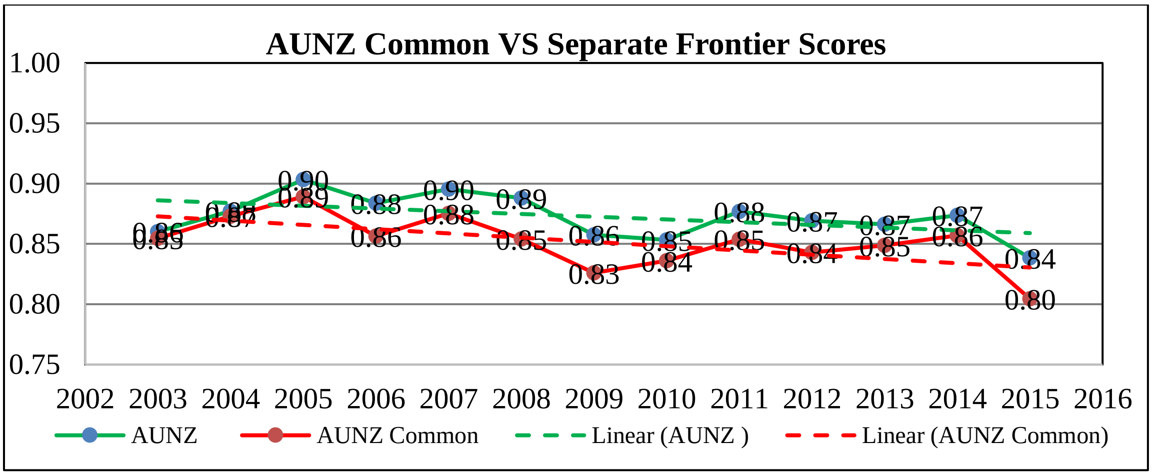


Figure 5.3 Mean Cost Efficiency Scores for Australia and New Zealand

Separate frontiers were estimated for the US banking sector (USA) and the banks of Australia and New Zealand (AUNZ) only. It was not feasible to estimate separate frontiers for the UK and Canada because of insufficient observations for separate stochastic frontiers. The economies and banks of AUNZ are very closely related and provide a sufficient number of observations for estimation; therefore, a single separate frontier was estimated for both countries. In both graphs, the average CE scores of each country estimated from the common frontiers are lower than from the separate frontiers, but the movement of scores s similar over the study period. The mean CE score of the US banks was 0.90 for the separate frontiers, and 0.68 for the common frontier. It means there was a 10% cost inefficiency in the US banking sector if we compare them with peers in the United States, but the level of cost inefficiency reached 32% when compared to other international banks. The higher cost inefficiency level of the common frontier suggests a difficulty for the US banking sector in competing globally on the basis of cost efficiency.

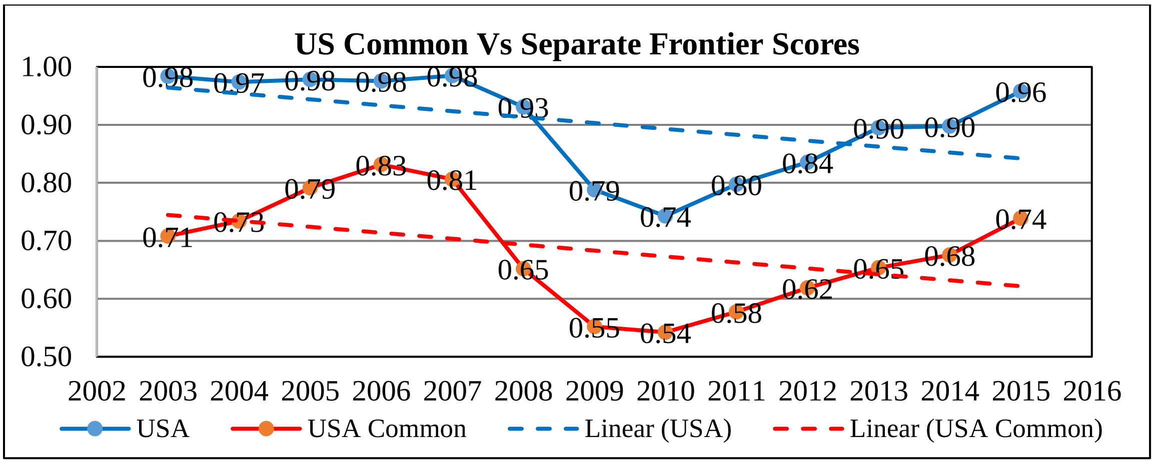


Figure 5.4 Average Cost Efficiency Scores for the USA

Conversely, the mean cost efficiency score for Australia and New Zealand was 0.87 for separate and 0.85 for common frontiers, which shows the ability of their banking sectors to compete globally. The inefficiency level for the Australian and New Zealand banks increased by only 2% when compared with other renowned international banks. The cost efficiency model is based on a minimization function, and the common frontier is actually a frontier of frontiers, so the value for the common frontier should be lower than those for separate frontiers because it has to account for the most inefficient and efficient banks of the whole sample. Also, the common cost frontier includes 10 banking environment variables and one GFC dummy that were not part of separate frontiers; the influence of those variables may have reduced the efficiency score compared to the common frontier. The consistent movement and the trend line of the cost efficiency scores from common and separate frontiers justify the selection of a common frontier for the study sample.

The reported results of these countries are consistent with results from prior studies (Vu & Turnell, 2011; Xiang et al., 2015) that show that Australian and Canadian banks have better cost efficiency compared to most other developed nations. Also, the banks of Australia, Canada, and New Zealand were among those least impacted by the GFC (Calomiris & Haber, 2014; Vu & Turnell, 2011; Xiang et al., 2015). The reasons behind the variation in the impact of the GFC on the bank efficiency of selected countries are discussed in later sections of this chapter. The use of a common frontier among countries of a similar economic environment has produced more robust results (Berger, 2007; Xiang et al., 2015). The impact of the GFC was severe on the global banking system, especially on the banks of the UK and the United States. Moreover, most of the banking sectors have not been able to achieve cost efficiency at their pre-GFC level.

5.1.2 Alternative Profit Efficiency

Profit efficiency models are based on a profit maximization function, which is a ratio of the actual profits to the predicted maximum profits that could be earned by the best banks in a sample of given inputs and outputs (Debreu, 1959; Hancock, 1985). The concept of profit efficiency is assumed to be superior to the concept of cost efficiency for evaluating the overall performance of the firm and is closer to the firm's economic goal of profit maximization. Profit efficiency accounts for errors in the output side as well as those on the input side (Berger et al., 1993). Most initial bank efficiency studies estimated technical, profit, and cost efficiencies only (Berger, 1993; Berger et al., 1987; Sherman & Gold, 1985), but some later studies introduced the concept of alternative profit efficiency (APE), which is a bit different in its estimation and assumptions (Assaf et al., 2019; Humphrey & Pulley, 1997). Today, most studies estimate APE along with cost and profit efficiencies.

In the APE model, the output amount and input prices were given, output prices were allowed to vary to achieve the maximum level of attainable profit efficiency, and the deviation from the frontier of maximum attainable profit was alternative profit inefficiency (Berger & Mester, 1997; Humphrey & Pulley, 1997). Theoretical and econometric details of this concept are discussed in the previous chapter. It is appropriate to estimate APE in this study because the selected banking sectors were not perfectly competitive and output prices could not be measured accurately. Also, the APE model provided a robustness test for our standard profit efficiency estimates. The maximum likelihood (ML) parameters for all frontier variables, along with some model statistics, are provided in Table 5.3. The APE scores and their determinants are reviewed later in this chapter.

Table 5.3 Parameter Estimates from Alternative Profit Efficiency Model

Variable	**Parameter**	**Coefficient**	**t-ratio**
Constant	α_0	3.80***	11.15
ln Y_1 (total loans)	α_1	-0.02	-0.14
ln Y_2 (total investment)	α_2	-0.09	-0.90
ln Y_3 (non-interest income)	α_3	-0.98**	-1.83
0.5(ln Y_1)(ln Y_1)	α_{11}	0.05	0.07
0.5(ln Y_2)(ln Y_2)	α_{22}	0.05**	2.07
0.5(ln Y_3)(ln Y_3)	α_{33}	-1.53***	-6.92
(ln Y_1)(ln Y_2)	α_{12}	0.03	0.90
(ln Y_1)(ln Y_3)	α_{13}	0.45***	2.65
(ln Y_2)(ln Y_3)	α_{23}	-0.25***	-3.13
ln W_1/W_3 (price of labour)	β_1	-0.12	-1.04
ln W_2/W_3 (price of physical capital)	β_2	0.24**	2.18
0.5(ln W_1/W_3)(ln W_1/W_3)	β_{11}	0.01	0.28
(ln W_1/W_3)(ln W_2/W_3)	β_{12}	0.08***	2.99
0.5(ln W_2/W_3)(ln W_2/W_3)	β_{22}	-0.08***	-4.09
(ln Y_1)(ln W_1/W_3)	ω_{11}	-0.03	-0.63
(ln Y_2)(ln W_1/W_3)	ω_{21}	-0.08	-0.28
(ln Y_3)(ln W_1/W_3)	ω_{31}	0.30***	2.39
(ln Y_1)(ln W_2/W_3)	ω_{12}	-0.08	-0.26
(ln Y_2)(ln W_2/W_3)	ω_{22}	0.01	0.81
(ln Y_3)(ln W_2/W_3)	ω_{32}	0.16***	2.56
t	λ	-0.02***	-5.41
t^2	κ	0.03***	5.31
Sigma-squared	σ^2	0.13***	7.18
Gamma	γ	0.98***	57.92
Log-likelihood function		471	
LR test		390	
Observations		377	

Note: *** and ** indicate 1% and 5% significance levels respectively. FRONTIER 4.1 software is used to estimate these parameters, based on the common frontier for all five countries.

$$\ln PBT_{it} = \alpha_0 + \sum_{n=1}^{3} \alpha_n \ln y_{nit} + \frac{1}{2}\sum_{n=1}^{3}\sum_{k=1}^{3} \alpha_{nk} \ln y_{nit} \ln y_{kit} + \sum_{j=1}^{2} \beta_j \ln w_{jit} + \frac{1}{2}\sum_{j=1}^{2}\sum_{m=1}^{2} \beta_{jm} \ln w_{jit} \ln w_{mit} + \sum_{n=1}^{3}\sum_{j=1}^{2} \omega_{nj} \ln y_{nit} \ln w_{jit} + \lambda t + \kappa t^2 + v_{it} - \mu_{it}$$

A total of 25 parameters are given in Table 5.3 with their *t*-ratios; 15 were found to be significantly different from zero. The significant results of σ^2, γ, and the LR test proved the best fit of the selected model to estimate the APE for 29 banks from five developed economies. The relationship of technological change to profitability is very similar to the earlier discussed cost function relationship, which is non-linear. This means that profit declined initially due to technological change and increased later. It looks more like a revenue phenomenon, where bank revenue declines initially and increases later due to technological change, which results in higher profits. This seems consistent with banking market conditions where banks may lose their market share with the introduction of many Fintech companies and regain their market share after restructuring and adoption of Fintech (Boot, 2017; Xue et al., 2011). The relationship of input and output variables with bank profit is very complex in a translog form (Weill, 2013; Daglish, Robertson, Tripe, & Weill, 2015) and beyond the research objectives of this study, however, the determinants of the profit efficiency are discussed later in this chapter.

The annual mean APE scores for all selected banks and each banking sector, based on the common frontier, are shown in Table 5.4. At the bottom of the table, the mean and standard deviation of the APE score for the whole study period for all banks and each country is shown. It can be observed that a lower mean efficiency score has a higher standard deviation and vice versa. The mean APE score for the study period was 0.92; in other words, the selected banks had only an 8% inefficiency level, which is lower than that of most of the developed economies (Belke et al., 2016; Matousek et al., 2015). However, there was an 11-point variation among the five selected countries, with the lowest 4% inefficiency in New Zealand; the UK banking sector had the highest, with 15% alternative profit inefficiency.

Table 5.4 Mean Alternative Profit Efficiency Scores

Year	APE	New Zealand	Australia	Canada	USA	UK
2003	0.94	0.96	0.92	0.90	0.98	0.96
2004	0.95	0.97	0.93	0.94	0.94	0.98
2005	0.95	0.97	0.93	0.92	0.97	0.97
2006	0.96	0.97	0.95	0.95	0.97	0.96
2007	0.95	0.97	0.95	0.94	0.94	0.94
2008	0.88	0.96	0.95	0.91	0.86	0.77
2009	0.87	0.93	0.96	0.90	0.79	0.82
2010	0.92	0.96	0.97	0.96	0.86	0.85
2011	0.92	0.97	0.96	0.97	0.88	0.85
2012	0.90	0.97	0.96	0.96	0.87	0.75
2013	0.89	0.97	0.97	0.95	0.87	0.73
2014	0.90	0.97	0.96	0.94	0.84	0.83
2015	0.89	0.97	0.96	0.94	0.86	0.71
Mean	**0.92**	**0.96**	**0.95**	**0.94**	**0.89**	**0.85**
Ranking		**1**	**2**	**3**	**4**	**5**
SD	**0.03**	**0.01**	**0.02**	**0.02**	**0.06**	**0.10**

Note. Annual average alternative profit efficiency (APE) scores from the one-stage SFA model for the entire sample (N = 377) were estimated with equation 4.13 using FRONTIER 4.1 software.

The ranking of selected banking sectors on the basis of their mean APE scores is shown at the bottom of Table 5.4. The New Zealand banking sector is ranked at the top, having the highest mean APE score and the lowest fluctuation during the period 2003–2015. The mean APE score of the UK banks was lowest among all five countries, and the fluctuation in their APE score was the highest over the study period. Overall, the APE level declined over the study period. As shown in Figure 5.5, most of the decline in APE might have been due to the GFC, although it may have declined due to internal vulnerabilities of the banking sector, because some countries achieved a better APE score in the post-GFC period. It can be observed from Figure 5.5 that there was not much divergence in the APE scores for the five selected countries before 2007 and that the banking sectors of the UK and the United States outperformed those of the other three countries. The varying impact of the GFC was visible from 2007 to 2009. Divergence and fluctuation in the APE level evidently increased among the five selected countries after the GFC. The banks of Australia, Canada, and New Zealand show more convergence, whereas the banks of the United States and the UK show more divergence and fluctuation in their efficiency levels.

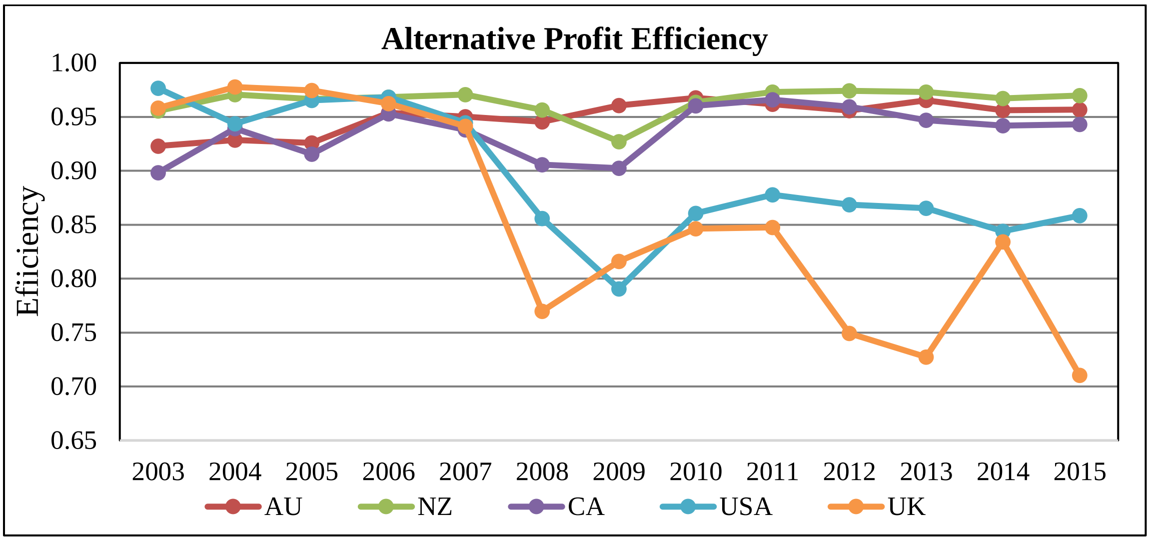


Figure 5.5. Annual mean alternative profit efficiency (APE) scores (common frontier) for each country from the one-stage SFA model for the entire sample (N = 377) estimated with equation 4.11 using FRONTIER 4.1 software. AU, results for Australian banks; NZ, for New Zealand; CA, for Canada; USA, for the United States; and UK, for the United Kingdom.

The APE levels in the pre-crisis, crisis, and post-crisis periods for each country are compared in Figure 5.6. The mean APE score for the whole study sample was the same during and after the crisis but lower than the pre-crisis efficiency level. The average APE level for Australia, Canada, and New Zealand improved in the post-crisis period relative to the pre-crisis period. The APE level for the US banking sector was similar in the post-crisis and crisis periods but lower than in the pre-crisis period. In the post-crisis period, the average APE level for the UK banks severely declined (18 points lower than the pre-crisis level).

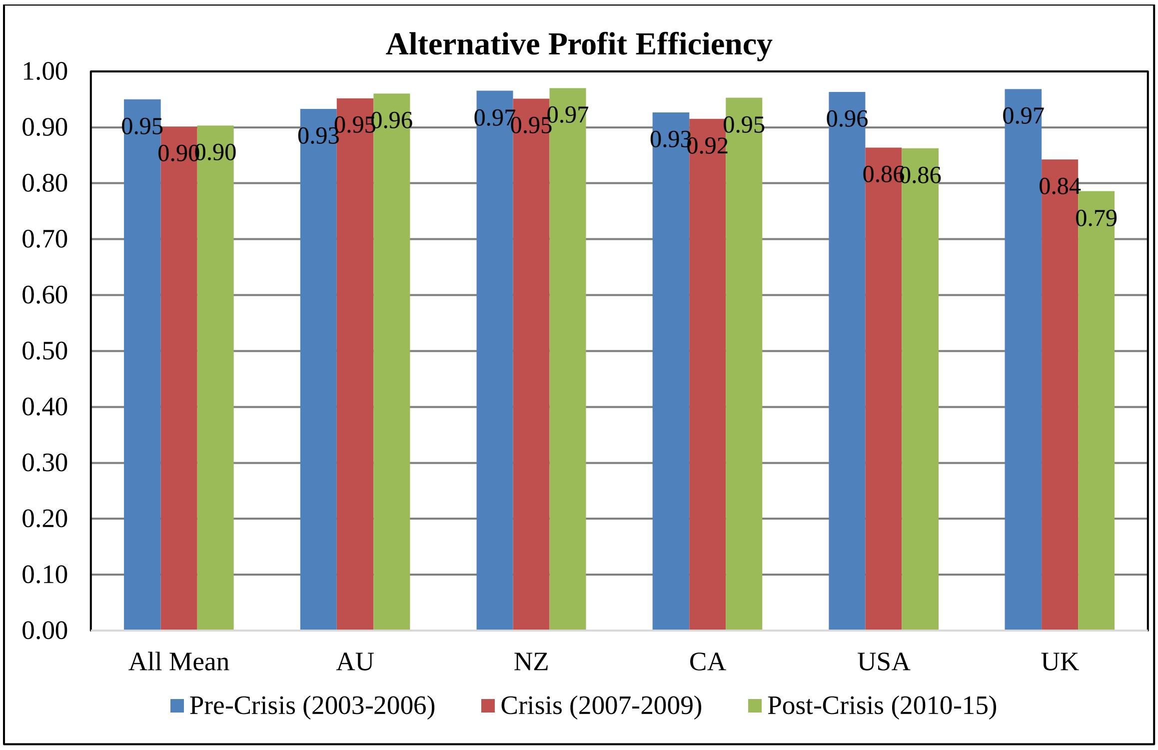


Figure 5.6. Pre- and post-GFC alternative profit efficiency scores for each country. AU, results for Australian banks; NZ, for New Zealand; CA, for Canada; USA, for the United States; and UK, for the United Kingdom

The results for common and separate cost frontiers are compared in the previous section; here we want to confirm those findings for the profit function because it is different from the cost function. A comparison of APE scores from common and separate frontiers is shown in Figures 5.7 and 5.8. In both figures, the average APE scores for each country estimated from the common frontier are higher than for the separate frontier, but the movement of the scores is similar over the study period. The common APE model includes 10 additional banking environment variables and one GFC dummy variable, compared to the separate frontier models. It might be that due to those variables, the inefficiency level for the common profit frontier was lower than the level for the separate frontiers of the selected countries. The consistent movement and trend line of the APE efficiency scores from the common and separate frontiers prove that the selection of a common frontier for the study was justified.

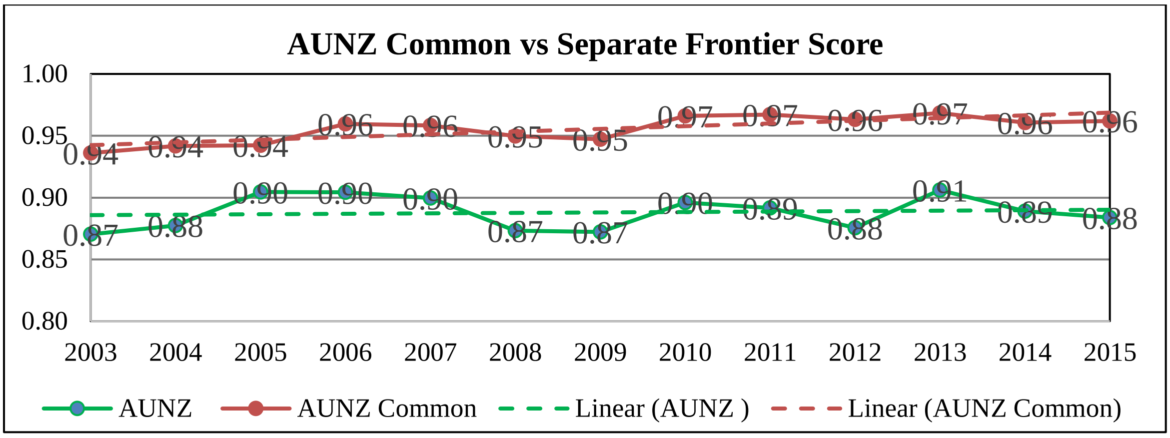


Figure 5.7. Mean alternative efficiency scores for Australia and New Zealand.

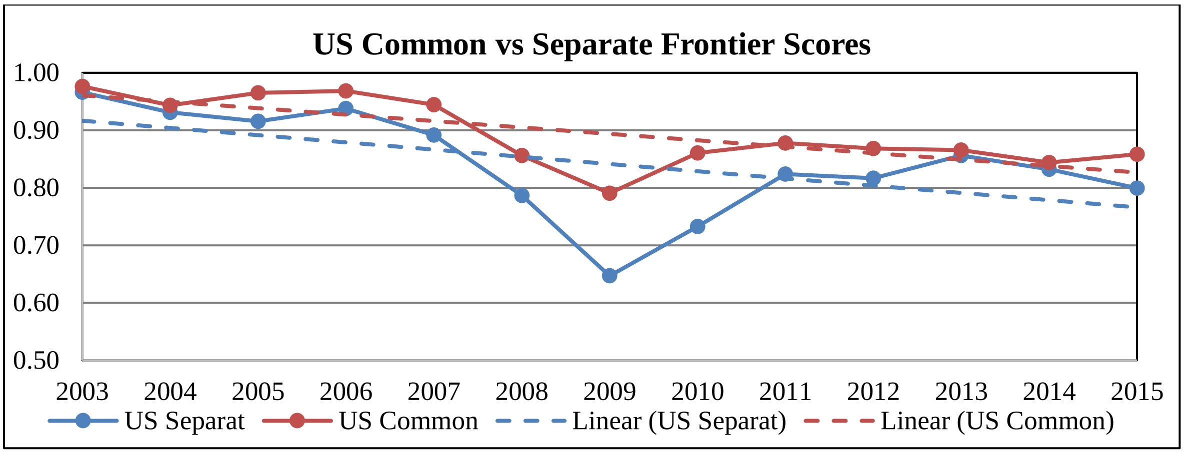


Figure 5.8. Mean alternative profit efficiency scores for the United States.

The reported APE results are consistent with those of prior studies involving the selected countries: the Australian, Canadian, and New Zealand banks were more efficient than the banks of many other developed nations (Bandyopadhyay, Jha, & Kennedy, 2017; Calomiris & Haber, 2014; Xiang et al., 2015). Also, the banks of Australia, Canada, and New Zealand were among the least impacted by the GFC. The US and UK banking sectors were among the most impacted; they have not been able to fully recover since the crisis (Greenbaum et al., 2016; Savona et al., 2011). Reported results show that the APE level did not help banks become more resilient during the GFC or the post-GFC recovery period.

5.1.3 Profit Efficiency

Profit efficiency is the ability of a bank to achieve the highest possible profit at the given prices of bank inputs and outputs. In contrast to the cost efficiency model, the profit efficiency model specifies variable profits in place of variable cost and takes variable output prices as given, rather than holding all output quantities fixed. This study used the standard profit efficiency model with two output prices (price of loans, price of other assets) and three input prices (price of labour, price of physical capital, price of funds), along with 10 banking environment variables and one GFC dummy variable in inefficiency error terms (μ). Although the APE model was also used in this study, the standard profit efficiency model used a different approach for optimization of the outputs side, as explained above. The details of the estimation model and selected variables are provided in the research methodology chapter. The ML parameters for all input, output, and time variables are reported in Table 5.5.

The model statistics σ^2, γ, and the likelihood ratio (LR) test reported in Table 5.5 show the best fit of the selected one-stage SFA model for the estimation of profit efficiency. Most of the reported parameters are also significantly different from zero and further discussion on the coefficient of these parameters is not required as per research objectives of this study. The non-linear relationship of *time* or technological change is also apparent from Table 5.5. The reported results for technological change are similar to those for the alternative profit and cost efficiency models. The possible explanation for this relationship is discussed in the previous section.

Table 5.5 Parameter Estimates of Profit Efficiency Model

Variable	Parameter	Coefficient	t-ratio
Constant	α_0	3.90***	25.65
ln P_1 (price of loans)	α_1	-0.37***	-2.33
ln P_2 (price of other assets)	α_2	0.19***	2.50
0.5(ln P_1)(ln P_1)	α_{11}	-0.34***	-2.82
0.5(ln P_2)(ln P_2)	α_{22}	0.02	0.50
(ln P_1)(ln P_2)	α_{12}	0.13***	2.41
ln W_1/W_3 (price of labour)	β_1	-0.10	-0.80
ln W_2/W_3 (price of physical capital)	β_2	0.16**	2.11
0.5(ln W_1/W_3)(ln W_1/W_3)	β_{11}	0.10	1.20
(ln W_1/W_3)(ln W_2/W_3)	β_{12}	0.01	0.38
0.5(ln W_2/W_3)(ln W_2/W_3)	β_{22}	-0.08***	-3.51
(ln W_1/W_3)(ln P_1)	ω_{11}	-0.08	-0.94
(ln W_2/W_3)(ln P_1)	ω_{21}	0.18***	4.93
(ln W_1/W_3)(ln P_2)	ω_{12}	-0.06*	-1.37
(ln W_2/W_3)(ln P_2)	ω_{22}	-0.06***	-3.13
t	λ	-0.09**	-1.89
t^2	κ	0.01*	1.60
Sigma-squared	σ^2	0.14***	11.75
Gamma	γ	0.98***	61.12
Log-likelihood function		445	
LR test		865	
Observations		377	

Note: ***, **, and * indicate 1%, 5%, and 10% significance levels, respectively. FRONTIER 4.1 software was used to estimate these parameters, based on the common frontier for all five countries.

$$\ln PBT_{it} = \alpha_0 + \sum_{s=1}^{2} \alpha_s lnp_{sit} + \frac{1}{2}\sum_{k=1}^{2}\sum_{s=1}^{2} \alpha_{ks}\ lnp_{kit}\, lnp_{sit} + \sum_{j=1}^{2} \beta_j\ lnw_{jit} + \frac{1}{2}\sum_{j=1}^{2}\sum_{m=1}^{2} \beta_{jm}\ lnw_{jit}\, lnw_{mit} + \sum_{s=1}^{2}\sum_{j=1}^{2} \omega_{sj}\ lnp_{sit}\, lnw_{jit} + \lambda t + \kappa t^2 + v_{it} - \mu_{it}$$

The annual average profit efficiency score is reported in Table 5.6, along with the mean profit efficiency score for the banking sectors of New Zealand, Australia, Canada, the United States, and the UK based on the common frontier for the period between 2003 and 2015. The average profit efficiency level for the five selected countries was 91%, which was better than for most developed economies (Belke et al., 2016; Matousek et al., 2015). However, there was a variation of 12 points in mean profit efficiency among the five banking sectors: the highest mean efficiency score was 96%, for the New Zealand banking sector; the lowest was 84%, for the UK. Table 5.6 shows that higher mean efficiency scores have lower standard deviations and vice versa, which means efficient banks are more stable than their less efficient peers.

Table 5.6 Mean Profit Efficiency Scores

Year	Profit Efficiency	New Zealand	Australia	Canada	USA	UK
2003	0.95	0.96	0.93	0.94	0.97	0.94
2004	0.95	0.96	0.93	0.96	0.95	0.96
2005	0.95	0.95	0.94	0.94	0.95	0.96
2006	0.96	0.95	0.96	0.97	0.95	0.95
2007	0.95	0.96	0.97	0.95	0.93	0.96
2008	0.86	0.95	0.95	0.90	0.81	0.73
2009	0.87	0.95	0.94	0.89	0.78	0.83
2010	0.91	0.95	0.95	0.95	0.86	0.83
2011	0.90	0.96	0.95	0.96	0.87	0.80
2012	0.90	0.96	0.94	0.96	0.87	0.74
2013	0.91	0.96	0.96	0.96	0.87	0.81
2014	0.90	0.97	0.95	0.96	0.84	0.79
2015	0.89	0.97	0.95	0.96	0.87	0.67
Mean	**0.91**	**0.96**	**0.95**	**0.95**	**0.89**	**0.84**
Ranking		**1**	**2**	**3**	**4**	**5**
SD	**0.03**	**0.01**	**0.01**	**0.02**	**0.06**	**0.10**

Note: Annual average profit efficiency (APE) scores from the one-stage SFA model for the entire sample (N = 377) were estimated with equation 4.14 using FRONTIER 4.1 software.

All banking sectors are ranked on the basis of overall mean profit efficiency scores at the bottom of Table 5.6. The mean profit efficiency score for the New Zealand banking sector was ranked first among the five countries, followed by the Australian banking sector. Although the mean profit efficiency score for the Canadian banking sector appears equal to that of its Australian counterpart, it is actually lower by three decimal points. Therefore, the Canadian banking sector was ranked in third place; its fluctuation was also higher than that of the Australian banking sector. The mean profit efficiency scores for New Zealand, Australia, and Canada improved over the study period. However, the mean efficiency scores for the United States and the UK declined from 2003 to 2015. Therefore, overall mean profit efficiency scores also declined. The decline in profit efficiency was apparent during the GFC in all selected countries, but subsequent recovery is not visible in the US and UK banking sectors.

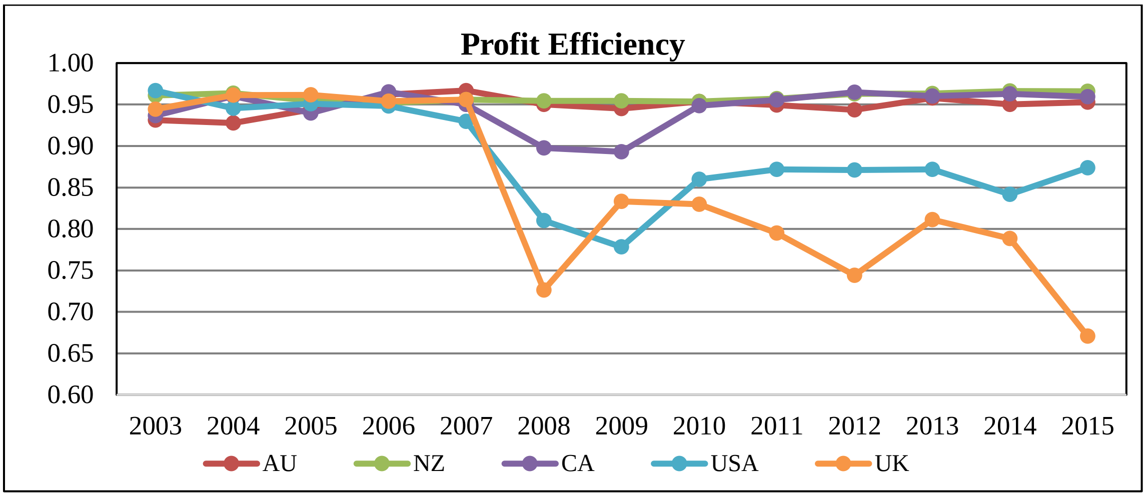


Figure 5.9. Annual mean profit efficiency scores (common frontier) for each country from the one-stage SFA model for the entire sample (*N* = 377) estimated with equation 4.12 using FRONTIER 4.1 software. AU, results for Australian banks; NZ, for New Zealand; CA, for Canada; USA, for the United States; and UK, for the United Kingdom.

The impact of GFC is more visible in Figure 5.9, which exhibits overall mean profit efficiency scores for all selected banks along with mean profit efficiency scores for each country estimated from the same common frontier. There is no considerable difference in annual mean profit efficiency scores for the five countries before the GFC. The varying impact of the GFC is apparent in Figure 5.9 and Table 5.6. The impact of the GFC was first observed in 2007 in the United States and Canada. The GFC originated in the United States, which is heavily integrated with the Canadian economy; therefore, the impact of GFC was first observed in those two economies. The severe impact of the crisis was visible across all countries in 2008 and continued in 2009. The banks of New Zealand, Australia, and Canada were less impacted than those in the United States and the UK, which is consistent with the findings of prior studies (Calomiris & Haber, 2014; Xiang et al., 2015). Recovery in the selected banking sectors started in 2010 and continued in a stable fashion in Australia, Canada, and New Zealand. The recovery path of the United States and the UK was rough after 2008, and general optimism was not visible before the end of 2015. The banking sectors of Australia, Canada, and New Zealand show more convergence in their profit efficiency scores after the crisis period, and an increased fluctuation is observed in profit efficiency scores of the United States and the UK.

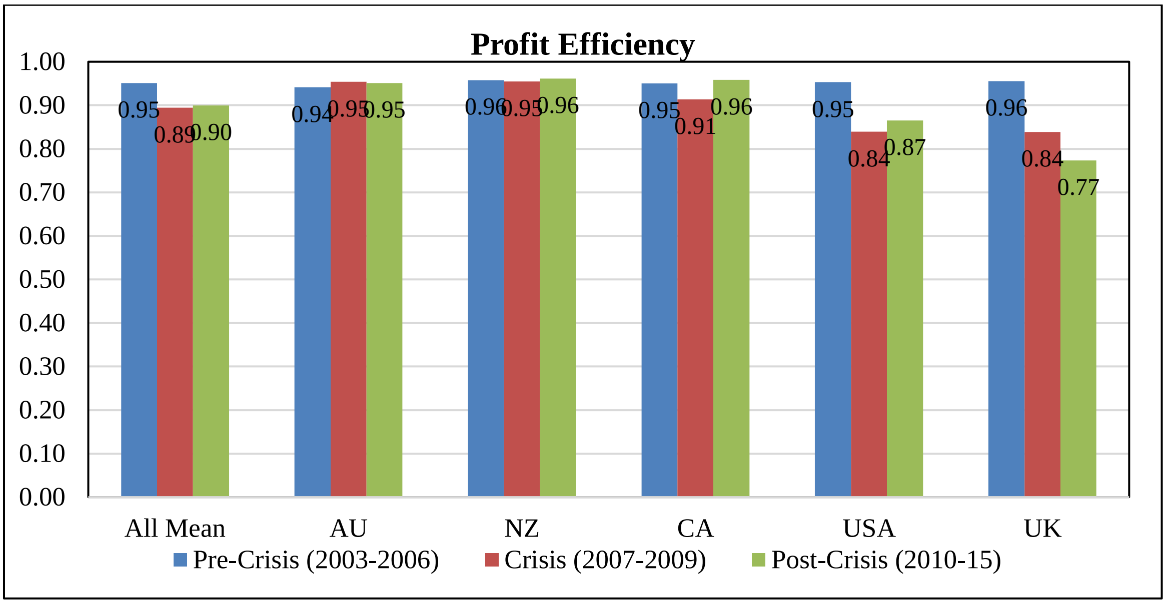


Figure 5.10. Pre- and post-GFC profit efficiency scores for each country. AU, results for Australian banks; NZ, for New Zealand; CA, for Canada; USA, for the United States; and UK, for the United Kingdom.

The mean profit efficiency scores for each country are compared for the pre-crisis, crisis, and post-crisis periods in Figure 5.10. Overall mean profit efficiency scores for the pre-crisis, crisis and post-crisis periods are also compared. Although the group of selected banks was able to increase mean profit efficiency from 89% to 90% after the crisis, it was still four points lower than in the pre-crisis period. This shows that banks have not been able to fully recover from the impact of GFC. The banking sectors of Australia, New Zealand, and Canada posted higher mean profit efficiency levels in the post-GFC period than in the pre-crisis period. The banking sector of the United States gained efficiency after the crisis period but has not been able to achieve a level equal to its pre-crisis efficiency level of 95%. In the UK, the pre-crisis profit efficiency level of 95% dropped to 84% during the crisis and fell further to 77% after the crisis. The pre-GFC level of profit efficiency did not help banks become more resilient during the crisis or in the post-GFC recovery period.

The findings of the profit efficiency analysis are consistent with the results of prior studies showing that Australian, Canadian, and New Zealand banks had higher profit efficiency than most other developed nations and were least impacted by the GFC (Calomiris & Haber, 2014; Xiang et al., 2015). The banking sectors of the United States and the UK were among the most impacted and have not fully recovered (Greenbaum et al., 2016; Savona et al., 2011). Results for profit efficiency are very similar to results for the APE, but the standard profit efficiency model added some further information to our analysis. The score for profit efficiency is a little less than that for the APE, and its fluctuation is also slightly different because profit efficiency is based on given output prices, which are not given in APE models. Thus, the use of the standard profit efficiency model has complemented and validated our findings from the APE models.

5.1.4 Shareholder Value Efficiency

Shareholder value efficiency (SVE) is a concept of relative performance, and it means the maximum possible shareholder value among peers. A shareholder value efficient bank produces the maximum possible shareholder value with its given output and input prices (Fiordelisi, 2007). This study used the one-stage SFA model to estimate SVE for 29 chosen banks for the period of 2003–2015. The SVE estimation model is similar to the APE model, which is based on three input prices (W_1, W_2, W_3) and three output quantities (Y_1, Y_2, Y_3). The dependent variable is economic value added (EVA) rather than profits before tax. Further details of this model are discussed in the research methodology chapter.

Most of the reported ML parameter coefficients of the estimation model are significant, as shown in Table 5.7. The model statistics σ^2, γ, and the LR test confirmed the best fit of the one-stage SFA model for the estimation of SVE. As discussed earlier, further discussion about the coefficients of parameters not required and the impact of time (t) or technological change is similar to profit efficiency models. Detail of the variables included in inefficiency error terms is discussed later in this chapter.

Table 5.7 Parameter Estimates of Shareholder Value Efficiency Model

Variable	Parameter	Coefficient	t-ratio
Constant	α_0	3.80***	14.75
ln Y_1 (total loans)	α_1	-0.10	-0.75
ln Y2 (total investment)	α_2	0.06	0.84
ln Y3 (non-interest income)	α_3	-0.57*	-1.47
0.5(ln Y_1)(ln Y_1)	α_{11}	0.04	0.70
0.5(ln Y_2)(ln Y_2)	α_{22}	-0.02	-0.70
0.5(ln Y_3)(ln Y_3)	α_{33}	-1.47***	-8.29
(ln Y_1)(ln Y_2)	α_{12}	-0.01	-0.58
(ln Y_1)(ln Y_3)	α_{13}	0.36***	2.95
(ln Y_2)(ln Y_3)	α_{23}	-0.01	-0.21
ln W_1/W_3 (price of labour)	β_1	-0.16**	-1.64
ln W_2/W_3 (price of physical capital)	β_2	0.16**	1.95
0.5(ln W_1/W_3)(ln W_1/W_3)	β_{11}	-0.09**	-2.08
(ln W_1/W_3)(ln W_2/W_3)	β_{12}	0.08***	3.42
0.5(ln W_2/W_3)(ln W_2/W_3)	β_{22}	-0.06***	-3.88
(ln Y_1)(ln W_1/W_3)	ω_{11}	-0.08	-0.21
(ln Y_2)(ln W_1/W_3)	ω_{21}	-0.03*	-1.31
(ln Y_3)(ln W_1/W_3)	ω_{31}	0.22**	2.09
(ln Y_1)(ln W_2/W_3)	ω_{12}	0.01	0.05
(ln Y_2)(ln W_2/W_3)	ω_{22}	0.02	0.12
(ln Y_3)(ln W_2/W_3)	ω_{32}	0.03	0.67
t	λ	-0.01***	-3.64
t^2	κ	0.002***	2.96
Sigma-squared	σ^2	0.11***	9.49
Gamma	γ	0.99***	92.02
Log likelihood function		514	
LR test		588	
Observations		377	

Note: ***, **, and * indicate 1%, 5%, and 10% significance levels, respectively. FRONTIER 4.1 software was used to estimate these parameters, based on the common frontier for all five countries.

$$\ln EVA_{it} = \alpha_0 + \sum_{n=1}^{3} \alpha_n \, lny_{nit} + \frac{1}{2}\sum_{n=1}^{3}\sum_{k=1}^{3} \alpha_{nk} \, lny_{nit} lny_{kit} + \sum_{j=1}^{2} \beta_j \, lnw_{jit} + \frac{1}{2}\sum_{j=1}^{2}\sum_{m=1}^{2} \beta_{jm} \, lnw_{jit} lnw_{mit} + \sum_{n=1}^{3}\sum_{j=1}^{2} \omega_{nj} \, lny_{nit} lnw_{jit} + \lambda t + \kappa t^2 + v_{it} - \mu_{it}$$

Table 5.8 shows the annual average SVE for all banks, along with the mean for each country, based on the common frontier. The technical details of efficiency estimation have been discussed previously. The mean SVE score for all banks is 0.92 for the period 2003–2015, which means that the shareholder value inefficiency for the selected banks in the five countries is 8%. However, the level of inefficiency varies for each country, ranging from the lowest, 3%, in New Zealand to the highest, 17%, in the UK. A higher standard deviation or fluctuation of SVE relative to profit efficiency measures was expected because some market data is involved in the measurement of EVA. Although the proxy for market data of non-listed New Zealand banks is the data from their parent bank in Australia, the level of SVE and its standard deviation are different from those of their Australian parent banks. The lowest fluctuation in SVE is for the Australian banks, and the highest is for the UK banks. The reasons behind this variation in the level of SVE and its standard deviation are discussed later in this chapter.

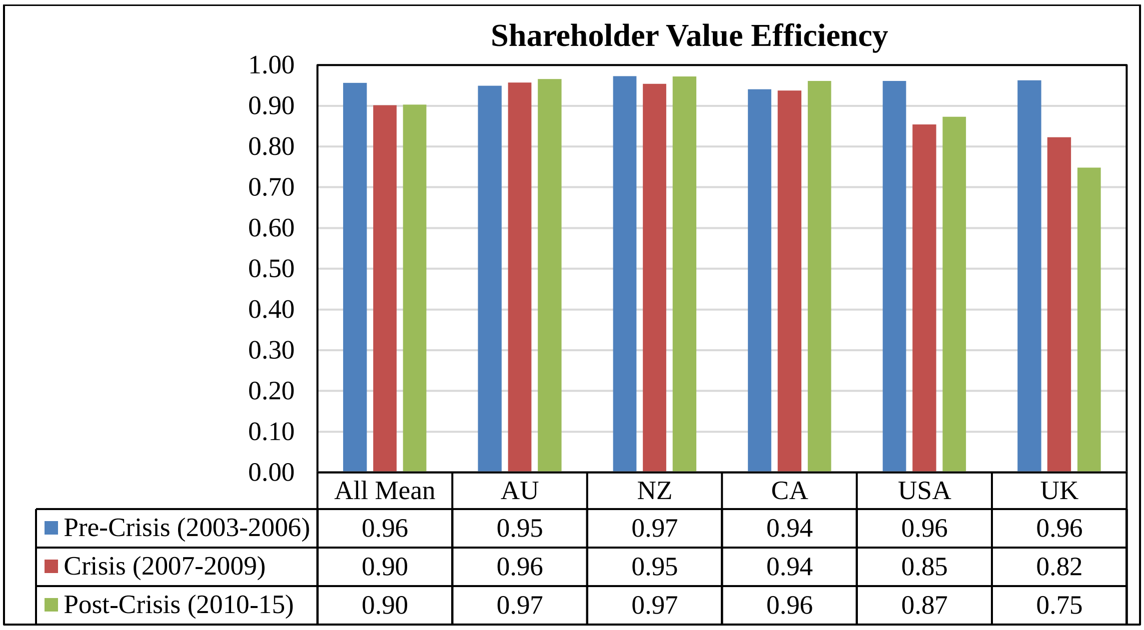
The banking sectors of all five countries are ranked at the bottom of Table 5.8 on the basis of overall mean SVE scores during the study period. The mean SVE score for the New Zealand banking sector is ranked first; Australia is ranked second, with a mean SVE score 0.96; and Canada, third. Mean SVE scores for the United States and the UK are lower and standard deviations are higher than the other three selected countries. The decline in SVE is apparent during the study period. The SVE did not help banks of the selected countries become more resilient during the GFC; furthermore, the level of SVE declined over the period.

Table 5.8 Mean Shareholder Value Efficiency (SVE) Scores

Year	Mean SVE	New Zealand	Australia	Canada	USA	UK
2003	0.96	0.97	0.96	0.94	0.97	0.96
2004	0.96	0.97	0.95	0.95	0.96	0.97
2005	0.95	0.97	0.94	0.91	0.96	0.96
2006	0.96	0.98	0.95	0.97	0.96	0.96
2007	0.95	0.98	0.95	0.95	0.93	0.96
2008	0.89	0.97	0.97	0.93	0.86	0.75
2009	0.86	0.92	0.95	0.93	0.77	0.75
2010	0.91	0.95	0.97	0.98	0.92	0.74
2011	0.94	0.98	0.98	0.96	0.92	0.85
2012	0.89	0.97	0.96	0.98	0.84	0.70
2013	0.88	0.97	0.96	0.94	0.81	0.76
2014	0.89	0.98	0.97	0.95	0.86	0.70
2015	0.90	0.98	0.97	0.95	0.88	0.74
Mean	**0.92**	**0.97**	**0.96**	**0.95**	**0.90**	**0.83**
Ranking		**1**	**2**	**3**	**4**	**5**
SD	**0.04**	**0.02**	**0.01**	**0.02**	**0.06**	**0.11**

Note. Annual average shareholder value efficiency (SVE) scores from the one-stage SFA model for the entire sample (*N* = 377) were estimated with equation 4.17 using FRONTIER 4.1 software.

A variation in the impact of the GFC on SVE is visible during the crisis period of 2007–2009. The impact of the crisis was first felt in Canada and the United States during 2007, and it spread to the UK and New Zealand the next year. The worst across-the-board impact of the GFC was felt in 2009, and all selected banking sectors started to recover in 2010 except the UK. The banking sector of Australia was the least impacted of the five selected countries, and it was one of the least impacted among most of the developed economies (Calomiris & Haber, 2014; Xiang et al., 2015). A dummy variable for the crisis period 2008–2009 is included in the estimation model; it reported a negative and significant relationship with SVE. Commonly, informationally efficient markets feel market sentiments earlier and adjust more quickly than the accounting data. Therefore, the period of GFC impact on SVE is a bit different from profit efficiencies, and it fluctuates more. It proves the effectiveness of operational efficiency as a performance measure in informationally efficient financial markets.



	All Mean	AU	NZ	CA	USA	UK
Pre-Crisis (2003-2006)	0.96	0.95	0.97	0.94	0.96	0.96
Crisis (2007-2009)	0.90	0.96	0.95	0.94	0.85	0.82
Post-Crisis (2010-15)	0.90	0.97	0.97	0.96	0.87	0.75

Figure 5.11. Pre- and post-GFC shareholder value efficiency scores for each country. AU, results for Australian banks; NZ, for New Zealand; CA, for Canada; USA, for the United States; and UK, for the United Kingdom.

Average SVE scores for each country, based on the common frontier, are compared for the pre-crisis, crisis, and post-crisis periods in Figure 5.11. The banking sectors of Australia, Canada, and New Zealand were able to post better mean SVE values in the post-GFC period relative to the pre-crisis period. The US banking sector improved its SVE score after the crisis, however, the score was lower than in the pre-crisis period. The SVE score for the UK dropped to 0.82 from 0.96 during the crisis and further fell to 0.75 after the crisis. Overall, an improvement in SVE is apparent in the last year of the study period; this trend is expected to persist because global financial markets have been gaining for the last few years. The varying impact of the GFC and divergence in the recovery of the selected bank sectors are further explored at the end of this chapter.

The SVE results are consistent with profit and the APE, but the impact of the GFC and the movement of the efficiency score are a bit different. The SVE superiority in the Australian, Canadian, and New Zealand banks persists, compared to levels in most developed economies (Belke et al., 2016; Calomiris & Haber, 2014; Xiang et al., 2015). The varying impact of the GFC is apparent during the crisis and increases the divergence and fluctuation in the level of SVE in the post-crisis period. The next section discusses the role of different banking environment variables in varying the impact of the GFC on measures of bank efficiency.

5.2 Banking Environment and Bank Efficiency

A set of 10 banking environment variables and one GFC dummy are included in each efficiency estimation model for three reasons. First, these variables help to control for remaining cross-country differences in the banking environment of otherwise relatively homogeneous economies. Although using this set of variables is unlikely to control for all differences among various banking sectors, the careful selection of environmental/environment-related variables can minimize them (Berger, 2007). Second, these banking environment variables or determinants of bank efficiency can be used to estimate more precise efficiency scores. Prior studies found that environmental factors account for about 20% of the differences in efficiency among a group financial institutions (Bos & Kool, 2006). Third, the inclusion of banking environment variables can help identify the role of each variable in the operational efficiency of banks. A positive or negative relationship of these determinants of bank efficiency may suggest policy implications for bank management and regulators. Therefore, each SFA model for cost, profit, alternative profit, and SVE has 10 banking environment variables altogether in inefficiency error terms along with a dummy for the crisis period. Banking environment variables are further divided into three groups on the basis of their theoretical background for analysis purposes. The selection of these variables was based on the findings of prior studies and a review of each selected economy. Details of these variables and models are provided in the research methodology chapter.

The software FRONTIER 4.1 reports the relationship of selected variables to inefficiency scores in each model. The signs of the reported coefficients are reversed to show their relationship to efficiency scores. A positive sign for coefficients denotes that an increase in a selected variable may increase the efficiency score and vice versa. The results for the whole study period (2003–2015) and the pre-crisis (2003–2006), crisis (2007–2009), and post-crisis (2010–2015) periods are reported. The results for the whole study period are based on the common frontier of all banks for the period 2003–2015. However, the results for the pre-crisis, crisis, and post-crisis periods are based on separate common frontiers for each period. The coefficients of each variable are estimated for three different periods so that the difference in the behavior of these variables before, during, and after the GFC can be observed. The efficiency scores from three separate common frontiers are consistent with the score for the common frontier for the whole study period. The relationship of each banking environment variable to cost, profit, alternative profit, and shareholder value efficiencies is discussed in the next few sub-sections.

5.2.1 Macroeconomic Variables

The first group of variables included in estimation models consists of the macroeconomic variables that help control for the differences in the economic environment among the five economies. The reasons for selecting these variables are discussed in the research methodology chapter. The macroeconomic variables are the nominal interest rate, GDP per capita, and population density.

Nominal interest rate. Differences in nominal interest rates across countries can impact bank funding costs and profit margins. The inclusion of the nominal interest rate in the estimation model helps to control for cross-country differences in interest rates and allows one to observe its impact on bank efficiency. The annual average 5-year bond rate for each country for each year from 2003 to 2015 is shown in Figure 5.12. The level of nominal interest rates fell during the study period, and movement was quite similar in all countries except Australia. The mean interest rate was highest in New Zealand and the lowest in the United States.

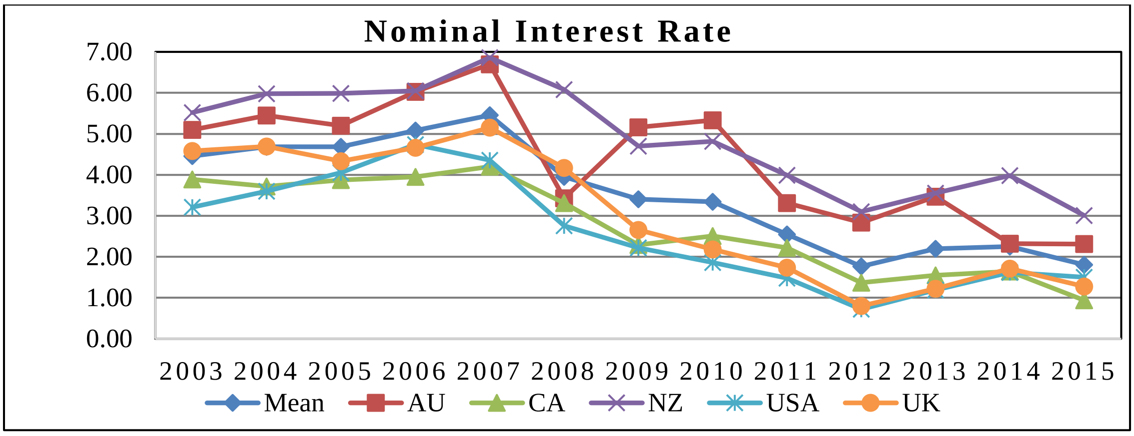


Figure 5.12. The annual nominal interest rate for 5-year bonds in each country. Mean = average of all countries for a given year. AU, results for Australian banks; CA, for Canada; NZ, for New Zealand; the USA, for the United States; and UK, for the United Kingdom.

A positive and significant relationship between the nominal interest rate and cost efficiency is reported in Table 5.9 for the period 2003–2015. This shows that a higher interest rate can help banks to improve their cost efficiency. The reported results are consistent with those of prior studies that state that a low interest rate impairs bank performance and compresses net interest margins (Bikker & Vervliet, 2018; Delis & Kouretas, 2011; Hancock, 1985). As a result, banks react by easing their lending standards, incurring more loan losses. Another reason for reduced cost efficiency in a lower interest rate environment is the decrease in deposit rates offered by the banks. It is difficult for banks to attract funds at low interest rates, so they cut their margin to try to attract more funds, which increases their costs and may lower their cost efficiency. However, some country-specific studies have found a negative impact of interest rate on bank efficiency (Avkiran, 2009). It may be concluded that a higher interest rate contributes to better cost efficiency.

The lack of a relationship between the interest rate and profit efficiency is observed in Table 5.9; this lack of relationship means the level of the interest rate has not impeded profit efficiency at given input and output prices. There was no impact of interest rate on profit efficiency before the GFC, but the effect became negative and significant during the crisis, implying that banks were not able to sell optimal levels of products and services because of low demand. As mentioned earlier, in profit efficiency the optimal level of output is estimated to maximize profit with given output prices. The impact of interest rate turns positive in the post-GFC period because the demand for bank products and services increases with growth in selected economies.

Table 5.9

Nominal Interest Rate and Bank Efficiency

Variable	2003–2015	2003–2006	2007–2009	2010–2015
Cost efficiency	0.27***	0.08	-0.05	0.18***
Profit efficiency	-0.06	-0.04	-1.26***	0.10*
Alternative profit efficiency	0.58***	0.11	-0.32***	0.26*
Shareholder value efficiency	0.57***	-0.04	0.35***	0.39***

***, **, and * indicate 1%, 5%, and 10% significance levels, respectively.

The positive relationship of the nominal interest rate to APE implies that higher interest rates helped banks to achieve better APE. This relationship is different from standard profit efficiency, which means the interest rate is more important in setting prices of bank outputs than in selling output quantity. As discussed earlier, APE is estimated for optimal levels of output prices and profit efficiency is estimated for optimal levels of output quantity. The relationship with interest rate turned negative during the GFC period: the lower demand for bank output during the crisis lowered both the price and quantity of bank outputs. It may be concluded that the expansionary monitory policies of the chosen economies helped banks emerge from the crisis and achieve better profit efficiency, especially when they had more power to set output prices.

The positive and significant relationship between the interest rate and SVE implies that the level of interest rates made a positive contribution toward improving SVE of the five banking sectors during the study period. This means that higher interest rates in a country allow banks to set a better price for their outputs and create more value for their shareholders. Although there was no significant relationship between the interest rate and SVE in the pre-GFC period, the relationship was positive and consistent during and after the GFC. The positive influence of interest rates during the crisis period might have been due to the lower opportunity cost for shareholders. Overall results prove that a higher interest rate supports better cost, profit, and shareholder values. Better efficiency is achieved through the lower cost of funds and better prices for their outputs.

GDP per capita. GDP per capita is used to control for the difference in income level among countries and to explore the relationship of GDP to bank efficiency for policy implications. The annual average GDP per capita for each country in US dollars during the study period is shown in Figure 5.13. GDP per capita increased over the study period; Australians experienced the highest growth in average income. The level of average income is lowest in New Zealand and the highest in the United States. A decline in GDP per capita for countries other than the United States during 2015 is due to the lower exchange rate for their currencies against the US dollar.

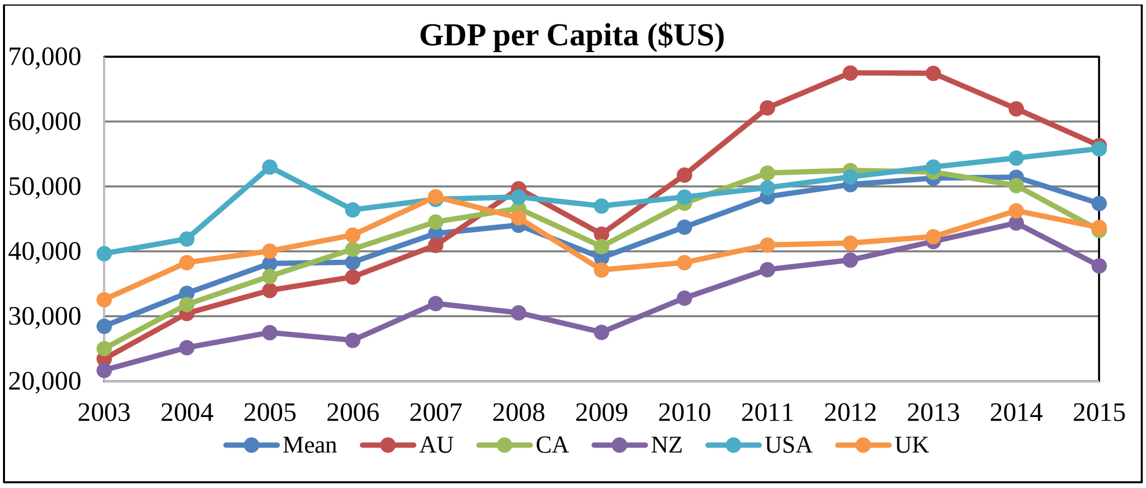


Figure 5.13. Annual average GDP per capita for each country. Mean = average of all countries for a given year. AU, results for Australia; CA, for Canada; NZ, for New Zealand; USA, for the United States; and UK, for the United Kingdom.

The relationship between GDP per capita and different measures of bank efficiency is reported in Table 5.10. The average income level of selected countries helped banks achieve better cost efficiency. Normally, high-income clients have more banking products, which can offer scale and scope economies for banks. Although the relationship between cost efficiency and GDP per capita was not highly significant for the whole period, this relationship was stronger before and after the GFC. The level of consumer income did not impact bank performance during the crisis. This proves that higher levels of income can help banks improve their cost efficiency during normal times, although the level of customer income did not matter for banks during the crisis. Furthermore, the level of GDP per capita declined during the crisis period, alongside bank efficiency levels.

The estimation model shows a positive and significant impact of GDP per capita on profit efficiency in Table 5.10. The level of significance is 10%, which means that higher income helped banks achieve better profit efficiency in 90% of cases. It becomes clearer when the results for the three sub-periods are compared. There was no impact from customer income level during the GFC, which means that people did not want to buy more banking products during the crisis. The relationship between income level and profit efficiency turned negative after the crisis. It seems that most bank products and services were bought by lower-income customers after the GFC; high-income clients only consolidated their portfolios. The results of the APE model are quite similar to those of the profit efficiency model, except they have a stronger level of significance. This means that banks may set higher output prices for high-income clients in order to achieve better profit efficiency. This relationship turned negative and significant during the crisis period, which means banks were not able to set higher prices for their outputs during the low-demand period of the GFC. Income level is otherwise positively associated with bank profit efficiency.

Table 5.10

GDP per Capita and Bank Efficiency

Variable	2003–2015	2003–2006	2007–2009	2010–2015
Cost efficiency	1.55*	3.55**	-0.25	11.61***
Profit efficiency	7.35*	0.82	0.05	-1.94**
Alternative profit efficiency	1.68***	3.50***	-5.40***	-6.68
Shareholder value efficiency	8.36***	1.32	-1.11	-1.69

***, **, and * indicate 1%, 5%, and 10% significance levels, respectively.

The results in Table 5.10 show a positive and significant relationship between GDP per capita and SVE. This implies that a higher income level in a country can help banks to achieve better SVE when prices of their outputs are set at an optimal level. A 1% increase in income level can increase the SVE of the banks by 8.36%, which is quite encouraging. The relationship between GDP per capita and SVE was not significant during or after the GFC. The conclusion of the results reported in Table 5.10 is consistent with prior studies (Delis & Tsionas, 2009; Xiang et al., 2015): that the average level of income in a country can help banks to achieve better efficiency, but this relationship may change in different phases of the economic cycle.

Population density. The human population per square kilometer is a control variable for banking environment differences among the studied countries. Differences in population density are presented in Figure 5.14. Population density increased in all chosen countries during the period 2003–2015. Among the five countries, the population density was highest in the UK and the lowest in Australia. A higher population density is an opportunity for banks, as well as a challenge. They need to spend more to provide products and services to more people, but it is also an opportunity to get more business from a larger population using the same distribution network. Several prior studies reported a positive relationship between population density and bank efficiency (Chaffai et al., 2001; Dietsch & Lozano-Vivas, 2000). A change in this relationship is expected due to changing banking and technological dynamics.

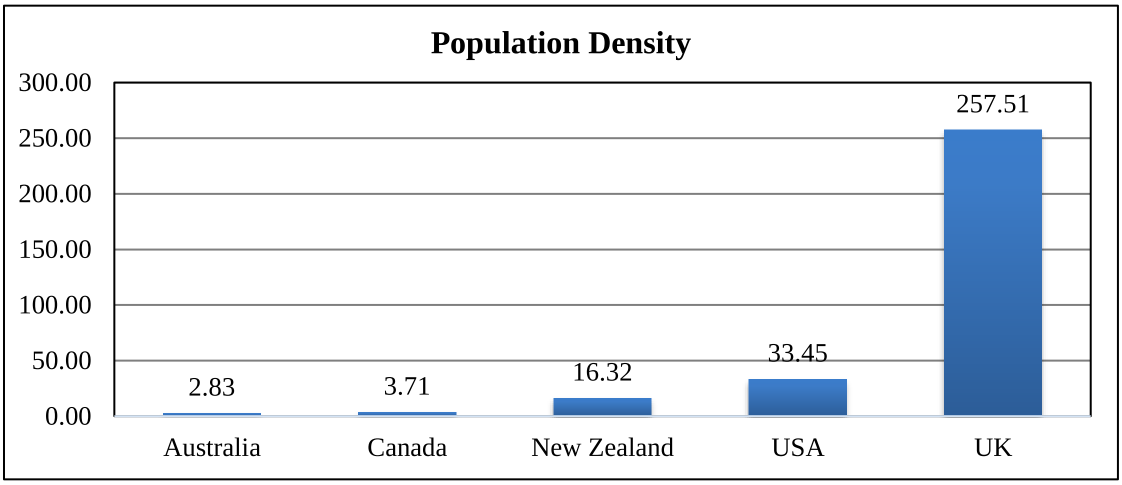


Figure 5.14. Population density per square kilometre for each country.

All four estimation models in this study reported a negative and significant relationship between population density and bank efficiencies, as shown in Table 5.11. This means that banks are not able to spend optimally on their distribution networks to serve a higher population; it is cheaper to serve fewer people through their service channels. In other words, banks do not earn correspondingly more profit from their investment in distribution networks to serve a larger population. Most Fintech companies offer cheaper and more convenient banking products, which compels banks to lower their margins, too. The argument around Fintech becomes clearer once we compare the relationship between population density profit efficiencies in the three sub-periods. The impact of population density was positive and significant before the crisis, but it turned negative during and after the GFC when there was a spur in momentum for Fintech adoption.

Table 5.11

Population Density and Bank Efficiency

Variable	2003–2015	2003–2006	2007–2009	2010–2015
Cost efficiency	-08***	-0.07***	-0.06***	-0.09***
Profit efficiency	-0.18***	0.02***	-0.24***	-0.20***
Alternative profit efficiency	-0.12***	0.05**	-0.12***	-0.49**
Shareholder value efficiency	-0.22***	0.03***	-0.05***	-0.47***

***, **, and * indicate 1%, 5%, and 10% significance levels, respectively.

These results are consistent with the findings of several recent studies that claimed that customer adoption of online banking can reallocate demand for services across multiple service channels, affecting the optimal capacity of other banking channels, such as branches or ATMs (Boot & Thakor, 2018; Xue et al., 2011). Moreover, transaction-oriented banking has moved to online channels, which has challenged the scope and scale economies of existing distribution networks (Boot, 2017). It seems that bank investments, in developing their distribution network for a larger population and the adoption of online banking, caused sub-optimal utilization of their investments in other service channels. Furthermore, it seems all banks are competing for business in more populated urban centers, giving customers more bargaining power, which reduces bank profitability. It may be concluded that sub-optimal utilization of bank distribution channels has negatively impacted bank efficiencies. Moreover, the negative impact of population density on profit efficiencies has led to negative outcomes for shareholder value.

Overall, two macroeconomic variables, nominal interest rate and GDP per capita have helped banks to achieve better efficiencies, however, population density has not. Overall results are consistent with the findings of several past and recent studies (Bikker & Vervliet, 2018; Delis & Tsionas, 2009; Xiang et al., 2015; Xue et al., 2011). The statistically significant relationship of selected macroeconomic variables to all measures of bank efficiency proves the importance of the macroeconomic environment in the estimation of bank efficiency. The use of the one-stage SFA model has helped record the important role of macroeconomic variables in a precise estimation of various bank efficiencies during the study period.

5.2.2 Bank Risk Variables

Many prior studies have concluded that lenient regulations, reliance on short-term funding, excessive risk-taking, and failure of corporate governance were responsible for the GFC (Anginer & Demirguc-Kunt, 2014b; Greenbaum et al., 2016; Hoque, Andriosopoulos, Andriosopoulos, & Douady, 2015). Therefore, four banking risk variables are included in the estimation models. These are the loans to assets ratio, the equity ratio, the loan losses to total loans ratio, and the *Z*-score. These variables helped to increase the precision of bank efficiency scores, and their relationship to bank efficiencies has important policy implications for bank management and regulators. The theoretical background and selection of these variables are discussed in earlier chapters.

Loans to assets ratio. The ratio of total loans to total assets (LAT) proxies a bank's earnings stability and liquidity. The lending portfolio is considered to be more stable in value and revenue during economic shocks. However, the loan portfolio is less liquid than other bank assets; therefore, a larger loan portfolio is taken as a proxy for lower liquidity (Dietsch & Lozano-Vivas, 2000; Xiang et al., 2015). Thus, the relationship of liquidity to a dependent variable should be the inverse of LAT. The annual average LAT for each country is shown in Table 5.12. The banking sector of New Zealand has the highest ratio of lending to assets at 0.81, followed by 0.74 for the Australian banks. The banking sectors of the other three countries have a relatively similar LAT. The average LAT ratio for selected banking sectors was higher in the pre-GFC period than in the post-GFC period. The impact of GFC is not evident for this ratio during the crisis period because loans and total assets both declined then.

Table 5.12

Mean Loans to Assets Ratios

Year	Australia	New Zealand	Canada	UK	USA
2003	0.73	0.82	0.52	0.63	0.50
2004	0.74	0.85	0.52	0.64	0.52
2005	0.75	0.85	0.51	0.56	0.51
2006	0.76	0.82	0.49	0.56	0.51
2007	0.74	0.81	0.48	0.53	0.52
2008	0.73	0.81	0.48	0.44	0.54
2009	0.75	0.78	0.48	0.50	0.50
2010	0.73	0.79	0.48	0.47	0.49
2011	0.73	0.76	0.48	0.45	0.50
2012	0.73	0.78	0.53	0.45	0.50
2013	0.73	0.81	0.54	0.55	0.51
2014	0.71	0.81	0.54	0.44	0.49
2015	0.73	0.79	0.54	0.46	0.50
Mean	**0.74**	**0.81**	**0.51**	**0.51**	**0.51**

A negative and significant relationship between LAT and cost efficiency is shown in Table 5.13; this relationship means that a larger portfolio of loans may lower a bank's cost efficiency. The impact of LAT on cost efficiency was positive before the crisis and turned negative during and after the crisis. It seems that a larger loan portfolio did not create a problem before the crisis, but the higher cost of the non-performing loans during and after the GFC negatively affected cost efficiency. Generally, loans have three costs for the banks: interest on borrowed funds, loan losses, and loan monitoring expenses. The negative relationship of LAT to cost efficiency implies that one or all of these loan costs were not at an optimal level during this period. The more significant relationship between LAT and cost efficiency during and after the GFC suggests an increase in loan losses and monitoring expenses.

Table 5.13

Loans to Assets Ratio and Bank Efficiency

Variable	2003–2015	2003–2006	2007–2009	2010–2015
Cost efficiency	-0.46**	0.03**	-1.41***	-1.24***
Profit efficiency	2.89***	0.14	2.38***	0.66*
Alternative profit efficiency	0.74**	0.26	-0.67	-0.35
Shareholder value efficiency	2.10***	0.08	0.67*	1.72***

***, **, and * indicate 1%, 5%, and 10% significance levels, respectively.

An alternative perspective is that a negative relationship of LAT with cost efficiency implies a positive relationship of bank liquidity with cost efficiency. This latter relationship is consistent with the results of prior studies that found that banks with higher liquidity are able to raise long-term funds at a lower cost and do not need to raise expensive short-term funds in emergencies (Carvallo & Kasman, 2016; Nguyen, Perera, & Skully, 2017). There was a negative relationship between pre-crisis bank liquidity and cost efficiency, which might have led banks to the GFC. The later initiatives of regulators to increase the level of liquidity in banks resulted in a positive relationship between liquidity and cost efficiency during and after the GFC.

Reported results in Table 5.13 show a positive and significant relationship between LAT and profit efficiency, which implies that banks improved their profit efficiency by selling more lending products. This positive and significant relationship was not evident before the GFC, but it became significant during the crisis. This affirms the role of loans in bank stability because during the crisis the value of and income from investments became unstable, while sound lending portfolios kept on generating interest income for banks. The impact of LAT on profit efficiency was also positive and significant in the post-GFC period. The relationship of LAT to APE was fairly similar to standard profit efficiency estimates except during the sub-periods. This means that current prices of bank output are more supportive of profit efficiency than optimal prices, which the APE model uses to estimate efficiency. The relationship of LAT to SVE is very similar to the profit efficiency model results.

The liquidity role of LAT has not helped banks achieve better efficiency for either measure of profit efficiency. Reported results are consistent with the results of prior studies (Bikker & Bos, 2008; Diamond & Rajan, 2000) that stated that liquid assets cannot provide a higher level of earning for banks. A lower earning capacity of liquid assets can lower the profit efficiency of banks. Results are consistent with the notion among banks that strengthened requirements of liquidity under Basel III may lower bank profitability, and lower profit efficiency may be reflected in reduced shareholder value. It may be concluded from Table 5.13 that a larger loan portfolio can help banks to achieve better profit efficiency, but it lowers their cost efficiency. In contrast, a higher level of liquidity is a source of better cost efficiency but lower profit efficiency. This suggests that the optimal size of the loan portfolio is critical for bank efficiencies.

Equity ratio. The ratio of total equity to total assets is a means of discouraging the risk-taking propensity of the banks. Therefore, this ratio is considered to be the proxy for bank stability and insolvency risk (Altunbas et al., 2007). However, it can also play a role in lowering the profit efficiency of banks, because it is more expensive to raise equity capital relative to borrowing, and avoidance of risk-taking activities can lower the revenue of banks. Annual average equity ratios for each country over the study period are compared in Table 5.14. The banking sector of the United States had the highest level of equity among selected countries; the lowest level of equity capital was for Canadian banks. One reason for the higher equity of the US banks is their accounting definition of equity, which also includes some hybrid debts. The level of equity increased over the study period in the UK, the United States, Canada, and New Zealand, but it remained stable in Australia.

Table 5.14

Mean Equity Ratios

Year	Australia	New Zealand	Canada	UK	USA
2003	0.065	0.052	0.049	0.055	0.081
2004	0.064	0.065	0.048	0.050	0.091
2005	0.065	0.061	0.045	0.043	0.087
2006	0.055	0.059	0.045	0.044	0.091
2007	0.051	0.057	0.044	0.040	0.085
2008	0.054	0.050	0.045	0.030	0.090
2009	0.061	0.046	0.054	0.048	0.099
2010	0.062	0.051	0.054	0.053	0.102
2011	0.063	0.054	0.056	0.053	0.105
2012	0.065	0.060	0.052	0.055	0.109
2013	0.065	0.067	0.054	0.057	0.112
2014	0.063	0.069	0.054	0.058	0.112
2015	0.065	0.067	0.056	0.066	0.117
Mean	**0.061**	**0.058**	**0.049**	**0.050**	**0.099**

The estimation model used in this study did not find an impact of equity on cost efficiency. However, Table 5.15 shows that higher capital helped banks to survive and perform during the GFC, consistent with the findings of many prior studies (Belke et al., 2016; Molyneux, 2018). Prior studies have recognized the role of capital in bank survival and performance (Berger & Bouwman, 2013). A higher level of capital strengthens the competitive position of the bank in asset and liability markets, which can improve its odds of survival. Higher capital banks do not take excessive risk to compete in the market, so they may lose some revenue and market share. Therefore, the role of capital in bank survival and performance depends on bank size and market conditions (Berger & Bouwman, 2013). A recent study by Berger and Bouwman (2013) reported that higher capital is associated with a higher survival rate and better performance for small banks at all times, but these results hold for medium-sized and large banks only during the crisis period. The present study, which is based on large banks in five countries, found that higher capital levels helped those banks to survive and perform during the crisis period, and equity did not have an impact on cost efficiency during the rest of the study period. Results seem to be consistent with the findings of Berger and Bouwman (2013) for cost efficiency.

A negative and significant impact of equity on profit efficiency is reported in Table 5.15; this impact was consistent during and after the GFC. The coefficient increased through time, which suggests an increase in the intensity of the negative relationship between a bank’s equity and its profit efficiency. This means that banks with lower equity capital were more profit-efficient than highly capitalized banks over the period 2003–2015. These results reflect the nature of the banking business, where deposits of public and money market funds are available to banks at a lower cost than that of raising equity.

The relationship of equity to APE is quite similar to the findings of the profit efficiency model.

Table 5.15

Level of Equity and Bank Efficiency

Variable	2003–2015	2003–2006	2007–2009	2010–2015
Cost efficiency	-0.41	0.47	3.91***	-0.92
Profit efficiency	-1.92***	-0.85	-3.82***	-9.53***
Alternative profit efficiency	-10.78***	-0.63	-7.91***	-3.21*
Shareholder value efficiency	-5.90***	0.07	-5.45***	9.44***

***, **, and * indicate 1%, 5%, and 10% significance levels, respectively.

The relationship between the level of equity and SVE is similar to profit efficiency for the period of 2003–2015; however, it is different in the post-GFC period. A positive and significant relationship between the level of equity and SVE during 2010–2015 is consistent with the findings of prior studies (Bikker & Vervliet, 2018; Blanchard, 1981): that a lower interest rate environment boosts the performance of common stocks. Therefore, it seems to be a stock market phenomenon instead of a bank efficiency effect. Overall results are consistent with the results of several prior studies and with bank concerns that suggest that increased equity and restrictions on participation in certain risk-taking activities will lower banks' profitability (Altunbas et al., 2007; Pasiouras, Tanna, & Zopounidis, 2009; Vu & Turnell, 2011). Although the level of equity lowered bank efficiency, it played an important role by building the resilience of the banks during the crisis period.

Loan losses. The ratio of loan loss expense to total loans (LOS) is a proxy for a bank's credit risk. Further details about the calculation of this ratio are provided in the research methodology chapter. The annual LOS percentage for each country is shown in Figure 5.15. It can be seen that the overall level of loan losses declined from 2003 to 2015 except for the UK, where LOS increased after declining in 2013. The impact of the GFC on LOS can be observed during the period 2008–2010. During the study period, the banking sector of the United States had the highest LOS and that of New Zealand the lowest.

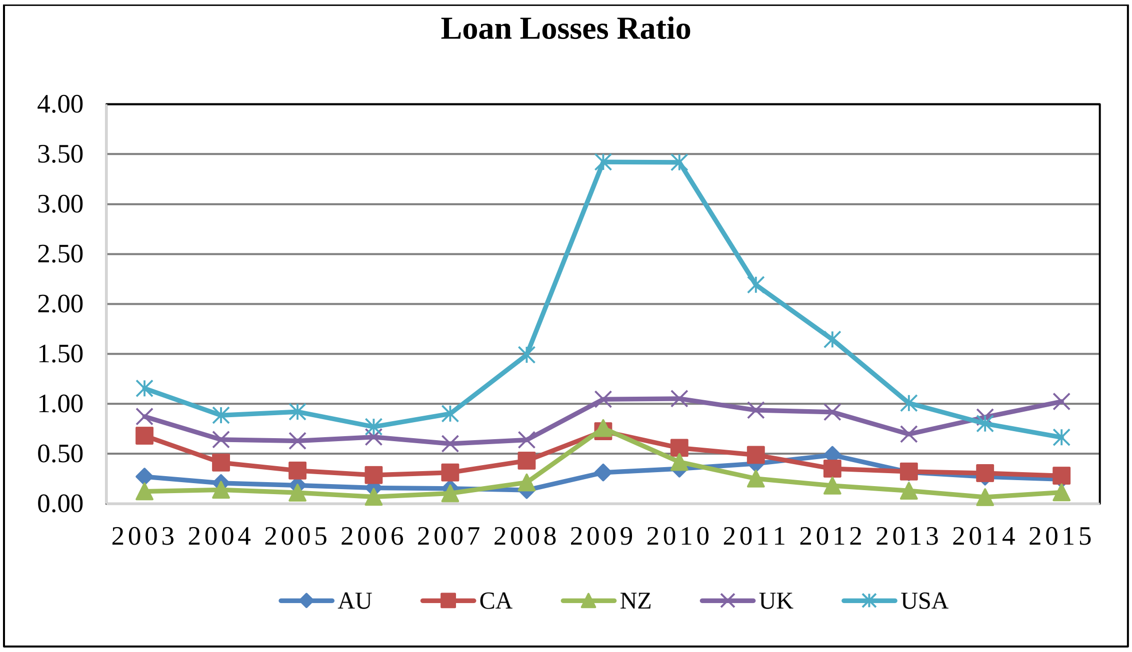


Figure 5.15. Ratio of annual loan losses to total loans for each country. AU, results for Australian banks; CA, for Canada; NZ, for New Zealand; UK, for the United Kingdom; USA, for the United States.

The negative influence of loan losses on cost efficiency is apparent before, during, and after the crisis in Table 5.16. Reported results are consistent with the results of prior studies that stated that the higher loan loss expense can increase bank cost, which may negatively affect the cost efficiency of the bank (Altunbas et al., 2007; Berger & DeYoung, 1997; Schaeck & Cihák, 2014). A positive and significant impact of LOS on profit efficiency in Table 5.16 suggests that commercial banks with a higher ratio of loan losses to total assets are more profit-efficient. This relationship was negative before the GFC, when higher loan losses lowered the profit efficiency of banks. Loan losses did not have an impact on profit efficiency during and after the crisis. Similar results are reported for the APE and SVE models, except the relationship of LOS with SVE became significantly more positive in the post-GFC period.

Table 5.16

Loan Losses and Bank Efficiency

Variable	2003–2015	2003–2006	2007–2009	2010–2015
Cost efficiency	-0.15***	-0.15***	-0.19***	-0.13***
Profit efficiency	0.74***	-0.14***	0.13	-0.09
Alternative profit efficiency	0.73***	-0.07***	0.02	0.10
Shareholder value efficiency	0.73***	-0.05	0.19	0.21**

***, **, and * indicate 1%, 5%, and 10% significance levels, respectively.

Loan losses reduced bank costs and increased profit efficiency during the study period. Results are consistent with those of past studies (Altunbas et al., 2007; Berger & DeYoung, 1997; Xiang et al., 2015) that found that once loans go bad, the cost of monitoring, collecting, or selling them may increase, although it may not have an impact on profit efficiency if the banks are able to increase the size of their loan portfolio or loan prices. In this case, banks with relatively low capital, higher profitability, or lower market share respond by lowering their underwriting standards to increase their lending portfolio. This may result in higher loan losses, but those losses may be lower relative to the size of the lending portfolio and its contribution to interest revenue (Berger & DeYoung, 1997; Bikker & Vervliet, 2018). Results are tested using a lag of one and two years for loan losses, as well as using the amount of loan losses instead of the ratio of loan losses but found consistent results. Therefore, it may be concluded that the positive relationship between the loan losses ratio and profit efficiencies is due to an increase in interest revenue from the lending portfolio in expectation of higher loan losses. Higher interest revenue can be obtained by increasing the size of the loan portfolio and setting higher loan prices. Higher profitability made more funds available for shareholders, which ultimately increased their wealth. Therefore, the relationship between loan losses and shareholder value is similar to the results of the profit efficiencies model. According to prior studies (Berger & DeYoung, 1997), another reason for a positive relationship between loan losses and shareholder value is that loan loss expense signals better earnings in the future. Once the non-performing loans are written off in the form of loan loss expense, the quality of the remaining loans improves (Musumeci & Sinkey, 1990).

Z-score. The *Z*-score is a proxy for bank stability; it assesses the survival of a bank against the fluctuation in its rate of return. A lower *Z*-score is a sign of higher banking risk and vice versa. Three components of *Z*-score that may help the bank to achieve financial stability are profitability, capital, and the volatility of returns. All three components are part of bank risk. Better profitability, more capital, and lower volatility in returns can increase the financial stability of a bank. The estimation model of cost efficiency shows a positive and significant relationship between *Z*-score and cost efficiency in Table 5.17. This means that risk is negatively associated with cost efficiency. The cost efficiency score is lower for the banks with higher risk, and banks with lower risk achieved better cost efficiency. Reported results are consistent before, during, and after the GFC; furthermore, this relationship became stronger during the crisis period. Results are consistent with those of several prior studies that showed that a higher level of risk can reduce cost efficiency (Berger & Bouwman, 2013; Kasman & Carvallo, 2014) because stable banks have a better market credit rating, which can help them to raise funds at a lower cost.

The estimation models for profit, alternative profit, and shareholder value efficiencies all report a positive and significant impact of *Z*-score on bank efficiency. Consistency among the results of these models can be observed in Table 5.17. The table shows that risk is negatively associated with profit and shareholder value efficiencies of the banks during the period of 2003–2015. Reported results are consistent during and after the GFC, however, they are not significant in the pre-GFC period. This means that the risk and returns of banks were not aligned before the crisis and became in line during and after the crisis. Reported results are consistent with those of some prior studies that reported a negative relationship between risk and bank efficiencies (Fiordelisi & Molyneux, 2010; Luo, Tanna, & De Vita, 2016; Radić, 2015).

Table 5.17

Z-Score and Bank Efficiency

Variable	2003–2015	2003–2006	2007–2009	2010–2015
Cost efficiency	0.06***	0.09***	0.17***	0.04**
Profit efficiency	0.74***	0.02	1.34***	0.14***
Alternative profit efficiency	0.82***	0.02	0.72***	0.29***
Shareholder value efficiency	0.47***	0.02	0.05*	0.15***

***, **, and * indicate 1%, 5%, and 10% significance levels, respectively.

All four selected risk variables negatively influenced the costs, profits, and shareholder value efficiencies of the banks in the five countries. The level of loans and loan losses are negatively associated with cost efficiency; however, bank liquidity and stability are positively related. The level of loans, loan losses, and stability are positively related to profit and SVE, but the level of liquidity and equity are negatively related. Overall results are consistent with the results of several prior studies as mentioned earlier, and the implications of these results are discussed in the next chapter.

5.2.3 Banking Market Structure Variables

As discussed earlier, the structure of selected banking sectors significantly changed over the study period. Therefore, three banking structure variables are included in each estimation model: bank size, the Herfindahl–Hirschman Index (HHI), and the

Lerner Index. Bank size and HHI have previously been used in the frontier analysis, but the Lerner Index has rarely been used in prior bank efficiency studies.

Bank size. Various proxies have been used in prior studies for bank size, as discussed in previous chapters. In this study, the total assets of a bank are used as a proxy for bank size. Details about the use of this proxy in prior studies are discussed in the previous chapter, and the median bank size of each country is shown in Figure 5.16. The mean total assets are not used for comparison because a different number and size of banks were selected from each country and the mean seems to be biased. Therefore, the median size of banks is used in Figure 5.16 instead, which seems to be more appropriate for comparison. There was a gradual increase in the size of banks in Australia, Canada, and New Zealand, but the size of banks in the United States and the UK was volatile over the study period. Heterogeneity in the size of selected banks increased considerably over the period of 2003–2015. Most of the variables used in the estimation models are normalized to minimize the size bias.

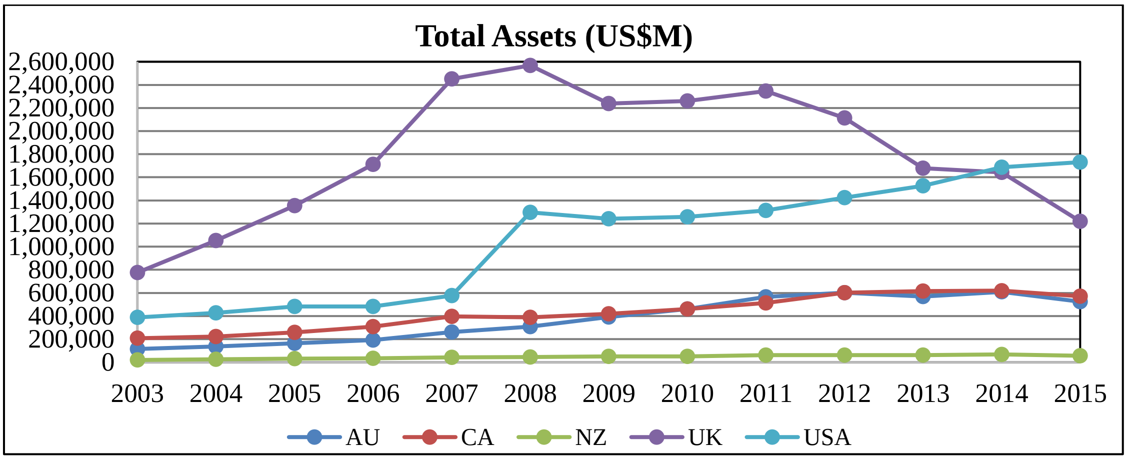


Figure 5.16. Median total assets of banks in each country. AU, results for Australian banks; CA, for Canada; NZ, for New Zealand; UK, for the United Kingdom; USA, for the United States.

Results reported in Table 5.18 show a positive and significant relationship between bank size and cost efficiency. These results are in line with our expectations from prior studies that larger banks might have benefited from economies of scale (Hughes & Mester, 2013). Usually, larger banks are able to attract cheaper capital and better managers and to achieve more business diversification (Berger et al., 2015). The positive influence of bank size is consistent before, during, and after the GFC. However, the coefficient is smaller in the post-GFC period than in the pre-GFC period, which implies diminishing scale economies in the banks. The results of these diminishing scale economies are consistent with the findings of a recent study by Wheelock and Wilson (2018). It may be concluded that while banks enjoy increasing returns to scale, these may not persist due to further growth in bank size and changing banking market structures.

Table 5.18

Bank Size and Efficiency

Variable	2003–2015	2003–2006	2007–2009	2010–2015
Cost efficiency	0.06***	0.10*	0.05***	0.07***
Profit efficiency	-0.11***	-0.04***	0.06	0.02
Alternative profit efficiency	-0.13***	0.02*	-0.10**	0.02
Shareholder value efficiency	-0.10***	0.01*	-0.10***	0.01

***, **, and * indicate 1%, 5%, and 10% significance levels, respectively.

A negative and significant relationship of bank size to profit, alternative profit, and shareholder value efficiencies are reported in Table 5.18. These results are consistent with several recent studies that reported exhaustion in the scale economies of bigger banks in the post-GFC period (Matousek et al., 2015; Wheelock & Wilson, 2018). Although the impact of bank size on profit efficiency was not significant during and after the GFC, the impact on alternative profit and shareholder value efficiencies was negative and highly significant. This may mean that the size of the banks did not help them perform better during the crisis period. The complication of the growth in bank size has already led to responses by the governments of Australia, the UK, and the United States, who have introduced initiatives to control growth in the size of banks.

Herfindahl–Hirschman Index. The HHI is a measure of banking market concentration, which is an important component of banking market structure. The level of concentration among the selected countries is compared in Figure 5.17. As discussed in previous chapters, the selected banking sectors are among the most concentrated in the world (Beck et al., 2013; Weill, 2013), therefore, this variable is included in the estimation models. The banking sector of New Zealand is the most concentrated and the US banking sector the least among the five nations. The level of concentration increased in all countries over the period 2003–2015. The highest increase and fluctuation were evident in the UK banking sector, whereas the Canadian banking sector stayed very smooth during the study period. The details of HHI calculation and its use in prior studies are discussed in the previous chapter.

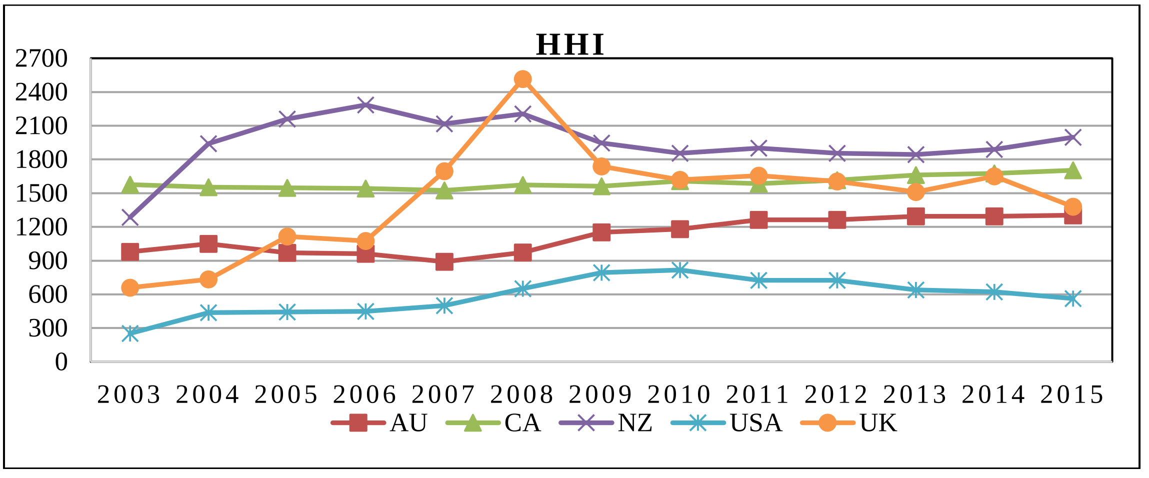


Figure 5.17. Herfindahl–Hirschman Index for banking sectors in each country. AU, results for Australian banks; CA, for Canada; NZ, for New Zealand; UK, for the United Kingdom; USA, for the United States; UK, for the United Kingdom.

As shown in Table 5.19, the impact of HHI on cost efficiency was not significant during the period 2003–2015. This means that the commercial banks of the selected countries did not feel pressure to control their costs in a concentrated banking environment. However, there was a significant positive influence of HHI on cost efficiency before and after the GFC. Market concentration did not have an impact on cost efficiency during the crisis period; the size of the banks grew significantly during those years. The level of market concentration decreased after the crisis period, and the positive influence of concentration on cost efficiency became vital again.

Table 5.19

Herfindahl–Hirschman Index and Bank Efficiency

Variable	2003–2015	2003–2006	2007–2009	2010–2015
Cost efficiency	-0.08	0.07**	0.04	0.25***
Profit efficiency	-0.48***	-0.04	0.02	-0.20*
Alternative profit efficiency	-0.11**	-0.01	-0.10*	0.90*
Shareholder value efficiency	-0.08*	0.02	-0.22***	0.92***

***, **, and * indicate 1%, 5%, and 10% significance levels, respectively.

A negative and significant relationship between HHI and bank profit efficiency is reported in Table 5.19. This means that a further increase in market concentration in the chosen countries may further reduce profit efficiency. Results were not significant before or during the GFC, but they became negative and significant after the GFC. As discussed earlier, market concentration increased in the countries under study over the period, and the intensity of the negative relationship also increased. Results for the alternative profit and SVE models are quite similar to those for the standard profit efficiency model for the whole period. However, this changed during and after the GFC, which means that banks used their market power in more concentrated markets to set higher output prices to achieve higher profitability during the crisis period. Banks were not able to achieve the expected level of profitability with higher output prices during the crisis period due to lower demand for banking products and services. But the relationship of concentration with profit efficiency turned positive in the post-GFC period when demand for bank outputs increased. It may be concluded that the results of this study are closer to the quiet life hypothesis (QLH), which states that managers enjoy a quiet life without making a sufficient effort to maximize the profit of banks in concentrated banking sectors.

Lerner Index: The Lerner Index represents the power of a bank to set the price of its products and services over the marginal cost for its customers; it is a proxy for market competition. The methodology for estimating the Lerner index and its use in prior studies are discussed in earlier chapters. The estimated Lerner Indices for the five countries are compared in Figure 5.18. The Canadian banking sector has the highest market power: it increased by 11 points from 2003 to 2015. The second highest market power is ascribed to the Australian banking sector, but it showed the highest growth in market power (18 points) over the study period. Market power reduced for the US and UK banking sectors during the period 2003–2015; their market power was the lowest among the five countries. The level of market power was more stable before the GFC and declined during the crisis in all countries. A surge in the level of market power after the GFC is visible in Canada, Australia, and New Zealand.

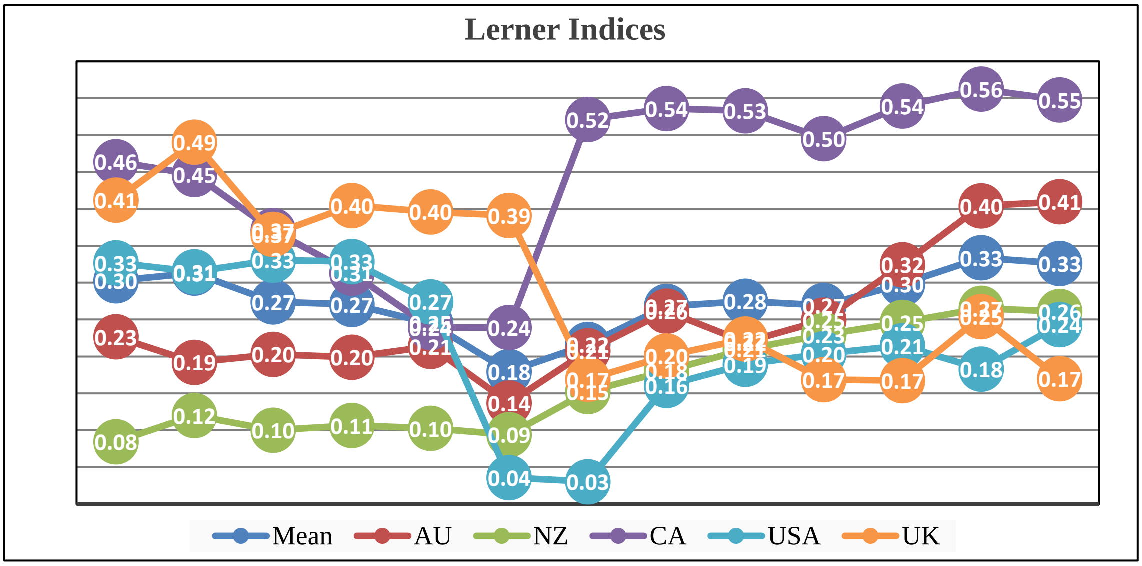


Figure 5.18. Lerner Index for each country. Mean = average of all countries. AU, results for Australian banks; NZ, for New Zealand; CA, for Canada; USA, for the United States; and UK, for the United Kingdom.

Results for the cost efficiency estimation model are reported in Table 5.20, which shows no statistically significant relationship between the Lerner Index and cost efficiency for the period 2003–2015. A bank can exercise its market power by either reducing the marginal cost or increasing the prices of products and services. The lack of a relationship between market power and cost efficiency shows the ineffectiveness of bank efforts to minimize marginal cost (predominantly interest costs). Furthermore, the marginal costs of banks increased before and after the GFC, which shows a negative and significant relationship between the Lerner Index and cost efficiency. Banks were not able to use their market power during the crisis period. Overall results are consistent with the results of several prior studies that found a negative or insignificant impact of market power on the cost efficiency of banks in various regions of the world (Ariss, 2010; Berger & Hannan, 1998; Efthyvoulou & Yildirim, 2014). The study by Efthyvoulou and Yildirim also concluded that the influence of market power was different during the crisis period compared to the pre- and post-crisis period, in line with the results of this study.

Table 5.20

Lerner Index and Bank Efficiency

Variable	2003–2015	2003–2006	2007–2009	2010–2015
Cost efficiency	-0.10	-0.61**	0.13	-0.58**
Profit efficiency	2.58***	-0.01	0.55	0.88**
Alternative profit efficiency	2.37***	0.25	0.39	2.48***
Shareholder value efficiency	2.95***	-0.06	0.29**	-0.11

***, **, and * indicate 1%, 5%, and 10% significance levels, respectively.

Reported results for the profit and APE models are quite similar. A positive and significant relationship between the Lerner Index and profit efficiencies is reported by both estimation models in Table 5.20. This shows that market power helped banks achieve better profit efficiency at both given and optimal prices of outputs. There was no influence of market power on profit efficiencies before or during the crisis, but it became significantly positive after the GFC. As mentioned in the previous section, the average market power of selected commercial banks increased over the study period and reported results are in line with this increase. A decline in market power is noticed in the UK and the United States, therefore, their profit efficiency has also declined in the post-GFC period. It may be concluded that market power had a positive influence on profit efficiency, but not during the crisis period. SVE also showed a positive and significant relationship to market power. There was no influence of market power on SVE before the GFC, but it became significantly positive during the crisis period. Although the market power of banks declined considerably during the crisis period, it still helped banks achieve better SVE. That could be due to the lower cost of capital and the positive perception of shareholders about more powerful banks during this crisis period, as discussed previously in this chapter.

Overall, the five selected banking sectors got help from the nominal interest rate and GDP per capita in improving their efficiency, but the population density is no longer an adequate indicator of bank efficiency. Bank stability helped improve bank efficiency in the countries under study, consistent with the results of prior studies (Fiordelisi & Molyneux, 2010; Luo et al., 2016; Radić, 2015). The level of liquidity and equity are vital for bank survival and cost efficiency, but not favourable for profit efficiency. The size of banks from 2003 to 2015 suggests increasing returns to scale for banks; however, the quiet life behavior of managers undermined benefits for shareholders. Increased market concentration was not beneficial for banks as it did not help them during the crisis period. Most selected banks and shareholders were able to benefit from increased market power. Most banking environment variables were found to be significantly associated with bank efficiencies in all estimation models, which proves the importance of including these variables in selected SFA models. Implications of the relationship between banking environment variables and bank efficiencies are discussed in the next chapter.

5.3 Bank Efficiency and Shareholder Value

As discussed in the review of the literature, frontier analysis is assumed to be the most sophisticated and comprehensive measure of relative firm performance, and shareholder value maximization is an economic goal for most operating firms. There are only a few studies on the relationship of shareholder value and the operating efficiency of banks; therefore, we decided to explore this relationship, estimated with improved econometric models after the GFC. The outcomes of shareholder value and operating efficiency models are already discussed in previous sections of this chapter. In this section, a Pearson correlation was used to measure relationships between SVE, EVA, and the operating efficiencies of banks for the period 2003–2015. The performance measure return on assets (ROA) is included for robustness, and results are reported in Table 5.21.

Table 5.21

Correlation Matrix of Efficiency Measures

	SVE	APE	CE	PF	EVA	ROA
Shareholder value efficiency (SVE)	1					
Alternative profit efficiency (APE)	0.80	1				
Cost efficiency (CE)	0.36	0.33	1			
Profit efficiency (PF)	0.78	0.91	0.39	1		
Economic value added (EVA)	0.71	0.57	0.23	0.59	1	
Return on assets (ROA)	0.53	0.62	0.17	0.63	0.55	1

A positive and strong correlation among shareholder value, profit, and APE can be observed in Table 5.21. Two other measures of bank performance that are not based on frontier analysis also formed a positive and strong association with the operational efficiency of the banks. However, cost efficiency was not strongly associated with other measures of bank efficiency or performance. The absence of a strong association between cost efficiency and shareholder value is consistent with the results of prior studies that stated that shareholders are more interested in the profitability of the firms as a source of dividends rather than in cost control (Beccalli et al., 2006; Fu et al., 2014b). It may be concluded that profit efficiency is associated with shareholder value creation by the banks and may be used as a measure of firm performance.

5.4 Robustness Tests

A few robustness tests were also conducted to confirm the reliability of the estimated statistical results. The chosen estimation models were used for sub-samples, sub-periods, and alternative functional forms.

Sub-samples. The total sample of 29 banks was divided into two groups in order of size. Group A had the first 15 banks by size, and group B had the remaining 14 banks. Each measure of bank efficiency was estimated for each sample with the same specifications. Cost, profit, alternative profit, and shareholder efficiencies for group A were a few points lower than for group B, which is consistent with the reported results. The majority of the efficiency determinants show a similar relationship to bank efficiency in both sub-samples. Results were found to be consistent after excluding the big four banks of the United States. Data for those four banks included the highest share of global operations among the 29 banks; therefore, it may be concluded that the use of consolidated global statements of the banks did not affect the results of this study. Moreover, the contribution of the global operations of the banks was not higher than the contribution of their domestic operations and was mostly from their investment operations instead of commercial banking. However, the omission of the Royal Bank of Scotland from the sample changed the estimated results due to its very high and sustained losses.

Sub-periods. The selected study period of 2003–2015 was divided into two periods: period A is 2003–2008, and period B is 2009–2015. Both periods included crisis and noncrisis years. Bank efficiency scores for period A are higher than for period B, which is consistent with results for the whole sample when selected banking sectors were not able to achieve their pre-GFC level of bank efficiency. Most determinants of bank efficiencies stayed stable during both periods. Results from before, during, and after the GFC are compared earlier in this chapter.

Alternative functional forms. The translog functional form was used in all estimation models of this study as it is more flexible. Reasons for selecting this functional form are discussed in the research methodology chapter. The Fourier flexible functional form was assumed to be better in prior studies (Berger & Mester, 1997; Fried et al., 2008), but it was not possible to use it in this study because of the given number of observations. The Cobb–Douglas functional form was the third most frequently used in prior studies and is considered a base for all other functional forms. Therefore, it was selected as an alternative functional form for robustness. The bank efficiency scores estimated with the Cobb–Douglas functional form were a few points lower than those estimated with the translog functional form, but parameter estimates for the required coefficients are very similar. A lower efficiency score was expected because Cobb–Douglas assumes constant technology, and translog allows the technological change to increase or decrease with time (Coelli et al., 2005).

A few diagnostic tests were also conducted to satisfy the assumptions of selected estimation models and identify potential statistical problems in the data set. The selected diagnostic tests included autocorrelation (Wooldridge test), multicollinearity (variance inflation factor (VIF), heteroscedasticity (White test), and correlation (Pearson) among error terms and selected variables. The results of these tests proved to be the best fit of the selected estimation models with the study data.

5.5 Summary

This chapter discussed the empirical results of four selected estimation models. A comparison of mean cost, profit, alternative profit, and shareholder value efficiencies scores was conducted for five banking sectors over the period 2003–2015. The impact of the GFC was assessed on each bank efficiency measure. Important determinants of the bank efficiency were identified, and a few robustness tests were also presented.

The estimated annual average cost efficiency scores were based on a common frontier among all banks. The cost efficiency of banks declined over the study period and declined considerably during the crisis period of 2008–2010. The banking sector of Australia achieved the highest level of cost efficiency during the study period among the five countries, followed by the Canadian banking sector. Banks of the UK were the least cost-efficient during the period 2003–2015. American banks were the most impacted by the GFC during 2007–2010, and the Australian banks were the least impacted during 2008–2009. Population density, the ratio of loans, level of risk, and loan losses negatively impacted the cost efficiency of the banks. Nominal interest rate, GDP per capita, and bank size helped banks to achieve better cost efficiency during the study period. Results indicate that a higher level of cost efficiency in the pre-GFC period helped banks to be more resilient during the crisis and enabled a better recovery after the GFC. The level of equity, liquidity, earning stability, and bank size helped banks to become resilient and cost-efficient during the crisis period. All these are bank-level variables; therefore, it may be concluded that the variation in the impact of the GFC was due to variation in bank management instead of the macroeconomic conditions of the countries. The banks with prudent management were less affected by the GFC than banks with incautious management.

The level of average profit efficiency in the selected countries was higher than in most developed economies, however, average profit efficiency declined over the study period, most noticeably during 2007–2009 because of the GFC. After the crisis period, the group of chosen banks has not been able to achieve profit efficiency equal to their pre-GFC levels. However, the higher level of profit efficiency in the pre-crisis period did not bolster the banks' resilience during the GFC. Of the banking sectors of the five countries, the UK's was the most impacted by the crisis and New Zealand's was affected the least. Higher profit efficiency scores showed less fluctuation over the study period, and lower scores had higher standard deviations. The banking sector of New Zealand posted the highest profit efficiency, followed by the sectors of Australia and Canada. The banking sector of the UK was ranked lowest in profit efficiency. The level of income, the ratio of loans to assets, loan losses, and market power helped banks achieve improved profit efficiency during the study period. Population density, level of liquidity and equity, bank size, and market concentration reduced profit efficiency.

Alternative profit efficiency was also estimated beside standard profit efficiency because the selected banking sectors were more concentrated, and banks had a higher level of market power during the study period. There was no significant difference in the efficiency scores of the estimates, however, APE was higher, and the relationship of some determinants was different from those in the standard profit efficiency model, as expected. The trend and country ranking were similar to those in the standard profit efficiency model however. The nominal interest rate, GDP per capita, loans to assets ratio, loan losses, financial stability, and market power proved to be helpful for achieving a better APE. Population density, level of liquidity and equity, bank size, and market concentration reduced the APE of the banks during the period 2003–2015.

The fourth measure of bank efficiency used in this study was SVE, which measures the maximization of shareholder value through the operational efficiency of a bank. Consistent with earlier measures of bank efficiency, banks were not able to achieve SVE equal to the pre-GFC level after it declined substantially during the crisis period of 2007–2009. The banking sector of New Zealand showed the most SVE during the study period, and the banking sector of the UK created the least shareholder value. Higher standard deviations for SVE scores prove that the inclusion of market data in the operational efficiency model produced an outcome closer to market movements. The level of interest rate and per capita income in a country, loans to assets ratio, loan losses, financial stability, and market power helped banks to post better SVE scores. Population density, level of liquidity and equity in a bank, bank size, and market concentration pulled down the SVE scores of banks during the study period. A strong and positive association between EVA, shareholder value, profit, and APE was found. There was no significant evidence of whether a higher level of profit or alternative profit or shareholder efficiencies helped banks become more resilient during the crisis or in the post-GFC recovery period.

Reported results proved to be consistent with a separate frontier for each country, Cobb–Douglas functional form, sub-periods of study, and sub-groups of the banks under study. Test results showed no multicollinearity, serial correlation, or high level of correlation between error terms and selected variables. These findings and policy implications are discussed in the next chapter.

Chapter 6

CONCLUSION AND POLICY IMPLICATIONS

The multiple forces of financial deregulation, globalization, technological innovation, and new product development have made the financial system more integrated and fragile (Berger et al., 1987; Luo et al., 2016; Molyneux, 2018). The 2008 global financial crisis (GFC) was a recent example of the financial disruption that threatened to utterly collapse the global financial system (Greenbaum et al., 2016). This study investigates the varying impact of the GFC on the efficiency of major banks of the United States, the UK, Canada, Australia, and New Zealand. We observed a variation in the impact of the GFC on these banking sectors, despite their common inheritance from an Anglo-Saxon banking model and a relatively homogeneous and well-integrated economic system. The study explored a group of banking environment variables to identify potential determinants of this variation in the impact of the GFC on bank efficiency. Furthermore, the study estimated SVE to assess the association between operational efficiency and shareholder value of banks.

This chapter has three sections. The next section summarizes the findings of this study against each research question. Section 6.2 identifies some policy implications for regulators and bank managers. The last section mentions some research limitations of the study and recommends future research issues.

6.1 Summary of Empirical Findings

The empirical findings of this cross-country study are based on the estimated results of the one-stage SFA model used on the panel data from 29 banks in Australia, Canada, New Zealand, the United States, and the UK for the period 2003–2015. Three selected banking inputs are prices of labour, funds, and fixed assets; three outputs are total loans, non-interest income, and total investments. Inputs and outputs of the banks were selected on the basis of their "financial intermediation" role in the economy. The study included 10 banking environment variables and one GFC period dummy variable in the inefficiency error terms of the estimation models in order to get more precise efficiency scores and to identify the potential determinants of bank efficiency. The outcomes of the four efficiency estimation models: cost, profit, alternative profit, and SVE have helped to answer the research questions and fill the gaps identified in the study.

The cost efficiency of the banking sectors of Australia and Canada was found to have been superior to that of New Zealand, the United States, and the UK. The impact of the GFC on the cost efficiency of the selected banking sectors started in 2007 and continued through 2010 in some countries. Of the five banking sectors, the worst impact was felt on that of the United States. The statistical significance of the impact is confirmed with the coefficient of the crisis period dummy variable. The banking sectors that were more cost-efficient before the crisis proved to be more resilient during the crisis and showed robust recovery after the GFC, which is supported by the pre- and post-GFC ranking of the countries. This finding, which implies that the less cost-efficient banks got in trouble during the GFC, is consistent with the results of prior studies that observed a high level of cost inefficiency in the US banking market in the pre-GFC period (Greenbaum et al., 2016; Hasannasab et al., 2019). The scores and fluctuations of the alternative profit efficiencies are higher than those of the standard profit efficiencies. The impact of the GFC was noted first in 2007 and was most adverse in 2009. The pre-GFC profit efficiency scores of the United States and the UK were higher than those of the other three countries, but they were the lowest during and after the GFC. This implies that the level of profit efficiency did not help bank resilience during the crisis or in the post-

GFC recovery. The average profit efficiency of the banking sectors of Australia, Canada, and New Zealand was superior to that of the other two countries and most developed economies (Belke et al., 2016; Savona et al., 2011; Xiang et al., 2015).

A varying impact of the GFC on selected banking sectors during the period 2003–2015 was confirmed, in line with prior theoretical hypotheses (Calomiris & Haber, 2014). The use of a common frontier among the five countries was validated, which proves that the results for US bank efficiency can be compared with those of Anglo-Saxon countries on the same frontier (Berger, 2007). Previously, the bank efficiency results for the US banks were mostly compared with those of European banks, which reduced the number of cross-country bank efficiency studies. Furthermore, the use of a common frontier supports the recommendations in the literature to use relatively homogeneous economies to estimate bank efficiency with the one-stage SFA model in cross-country studies (Belke et al., 2016; Berger, 2007; Xiang et al., 2015). We identified a significant role of operational efficiency in maximizing shareholder value and found it to be stronger than in prior studies (Chu & Lim, 1998; Fiordelisi, 2007; Fiordelisi & Molyneux, 2010). We also identified a few banking environment variables that played a vital role in varying the impact of the GFC.

Three macroeconomic variables: nominal interest rate, GDP per capita, and population density were used to control for the differences in cross-country macroeconomic environment and to assess their relationship to bank efficiency. The level of nominal interest rate and per capita GDP helped banks achieve better cost and profit efficiencies. These two variables were found to be irrelevant to cost efficiency during the crisis period, however, the level of nominal interest negatively impacted bank profit efficiency during the GFC. The influence of population density on cost and profit efficiency has changed in recent years and become negative. An unexpected spike in the adoption of various internet banking channels is assumed to be the reason behind the negative relationship of population density to bank efficiency, which is consistent with reported results of a few recent studies (Boot, 2017; Xue et al., 2011).

Various banking risk variables have been identified as the causes of the GFC. These include lower levels of liquidity and equity, higher loan losses, inferior quality of lending portfolios, and higher stock market exposure. Therefore, we included four banking risk variables in this study to find their relationship to bank efficiency and behavior during the crisis period. The selected banking risk variables are loans to assets ratio, *Z*-score, loan losses ratio, and equity ratio. The level of banking risk declined over the study period as the loans to assets ratio and loan losses decreased and the *Z*-score, level of equity, and liquidity increased.

The ratio of loans to assets is a proxy for earning stability and illiquidity. The proportion of loans in banks' asset portfolios declined and liquidity increased over the study period. The ratio negatively impacted cost efficiency but positively influenced the profit efficiency of banks during the study period, which proves the earning stability role of the loans. The level of liquidity helped banks to achieve better cost efficiency, however, as expected, it negatively influenced profit efficiencies. The earning volatility of banks (*Z*-score) was found to be negatively associated with bank efficiency and it worsened during the crisis. The ratio of loan losses to total loans lowered the cost efficiency of the banks in the five selected countries during the period 2003–2015. The ratio of equity to total assets positively affected cost efficiencies and negatively affected profit efficiencies. This implies that a higher level of equity helps banks to raise funds from the market at a lower cost due to a higher credit rating, but it lowers profit efficiencies because of the higher cost of equity and restraint from certain capital-intensive activities. We concluded that bank risk was negatively associated with bank efficiency in our five countries during the study period, consistent with the results of several prior studies (Altunbas et al., 2007; Berger & Bouwman, 2013; Pasiouras et al., 2009).

The important role of banking market structure in bank efficiency has been identified in prior studies. Therefore, we included three banking market structure variables: bank size, HHI, and Lerner Index in each estimation model. Bank size, concentration, and market power increased over the study period. A positive relationship of bank size to cost efficiency shows that a certain level of scale economies exists. However, a negative association of bank size with profit efficiency hints at a faster exhaustion rate in increasing returns to scale (Matousek et al., 2015; Wheelock & Wilson, 2018). The negative influence of market concentration (HHI) on bank efficiencies was observed in the five countries, consistent with the QLH of market structure. The QLH states that managers of concentrated banking markets enjoy perks and a quiet life without making a sufficient effort to maximize profitability (Berger & Hannan, 1998; Färe et al., 2015). The market power (Lerner Index) of the banks did not play any significant role in cost efficiency, however, it helped banks achieve better profit efficiencies. The empirical findings of this study confirmed a vital role of the banking market structure in bank efficiency.

A positive and significant association between shareholder value and profit efficiencies was found through correlation analysis; this shows that a bank's operational efficiency contributes to the maximization of shareholder value. A similar association of profit efficiencies with ROA was reported. The association of cost efficiency with shareholder value was not strong, but it was statistically significant. The reported results are robust and consistent with those of prior studies (Beccalli et al., 2006; Fiordelisi & Molyneux, 2010; Fu et al., 2014b). The impact of the GFC on shareholder value also varied among the five selected countries, similar to profit efficiencies. The level of nominal interest rate, GDP per capita, loans to assets ratio, and market power all had a positive impact, but bank size, concentration, population density, and equity negatively influenced SVE.

The relationship between a few banking environment variables and bank efficiencies significantly changed during the crisis period, which may help to identify the sources of the varying impact of the crisis among the five selected banking sectors. Moreover, banks that were cost-efficient before the GFC were found to be more resilient during the crisis, and their recovery was more robust. The level of liquidity, equity, earning stability, and bank size were among the few sources of this resilience; they had a positive relationship to cost efficiency during the crisis. The level of nominal interest rate, GDP per capita, market concentration, and market power were found to be irrelevant to cost efficiency during the crisis period. It may be concluded that bank-level variables played a more vital role in building bank resilience than the macroeconomic variables. The empirical findings of this study did not reveal a role for profit efficiency in the resilience of the banks during the crisis period. However, the ratio of loans to assets and the size of the banks helped the banks to be more profit-efficient during the crisis period, which may have helped the banks to better survive during the GFC.

6.2 Policy Implications

The empirical findings of a decline in bank efficiency, a reduction in risk, changes in market structure, and the contribution of operational efficiency to shareholder value during 2003–2015 have various policy implications for major stakeholders of the banking sector. The varying impact of the GFC significantly lowered the cost and profit efficiencies of selected banking sectors during the crisis period, and the post-crisis recovery was also not robust. The level of banking risk declined over the study period, and the level of equity and liquidity played a significant role in the survival of banks during the GFC. The current market structure of the banking sectors is no longer favorable for improving bank efficiency. A positive relationship between bank efficiency and shareholder value confirms that bank efficiency measures are well aligned with a market-based assessment of bank performance. The following five policy recommendations can help to lower the intensity of future crises and improve bank performance.

First, the resilience of cost-efficient banks during the GFC proves that banking regulatory bodies and policymakers should include the measure of cost efficiency in their early warning and monitoring systems. Furthermore, the regulators and policymakers should create a favorable banking environment for cost efficiency that can help banks to be more cost-efficient and provide a stable banking system for the country. However, most of the regulatory and supervisory initiatives have not helped banks to improve their cost efficiency in the post-GFC period: the level is lower than in the pre-GFC period.

Second, the level of bank liquidity and equity played a significant role in the stability of banks during the GFC, and the ratio of liquidity and equity improved over the study period, especially in the post-GFC period. Most of the enhanced liquidity and equity standards have already been implemented under Basel III in Australia, Canada, and New Zealand; however, the United States and the UK have extended the deadline for their banks. A more aggressive approach is required to implement these standards in the US and UK banking sectors and to monitor the risk management practices of all systemically important banks. The ratio of loans to assets has also declined, along with other banking risk parameters. Lending assets have very low volatility relative to other earning assets of the banks and are a stable source of revenue, which is confirmed by the empirical findings of this study. Bankers need to pay attention to the increase in the size and quality of their lending portfolios.

Third, the negative impact of bank size on profit efficiencies and market concentration on all measures of bank efficiency implies that the banking market structure is no longer favorable for better bank efficiency. The size of banks and market concentration increased over the study period; positive returns to scale may be exhausted soon. The too-big-to-fail guarantee for large banks has persuaded many smaller banks to seek mergers and acquisitions to join this bandwagon, which may further increase bank size and market concentration. The market power of banks also increased, which helped banks to achieve better profit efficiency, but it has not supported cost efficiency. Regulators and policymakers need to introduce some initiatives to promote more competition and discourage the growth of large banks. A few initiatives have already been introduced by the regulators of the United States, the UK, and Australia. The remaining countries may also need to assess the dynamics of their banking market structure to form more stable and efficient banking systems.

Fourth, a negative relationship between population density and bank efficiency has important implications for bank managers. Banks need to review their spending on various channels of the distribution network. Bank managers need to conduct thorough research before adopting or enhancing the capacity of their distribution channels because many physical and virtual distribution channels are not optimally used.

Fifth, the positive association between shareholder value and bank efficiency highlights the importance of bank efficiency, not only to the stability of the banking system but also to the stability of stock markets. Moreover, bank efficiency can be used as a more comprehensive and sophisticated measure of bank performance in market research. Bank shareholders should emphasize operational efficiency along with profit maximization in the long run.

6.3 Study Limitations and Future Research

Although the empirical results of this study were tested for enhanced validity and reliability, some difficulties and challenges may have limited the research scope of this thesis. First, as mentioned earlier, stochastic frontier analysis (SFA) was used in this study to estimate cost, profit, and shareholder value efficiencies. The SFA is based on the restrictive distributional assumption of error terms, which may limit the scope of the resulting efficiency scores. This study minimized this limitation by using proper statistical tests to find the best fit of data with the assumed distribution of error terms. Other available options for estimating bank efficiency also have their drawbacks.

Second, the selected banks from New Zealand are not listed on the stock market; therefore, market data for these banks was not available for market-based measures. Accounting data was collected from the banks' annual reports because it is not available on Datastream. Moreover, the data of Australia is adjusted to agree with the business of the Australian banks in New Zealand; the data of other countries cannot be adjusted for their international business due to the non-availability of data for our selected variables. The international business of the chosen commercial banks is not a major portion of their total business and is spread over 10–40 countries; therefore, its impact on each country should be minimal, as is confirmed with robustness tests discussed in the previous chapter.

Third, all bank-level data except New Zealand's was obtained from DataStream in domestic currencies. Data was converted to US dollars using the monthly average exchange rate for the banks' financial closing month which is consistent with accounting policies of the banks. Therefore, a major change in the exchange rate of any selected currency in the banks' closing month may affect the reported data.

Fourth, the estimated results are based on data from the large banks of each country, representing more than 50% of the selected banking sectors which is considered to be sufficient to assess the impact of the GFC on each banking sector. The selected banks of Australia, Canada, New Zealand, and the UK represent more than 80% of their banking sector. Results were tested after the inclusion of data from a few smaller banks from the selected countries, but this did not change outcomes significantly. Thus, conclusions drawn from comparing the efficiency scores of the selected countries need to be drawn with caution.

A review of the empirical findings of this study and some prior studies identified some research gaps that require further investigation. This study identified the role of numerous financial variables in the fluctuating impact of the GFC, but there is a need to investigate the management practices of bank managers, which may also have played a vital role in the GFC. A few prior studies found excessive compensation practices to be a key contributor to the GFC (Bebchuk, Cohen, & Spamann, 2010; Molyneux, 2018). During the presentation of the outcomes of this study at various forums, several participants asked about the role of loan securitization in the GFC. Collection of the cross-country data on holding of the debt securities and collateralized loans during the study period is a big task and could be taken on as a separate project. Investigation of this aspect would provide some valuable insight into the causes of the GFC.

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8. APPENDICES

Appendix 1: Variance Inflation Factor (VIF) Test

Variable	VIF	1/VIF
Total Assets	3.53	0.2830
Equity Ratio	3.01	0.332
Loans to Assets Ratio	2.99	0.333
Loan Losses	2.86	0.349
HHI	2.55	0.392
Interest Rate	2.21	0.452
Z-Score	1.77	0.565
GDP	1.68	0.594
Population Density	1.59	0.629
Lerner Index	1.57	0.639
Mean VIF	2.38	

Appendix 2: Correlation Matrix of Banking Environment Variables

Variables	IR	GDP	PD	TA	LAT	LOS	Z	HHI	Lerner	Eq
Interest Rate (IR)	1									
GDP per Capita (GDP)	-0.55	1								
Population Density (PD)	-0.16	-0.08	1							
Total Assets (TA)	-0.38	0.23	0.56	1						
Loans to Assets Ratio (LAT)	0.49	-0.23	-0.29	-0.68						
Loan Losses Ratio (LOS)	-0.34	0.16	0.29	0.71	-0.50	1				
Z-Score (Z)	0.26	-0.14	-0.15	-0.25	0.25	-0.27	1			
HHI	0.16	-0.33	0.09	-0.12	0.23	-0.23	-0.25	1		
Lerner Index (Lerner)	-0.21	0.20	0.01	-0.02	-0.26	-0.22	0.08	0.08	1	
Equity Ratio (Eq)	-0.34	0.33	-0.20	0.02	-0.06	0.21	0.15	-0.62	-0.28	1