An Analysis of Endogenous Sunk Cost Competition in the Banking Industry

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By

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Dedication

To my family.

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Statement of Authentication

To the best of my knowledge and belief, the work presented in this thesis is original except as acknowledged in the text. I hereby declare that I have not submitted this material, either in full or in part, for a degree at this or any other institution.

06/November/2022

Signature of Candidate

Date

I. Abstract

Banks play a critical role in providing liquidity to an economy by transforming small deposits into large loans (Kroszner & Strahan, 2014). Due to the importance of the banking system, bank performance has been an area of keen interest for regulators. Traditionally, regulators saw competition in the banking sector as a source of excessive risk-taking, adversely impacting bank performance and threatening the system's stability. Consequently, regulators globally supported a concentrated banking market. However, there was a paradigm shift towards the last quarter of the 20th century. Assuming deregulation will compete away inefficiencies stemming from concentrated market structure, regulators started desiring greater competition in the banking industry (Beck, De Jonghe, & Schepens, 2013). As a result, globally, regulators undertook several measures to reduce the market power of *national champions* (Vives, 2001). But, contrary to conventional economic theories and regulatory expectations, concentration in most banking markets remains elevated (see Drach, 2020; Murray, Davis, Dunn, Hewson, & McNamee, 2014; VanHoose, 2017). This situation concerns the authorities (see ACCC, 2018; European Banking Federation, 2018); however, the literature offers no clarity on what enables banks to forestall competition in expanding markets.

The present study addresses the issue by integrating Sutton's (1991) philosophy of endogenous sunk cost (ESC) with established theories in the banking literature. According to Sutton (1991), as the size of the market increases, incumbent firms attempt to soften competition through "a proportionate increase in fixed cost" in quality (p. 47). The author argues that fixed investments in the vertical form of product differentiation by a few large firms in an industry pushes rivals to either match the quality of their larger peers or quit the market (Ellickson, 2007). Consequently, as the market size expands, a few large firms incur higher ESC, discouraging new participation on the one hand and triggering consolidation on the other, resulting in a

concentrated market structure (Dick, 2007). Notably, as investments in quality are a firm-specific approach to handling competition beyond the purview of regulators, banks strategically invest in ESC to configure the market structure, quashing regulatory efforts to fragment the market.

The current study assesses two unique banking markets: Australia and the European Union (E.U.). On the one hand, the Australian banking sector is one of the most concentrated markets among the OECD countries, demonstrating exceptional resilience to economic shocks (Hoang, Hoang, & Yarram, 2020). On the other hand, the E.U. banking market operates in a unique competitive landscape where domestic banks safeguard their market share, competing with peers from the unified economic region on an equal footing; however, demonstrating extreme vulnerability to shocks (European Commission, 2012).

The banking literature exploring the impact of banking market structure on bank performance in the two markets is split between two dominant theories: the *competition-fragility* view (see Keeley, 1990) and the *competition-stability* hypothesis (see Boyd & De Nicoló, 2005). Assuming higher (lower) concentration reflects lower (higher) competition, both approaches make contradictory predictions about the impact of market structure on bank conduct, reflecting their performance. However, the results are inconclusive as sufficient empirical evidence justifying both hypotheses exists. Therefore, there is a dearth of substance to justify an appropriate position, even after three decades since the argument began.

Notably, both dominant views neglect the endogeneity of market structure and its influence on bank performance. Thus, by integrating Sutton's concept of ESC competition to evaluate the performance of Australian and E.U. banks, the present study presents a nuanced view of bank competition, addressing the shortcomings of the prior literature. A major highlight of the study is that it reaffirms that banks' ESC investments, which consume significant firm resources

(Senyuta & Žigić, 2016), on the one hand navigate concentration in the banking markets and, on the other, influence bank performance.

The study establishes advertising, branching, and information technology (IT) as the three major forms of ESC variables, and first tests their impact on the market share of Australian banks in the lending and deposit segments separately. While ESC investments are an established feature in the banking sector (see Cohen & Mazzeo, 2010; Dick, 2007; Jain & Gangopadhyay, 2020), their impact on two prominent yet diverse sets of banking operations (lending and deposit) has not been explored before. The study establishes that ESC investments drive concentration in the Australian deposit market but indirectly affect concentration in the lending market, indicating divergence in the behaviour of consumers of banking services. Intuitively, while depositors derive value from specific endogenous features, borrowers are not influenced by the quality banks indicate through ESC outlays. Nonetheless, the study concludes that lower funding costs stemming from higher concentration in the deposit segment are the source of concentration in the lending segment. Thus, ESC investments indirectly influence concentration in the lending market.

Further, the study evaluates the drivers of ESC investments in both Australian and E.U. banking markets from a managerial behaviour perspective. The study discovers that ESC investments, at best, have no influence on the cost efficiencies but a negative impact on the profit efficiencies of Australian banks. The study concludes that the *arms-race* phenomenon drives managerial interest in acquiring quality. However, in examining the E.U. banking market, the study found that ESC investments mildly lower cost efficiency frontiers but expand profit efficiency frontiers of sample banks. Thus, the study concludes that E.U. banks strategically select ESC investments to foster market power. The results support the operation of the *structure–conduct–performance* (SCP) paradigm, which posits that banks seek a higher concentration in the banking markets to exercise market power in their conduct, which reflects in their improved performance.

In examining the E.U. banking market, the study identifies that ESC investments in branching (advertising) adversely (positively) impact the cost and profit efficiencies of the sample banks; however, the evaluation of IT sunk cost investments yields confusing results. Although IT investments improve cost efficiencies, they fail to enhance banks' profit efficiencies. The discovery motivated the study to investigate the *productivity paradox* (see Solow, 1987) in IT sunk cost investments. Using Hansen's (1999) fixed-effect panel threshold model, the study successfully establishes that the relationship between banks' IT sunk cost investments and profitability is non-monotonic. The finding makes an important contribution as it highlights that assuming a linear relationship between bank investments in IT and profitability is inappropriate and is likely to produce biased results.

In conclusion, this research addresses significant voids in the banking literature. The study reveals the importance of ESC investments in evaluating banking market competition. Additionally, the study establishes the non-monotonic relationship between IT sunk cost investments and bank profitability. The study's findings give banking researchers and regulators valuable direction in assessing the competition in the banking markets. Additionally, it encourages supporters of the IT productivity paradox in banking to reassess their position following the discoveries of the present study.

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V. List of Acronyms

ACCC	Australian Competition and Consumer Commission
ADF	Augmented Dickey-Fuller
ADI	Authorised deposit-taking institutions
ADNIE	Advertising expense as a ratio of total non-interest expense
APRA	Australian Prudential Regulation Authority
ARDL	Autoregressive distributed lag model
BRNIE	Branching as a ratio of non-interest expense
CA	Cost approach to select banks’ input and output for efficiency estimation
CES	Cost efficiency scores
CI	Credit institutions
CIPS	Cross-sectional augmented Im-Pesaran-Shin – test of unit root
CM	Cost management: ratio of non-interest expense to total assets
CS	Capital strength: ratio of total bank equity to total assets
CS-ARDL	Cross-sectionally augmented autoregressive distributed lag model
DFE	Dynamic fixed-effect estimator
E.U.	European Union
ECB	European Central Bank
ECT	Error correction term
EMU	European Monetary Union
ES	Efficient structure hypothesis
ESC	Endogenous sunk cost
FMOLS	Fully modified ordinary least square estimation

GDP	Gross domestic product
GDPG	GDP growth
GFC	Global Financial Crisis
HHI	Herfindahl–Hirschman index
IA	Intermediate approach to select banks' inputs and outputs for efficiency
IFRS	International Financial Reporting Standards
INF	Inflation
IPS	Im, Pesaran, and Shin – test of unit root
IRB	Internal ratings-based
IT	Information technology
ITNIE	IT expense as a ratio of non-interest expense
LR	Likelihood ratio test
lnCM	Natural logarithm of cost management
lnGDP	Natural logarithm of gross domestic product
lnHHI	Natural logarithm of Herfindahl–Hirschman index
lnINF	Natural logarithm of inflation
lnNL	Natural logarithm of net loans
lnPBT	Natural logarithm of profit before tax
lnTA	Natural logarithm of total assets
lnTC	Natural logarithm of total cost
lnTD	Natural logarithm of total deposit
lnw_f	Natural logarithm of price of funding
lnw_k	Natural logarithm of price of physical capital
lnw_l	Natural logarithm of price of labour

$\ln Z_A$	Natural logarithm of advertising expense
$\ln Z_B$	Natural logarithm of branching
$\ln Z_T$	Natural logarithm of technology expense
LDR	Loan-to-deposit ratio
LML	Local maximum likelihood
MG	Mean group estimator
MSD	Market share in deposit segment
MSL	Market share in lending segment
NIM	Net interest margin
OECD	Organisation of Economic Co-operation and Development
OLS	Ordinary least squares
P-ARDL	Panel autoregressive distributed lag model
PA	Production approach to select banks' input and output for efficiency
PCA	Principal component analysis
PES	Profit efficiency scores
PMG	Pooled mean group estimator
QL	Quiet life hypothesis
R&D	Research and development
RMP	Relative market power
ROAA	Return on average asset
SCP	Structure–conduct–performance
SFA	Stochastic frontier analysis
SIC	Schwarz information criterion
U.S.	United States

VA	Value-added approach to select banks' input and output for efficiency
VECM	Vector error correction model
w_f	Price of funding
w_k	Price of physical capital
w_l	Price of labour
Z_A	Advertising expense
Z_B	Branching
Z_T	Technology expense

CHAPTER 1: Introduction

Chapter 1 provides the context and motivation for this study. First, the chapter presents an overview of the complexities in the banking literature about the relationship between competition and bank efficiency and highlights the research gap in micro-level literature on banking, particularly for Australia and the E.U. Further, the chapter discusses the theoretical framework and outlines the research questions, study objectives, research methods, and the study's contribution. Finally, the chapter outlines the structure of the thesis.

1.1 Background

Following the Great Depression of the 1930s, which triggered a banking crisis in various parts of the world, the legislative focus centred on fostering stability in the banking sector and avoiding similar bank runs in the future. Consequently, policymakers in most countries shared one basic idea: "…to preserve the stability of the banking and financial industry; [the] competition had to be restrained." (Hendrickson, 2010). As regulators saw competition as a source of excessive risk-taking in banking, they left no stone unturned to control it through extensive regulations. These included strict directives on what prices (interest rates) banks could pay or charge, what activities they could engage in, what risks they could take, what capital banking firms had to hold, and what locations they could operate in (Kroszner & Strahan, 2014; Matutes & Vives, 2000). Such stiff regulatory measures provided an extended period of stability to the banking system from the 1940s to the early 1970s (Beck et al., 2013; Matutes & Vives, 2000). However, towards the last quarter of the 20th century, there was a significant shift in the regulatory focus. Strict regulation in the banking industry, which fostered stability by limiting competition, came to be viewed as detrimental for the productivity and efficiency of the financial system. A general belief emerged that fiercer competition among banks would lead to higher productivity and efficiency, triggering a deregulation spiral across the globe[1] (Beck et al., 2013; Kroszner & Strahan, 2014).

Following industry deregulation, a natural expectation is that increased competition will result in a fragmented market structure. However, contrary to the anticipations of regulators, globally, concentration in the banking market has risen somewhat. For instance, since the mid-1980s, the number of commercial banks has dropped by about 70 per cent in the U.S. (VanHoose, 2017). Similarly, the number of banks operating in the E.U.[2] fell by 29 per cent from 1997 to 2007 (Vives, 2016, p. 28). Moreover, following the Global Financial Crisis (GFC), concentration in the region accelerated further, resulting in an even more condensed banking market dominated by larger banking firms (Beck & Casu, 2016). Comparable trends persist in Australia (Murray et al., 2014) and many emerging economies across Africa, Latin America, and Asia (see Fosu, 2013; Olivero, Li, & Jeon, 2011).

There is an ongoing debate in the banking literature about the effects of competition on the banking system's stability. Two opposing theories presenting contradicting arguments dominate the discussion. First, the *competition-fragility* view, founded by Keeley (1990), and second, the *competition-stability* debate, led by Boyd and De Nicoló (2005).

According to the proponents of the competition-fragility view, following the liberalisation of the banking industry, increased competition eroded banks' profits and lowered their franchise

[1] In the U.S., deregulation of the banking sector was initiated in the 1970s and was marked by the phasing out of Regulation Q, which regulated interest payments on demand deposits (Vives, 2016). Following the footsteps of the U.S., through the 1980s, several economies undertook numerous measures to deregulate their banking sector. For instance, the Australian Financial System Inquiry (1981) recommended deregulation of the Australian financial system, which resulted in the entry of 15 foreign banks into the country (Sturm & Williams, 2004). Korea adopted similar policies in 1982 (Hao, Hunter, & Yang, 2001), and France liberalised its banking sector in 1984 (Bertrand, Schoar, & Thesmar, 2007). By the early 1990s, several developing economies, such as Brazil (Studart, 2000), India (Kumbhakar & Sarkar, 2003), Jordan (Zeitun & Benjelloun, 2012), Mexico (Maudos & Solís, 2011), and the Philippines (Manlagñit, 2011) started liberating their banking sector, and deregulation of the financial system became a global trend.

[2] The E.U. is a political and economic consortium of 27 member countries (after the United Kingdom withdrew on 31st January 2020).

value. Consequently, banks increased their default risk through increases in asset risk and reduction in capital, making the banking system fragile. On the other hand, the advocates of the competition-stability argument suggest that lower competition is detrimental to the banking industry's stability. According to them, lower competition results in excessive profiteering by banks, especially in the loan market, which increases the risk of loan portfolios and makes the system fragile. There is substantial empirical evidence supporting both views; however, a careful analysis of the literature highlights a significant shortcoming in these prominent theories.

Like other industries, regulators foster competition in the banking sector, anticipating that the move will reduce the interest spread between banks' lending and deposit rates, improving consumer welfare through market fragmentation. However, in a pioneering work, Dick (2007) debunks this assumption and outlines the importance of quality. According to the author, consumers prefer "…paying a higher price to a bank in exchange for higher quality service" (p. 50). Relying on the theoretical framework offered by Sutton (1991), Dick (2007) claims that non-price competition is a significant feature of the banking industry. Notably, the author examined the banks' investments in branching, advertising, and other banking quality[3] and established that competition induced by deregulation resulted in a competitive escalation of sunk cost investments in quality by the dominant banks, resulting in concentrated market structures.

Notably, both dominant approaches assume that competition is induced only by regulatory interventions and completely ignore endogenous competition among banks. As competitive conditions tighten, banks seek to increase their market power and design and adapt their business models to gain a competitive advantage, even without regulatory intervention

[3] The authors examined other banking qualities, such as number of states the observed bank had presence in, number of employees in each branch, and the salary per employee.

(Badunenko, Kumbhakar, & Lozano-Vivas, 2021; Turk-Ariss, 2010). Hence, it is critical to assess the impact of banks' investments in quality attributes to attain product differentiation for a comprehensive analysis of the observed banking market structure and its influence on bank performance to analyse system-wide stability.

The present study focuses on two banking markets to assess the influence of Sutton's sunk cost competition on bank performance. First is the Australian[4] banking market. Second is the E.U.[5] banking market.

Since the 1980s, regulators have progressively deregulated the Australian banking sector to increase competition and reduce market concentration.[6] However, banks have been able to successfully dissuade regulatory efforts. According to the Australian Prudential Regulation Authority[7] (APRA) (APRA, 2019), the number of authorised deposit-taking institutions (ADIs) registered in Australia almost doubled in the past two decades. Still, contrary to the predictions of standard economic theories and expectations of regulators, the banking market remains unaffected and observes a two-tiered structure – in which four mammoth banks operate alongside many fringe banks with negligible market shares. The graphs below (Figure 1.1) illustrate the Australian lending and deposit markets structure as of 30th June 2019.

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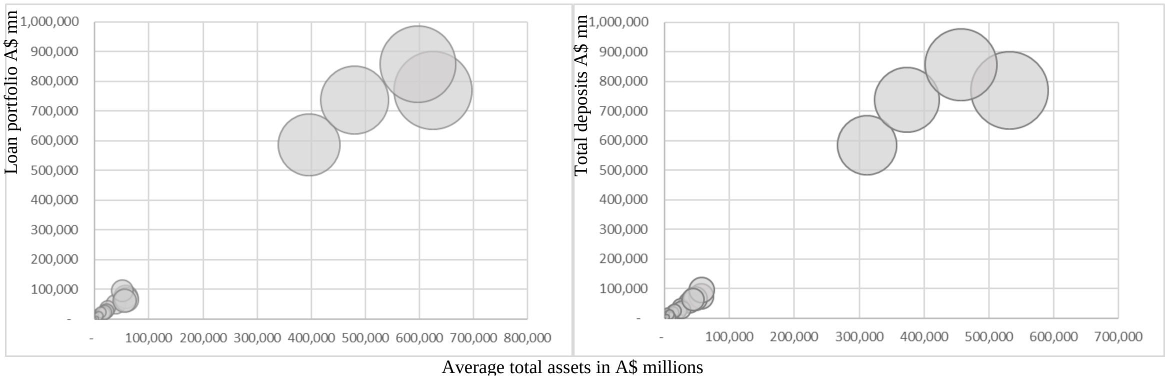
[4] The Australian banking sector has some unique characteristics. For instance, the market observes a higher market concentration than its peer economies. Moreover, even after consistent efforts of regulators to reduce market concentration (Murray et al., 2014), the incumbent banks have successfully maintained their position and an oligopolistic market structure. Yet, Australia's concentrated banking and financial sector performed exceptionally well throughout the GFC, with no bank succumbing to government bailout (Hoang et al., 2020), making it an ideal candidate for the examination of Sutton's theory.

[5] Following the second banking directive in 1993, banks in the unified economic region of the E.U. could freely establish operations in any member country (Murphy, 2000). Thence, banks in each member state of the E.U. faced competition from firms within their national boundaries and international banks headquartered within the E.U on an equal footing. However, the banking market in the E.U. demonstrated increased concentration over the years, and emergence of national champions (Vives, 2001), making it an interesting market to analyse Sutton's philosophy.

[6] Refer to Appendix 1 for a discussion on the evolution of the Australian banking sector.

[7] APRA is an independent statutory authority that supervises institutions across banking, insurance, and superannuation in Australia.

Figure 1.1: Market Share of Australian Banks in the Lending and Deposit Segments



Source: Data compiled from APRA publications.

As the graph shows, the market share of the four major Australian banks – Australia New Zealand Banking Group (ANZ), Commonwealth Bank of Australia (CBA), National Australia Bank (NAB) and Westpac Banking Corporation (WBC) – is substantially larger than their fringe counterparts, in both the lending and deposit market segments. The study thus evaluates ESC investments in the Australian banking sector as a source of market power, responsible for the observed two-tiered market structure, where numerous fringe banks compete alongside a few large banks.

Apart from Australia, the present study explores the E.U. banking market. Banks in the union operate in a unique setup. They enjoy access to a single, integrated financial system through which they can freely establish operations in a homogeneous competitive environment across the unified economic region (Drach, 2020; Maudos & Vives, 2019).[8]

The regulators' primary aim in deregulating and harmonising the member states' banking sector was to develop an efficient and competitive banking market. Nonetheless, data from European Central Bank (ECB, n.d.) indicate that, contrary to regulatory expectations, the five bank concentration ratio (C5)[9] has relatively increased in the union's member countries. The

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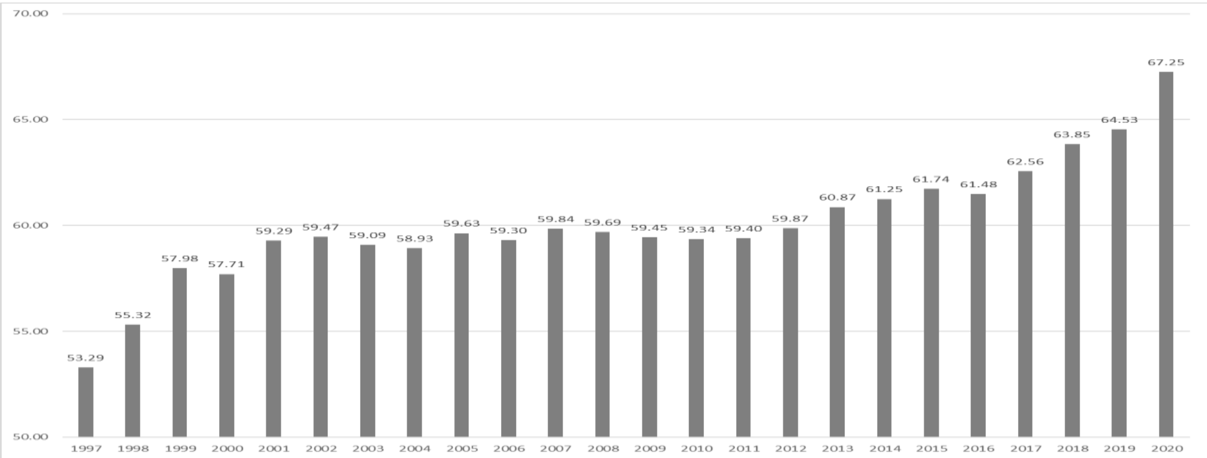
[8] Refer to Appendix 2 for a brief discussion on the evolution of the single banking market in the E.U.

[9] The five bank concentration ratio (CR5) measures the sum of total assets in percentage held by the five largest CI in the E.U. It is a common tool to evaluate market concentration.

graph below (Figure 1.2) reflects this trend, suggesting that the share of the five largest credit institutions (CI) in total banking assets, on average, has increased from 53.29 per cent in 1997 to 67.25 per cent in 2020. The increase in the share of the five largest CI in total banking assets highlights the ineffectiveness of regulatory intervention (see Casu & Girardone, 2009a) in introducing competition in the E.U. banking market. This phenomenon warrants an investigation into the role of ESC investments, which enables national champions (Vives, 2001) to preserve and gain market share against the will of regulators.

Figure 1.2: Five Bank Concentration Ratio in the E.U. Banking Market



Source: Data compiled from ECB Statistical Data Warehouse.

Both the Australian and E.U. banking markets have witnessed numerous regulatory interventions. While banks in the two markets operate in distinct regulatory environments, one thing is common: banks in both markets have been able to navigate the sector towards a more concentrated structure, even against the will of regulators.

Sunk cost investments in quality could be an effective tool for industry participants to churn the market structure in their favour. While numerous studies explore banking markets in the context of competition-stability and competition-fragility paradigms, the analysis is incomplete if the effect of ESC investments in quality is ignored.

The present research aims to address a significant vacuum in the banking literature by analysing the influence of ESC investments in quality on competition and efficiency in the two banking markets. In addition, relying on prominent behavioural accounting and finance concepts, the study attempts to uncover managerial motivations and biases that drive massive outlays in quality. The present research is the first to explore competition and performance issues in the Australian and E.U. banking markets through the lens of Sutton's sunk cost theory.

1.2 Literature Review

This chapter briefly reviews critical literature that explores the relationship between market concentration and banking sector performance before establishing the primary research gap the thesis addresses.

Since the seminal work of Keeley (1990), there has been an ongoing debate in the banking literature about the effects of competition on bank performance and the sector's stability. The banking literature is split between two dominant orthodoxies: first, the competition-fragility hypothesis, coined by Keeley (1990), and, second, the competition-stability theory, led by Boyd and De Nicoló (2005).

Following the deregulation of the U.S. banking sector, the industry witnessed a sharp increase in bank failures, which resulted in record payouts by deposit insurance. Keeley (1990) linked these systemic bank failures to competition introduced in the sector by deregulation. The author suggests that intense competition lowers banks' charter value and creates agency problems between bank owners and government-sponsored deposit insurance. Thus, when banks face competition, they engage in excessive risk-taking behaviour, which results in increased bank failures. Several other studies have documented similar relationships in different banking markets across the globe. For instance, analysing banks in 69 countries, Beck, Demirgüç-Kunt, and Levine (2006) concluded that crises are less likely in economies with a more concentrated banking sector. Similarly, Turk-Ariss (2010), in an analysis of 60 countries, documented a positive relationship between banks' market power, profit efficiency, and overall banking sector stability. Comparable findings have been reported in regional banking markets of Europe (Leroy & Lucotte, 2017), MENA[10] countries (Albaity, Mallek, & Noman, 2019), BRICS[11] economies (Moudud-Ul-Huq, 2021), and Baltic countries[12] (Cuestas, Lucotte, & Reigl, 2020).

However, a stream of academic literature proposes that competition fosters stability in the banking sector. For example, in an analysis of the U.S. banking market, Jayaratne and Strahan (1998) found a substantial decline in loan losses and operating costs post-deregulation of the sector. In addition, Mishkin (1999) argues that banks in a concentrated system are more likely to be subject to the regulator's "too big to fail" policies, which may encourage them to undertake more risks. Challenging the popular competition-fragility supposition, Boyd and De Nicoló (2005) devised the competition-stability hypothesis. Their key argument is that high borrowing costs in concentrated markets compel borrowers to choose riskier projects. Thus, reduced competition transforms into greater instability due to increased risk in the loan portfolio held by banks.

Several studies present empirical evidence in support of the competition-stability argument. For instance, analysing 31 systemic banking crises in 45 countries, Schaeck, Cihak, and Wolfe (2009) found that competition reduces the likelihood of a banking crisis and increases the time to a crisis. In addition, in a detailed examination of banking markets in 63 countries, Anginer, Demirguc-Kunt, and Zhu (2014) found that greater competition encourages banks to take on more diversified risks, making the banking system less fragile to shocks. Scholars have documented similar findings supporting the competition-stability view in the banking markets

[10] MENA is an acronym for the Middle East and North Africa region. Nineteen countries are generally considered part of the region: Algeria, Bahrain, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Palestine, Qatar, Saudi Arabia, Syria, Tunisia, United Arab Emirates, and Yemen.
[11] BRICS is an acronym for emerging economies of Brazil, Russia, India, China, and South Africa.
[12] The Baltic states consist of Latvia, Lithuania, and Estonia.

of Europe (Schaeck & Cihák, 2014), the U.S. (Goetz, 2018), South-East Asia[13] (Noman, Gee, & Isa, 2018), and Sub-Saharan Africa[14] (Brei, Jacolin, & Noah, 2020).

Considering the various competition and financial stability models, Allen and Gale (2004) found a range of possibilities concerning the relationship between competition and financial stability. Notably, the authors concluded that the effect of deregulation on competition and financial stability is complex and multi-faceted. Several scholars confirm the complexity associated with the issue and have reported mixed results and non-linear relationships between competition and bank stability (see Berger, Klapper, & Turk-Ariss, 2009; Martinez-Miera & Repullo, 2010).

1.3 Research Gap

A careful analysis of the banking literature reveals a significant omission in assessing the competition. Studies evaluating the relationship between market concentration and bank performance assume that only regulators can define the banking market structure, and participating banks lack the will and ability to alter it. Thus, while researchers have considered the effect of several bank-specific, industry-specific, and macroeconomic variables in their evaluations, they do not explore how firms respond to increased competition through endogenous strategies in vertical product differentiation. As a result, while there is an ongoing debate on the effects of market structure on the banking sector's stability, a significant omission persists in the literature as the ESC – a critical driver of market structure – is absent from the broader analysis.

[13] There are 10 countries collectively termed South-East Asia: Brunei, Cambodia, East Timor, Indonesia, Lao PDR (Laos), Malaysia, Myanmar (formerly Burma), Philippines, Singapore, Thailand, and Vietnam.
[14] Geographically, Sub-Saharan Africa is the area that lies south of the Sahara.

Further, prior studies evaluating the issue utilise conventional econometric approaches and datasets often covering short durations, which may restrict a comprehensive evaluation of the problem and thus be responsible for presenting contradictory results, even in analysing common banking markets. However, recent advances in econometric techniques now enable a deeper analysis of the issues, constantly offering new insights into pre-existing knowledge. For instance, most models analysing panel datasets fail to address the problem of potential cross-sectional dependence (see Chudik & Pesaran, 2015). In addition, efficiency studies commonly utilise the conventional two-step approach, which produces biased results (see Kumbhakar, Wang, & Horncastle, 2015). Similarly, studies often assume a monotonic relationship between variables, which is not an ideal assumption (Hansen, 1996). Therefore, analysing the relationships using novel econometric techniques can precisely uncover the market structure and bank performance dynamics.

1.4 Theoretical Framework: Sutton's Endogenous Sunk Cost Theory

The underlying assumption of analysis of entry is that firms must pay an upfront fixed cost *(x)* to enter an industry. This fixed cost x is known as a 'sunk cost' as it is irrecoverable upon exit. Various economic models suggest that cost and demand conditions determine the equilibrium number of firms in the market. For instance, as per the Cournot model: as x tends to zero, the equilibrium number of firms *(n)* tends to infinity. Similarly, as the market (M) size tends to infinity, the equilibrium number of firms n too tends to infinity (Belleflamme & Peitz, 2015, p. 91). However, contrary to popular economic theories and empirical observations, some industries reflect persistently high concentrations, even though there has been a substantial increase in market demand (Hubbard & Mazzeo, 2017). Similar trends are observable in the Australian and E.U. banking markets.

John Sutton (1991), provides a precise mechanism that explains how firms can use endogenous (discretionary) fixed sunk costs to enhance the quality of their products and drive competitors out of the market. According to Sutton (1991):

> If it is possible to enhance consumers' willingness to pay for a given product to some minimal degree by way of a proportionate increase in fixed cost (with either no increase or only a small increase in unit variable costs), then the industry will not converge to a fragmented structure, however large the market becomes (p. 47).

Sutton's sunk cost theory explicitly discriminates between exogenous sunk costs and ESC. Sutton identifies the cost to develop a manufacturing plant of "minimum efficient scale" as the critical exogenous sunk cost (Robinson & Chiang, 1996). All firms incur exogenous sunk costs to participate in a market, which depends on the underlying technology (Ollinger & Fernandez-Cornejo, 1998). On the other hand, ESC investments are investments in quality attributes, such as advertising and research and development (R&D), which increase the value of the product offered by the firm to its customers (Belleflamme & Peitz, 2015, p. 96). Unlike exogenous sunk costs, ESCs are choice variables that depend upon each firm's strategy, and thus differ among competing firms (Ollinger & Fernandez-Cornejo, 1998).

As exogenous sunk cost investments are considered unrelated to market size, most models predict that, as market size increases, more firms would participate in the market, monotonically declining the concentration to zero (Senyuta & Žigić, 2016). However, in industries with significant ESCs, as markets grow, firms are motivated to increase their provision of quality (Dick, 2007). By incurring higher fixed costs investments in ESCs, on the one hand, incumbent firms raise barriers to entry, and, on the other, force existing competitors to make similar investments to retain their respective market share or exit. Consequently, a dual-market structure emerges, in which a few dominant firms, who invest heavily in ESC, capture a much more significant fraction of the market and coexist with several fringe firms, who invest in quality at a relatively smaller scale (Dick, 2007).

Numerous studies explore and validate Sutton's theory in diverse industries. Examples include the pesticide industry (Ollinger & Fernandez-Cornejo, 1998), online retailing (Latcovich & Smith, 2001), the telecommunications sector (Gruber, 2002), the consumer package goods sector (Bronnenberg, Dhar, & Dubé, 2011; Sutton, 1991), medical care (Kessler & Geppert, 2005), the brewing industry (George, 2009), the supermarket industry (Ellickson, 2007), the newspaper market (Berry & Waldfogel, 2010), the aviation industry (Mazzeo, 2003), and the hotel and motel industry (Hubbard & Mazzeo, 2017).

The following subsections first outline the difference between exogenous and endogenous sunk cost industries and then the relevance of the theory in the banking industry.

1.4.1 Exogenous vs endogenous sunk cost industry

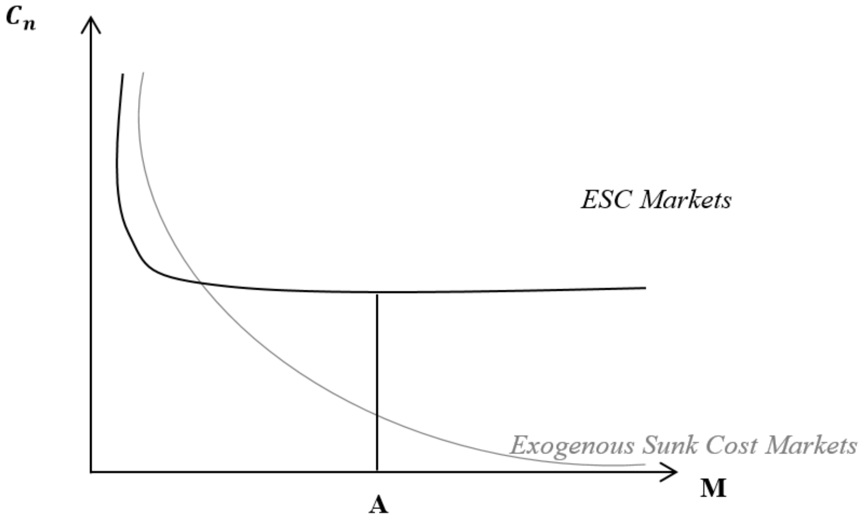
Sutton's theory predicts competition based solely on pricing in markets where products are horizontally differentiated[15] or homogenous. All sunk costs in such sectors are predominantly exogenous (compulsory). Thus, as the market size expands, new participants are encouraged to enter, which leads to a fragmented market structure (Goddard, Molyneux, Wilson, & Tavakoli, 2007; Senyuta & Žigić, 2016; Waldman, 2013), and concentration monotonically declines to zero. An example of one such industry is hair salons (Ellickson, 2007, p. 53).

However, according to Sutton, in markets where products are vertically differentiated,[16] firms compete alongside both price and non-price quality dimensions. In such industries, sunk costs are endogenous (discretionary). An increase in the market size motivates firms to increase their

[15] Horizontal product differentiation implies products or services are of similar quality, but offer different combinations of features, which may be valued differently by different consumers.
[16] Vertical product differentiation implies one product or services differ from another in terms of quality, and therefore in terms of price.

provision of quality to shift consumer demand (Dick, 2007; Goddard et al., 2007; Waldman, 2013).

Figure 1.3: Concentration Trends in an Exogenous and Endogenous Sunk Cost Industry



Source: Author's construct.

Figure 1.3 highlights how concentration C_n shapes an ESC industry, in contrast to an exogenous sunk cost industry, when the size of the market M increases. As investments in exogenous sunk costs are considered unrelated to market size, Sutton predicts that as market size increases, more firms would enter the market, and concentration would monotonically decline to zero (Senyuta & Žigić, 2016). However, in markets with significant ESC, even as the size of the market grows without bounds, contrary to the predictions of prominent economic theories, industry concentration remains bounded away from zero to a strictly positive number *A* (Belleflamme & Peitz, 2015).

In an industry with free entry and *N ex-ante* identical firms, the profit of a typical firm *i* is given by eq. (1) below (Schmalensee, 1992):

$$\pi_i = (P_i - c_i)q_i - A_i - \sigma \tag{1.1}$$

In eq. (1.1), P_i refers to firm i's price, c_i is its constant per-unit cost, q_i refers to its unit sales, A_i is the chosen level of ESC investment (advertising or any other demand-shifting expenditure), and σ is its exogenous sunk cost (technologically fixed setup cost). In the above eq. (1.1), A_i is the defining feature that distinguishes between exogenous and ESC markets. In an exogenous sunk cost market, A_i can be treated as exogenous, and in a symmetric model, one can set $A_i = 0$ for all i. Thus, in an exogenous sunk cost market, as the total spending S on this product $\rightarrow \infty$, N $\rightarrow \infty$, eroding any margins over and above marginal cost of production.

Sutton (1991) modelled rivalry in an ESC market as a two-stage game. In the first stage, firms decide whether or not to enter and select the level of A_i upon entry. In the second stage, A_i is treated as a sunk cost, and firms compete on price or output (Schmalensee, 1992). Sutton (1991) suggests that if payoffs in the second-stage subgame are adequately sensitive to alterations in the level of A_i, the market share of the largest firm will remain bounded away from zero, irrespective of the increase in S.

A handful of studies examine the operation of Sutton's (1991) theory in the banking sector (e.g. Cohen & Mazzeo, 2010; Dick, 2007; Jain & Gangopadhyay, 2020). The following subsection discusses the relevance of the theory in the banking industry.

1.4.2 Endogenous quality provisions in the banking industry

Sutton's ESC framework applies to industries where quality (non-price) competition is an essential feature (VanHoose, 2017, p. 74). Since price controls became commonplace in most banking markets following the regulations introduced post the Great Depression of the 1930s, banks started engaging in non-price (quality) competition to attract business (see Heggestad & Mingo, 1976; Lapp, 1976; Scott, 1978; White, 1976). Nonetheless, following the deregulation of the global banking industry, banks continue to compete on non-price dimensions to protect (and gain) market share (see Dick, 2007; Cohen & Mazzeo, 2010). Incumbent banks use ESC investments as a tool to deter new entrants from establishing operations on the one hand and, on the other hand, to push the cost of existing fringe competitors, fostering industry consolidation and a concentrated market structure. The present study considers three investments in non-price quality attributes by sample banks to model the effect of ESC investments in the analysis: branching, advertising, and information technology (IT). Section 2.2 of the thesis provides a detailed review of banking literature, establishing the three factors as relevant ESC variables for the study.

1.5 Research Questions

Banking studies analyse efficiency and stability in the industry from alternative perspectives using different methodological approaches and covering varying timeframes and markets. However, the effect of ESC investments in evaluating banks' efficiency and stability remains largely unexplored. Most importantly, as individual strategies of a firm navigate ESC investments (Sutton, 1991), its analysis could be a valuable tool to uncover the managerial motivation in selecting these extensive outlays to configure market structure. Thus, the overall research objective of the present study is to examine how ESC investment impacts banks and interpret the results to decode the puzzle around market structure and bank performance. More specifically, the study will address the following research questions:

RQ 1: Do ESC investments influence concentration in the deposit and lending segments similarly?

RQ 2: What is the impact of ESC investments on the performance of Australian banks?

RQ 3: What is the impact of ESC investments on the performance of the banks operating in the unified banking market of the E.U.?

RQ 4: Is the relationship between IT ESC investments and bank performance monotonic or non-monotonic?

1.6 Objectives of the Study

The study's primary objective is to explore the operation of Sutton's ESC theory in the context of Australian and E.U. banking markets. Specifically, the study aims:

- RO 1: To analyse the impact of ESC investments on the market share of Australian banks in the lending and deposit segments.
- RO 2: To examine the impact of ESC investments on the efficiency of Australian and E.U. banks.
- RO 3: To investigate the individual impact of different types of ESC investments on the performance of banks in the E.U.
- RO 4: To examine the monotonicity in the relationship between IT sunk cost investments and bank profitability.

1.7 Hypotheses of the Study

Based on the research questions outlined above, this study hypothesised the following:

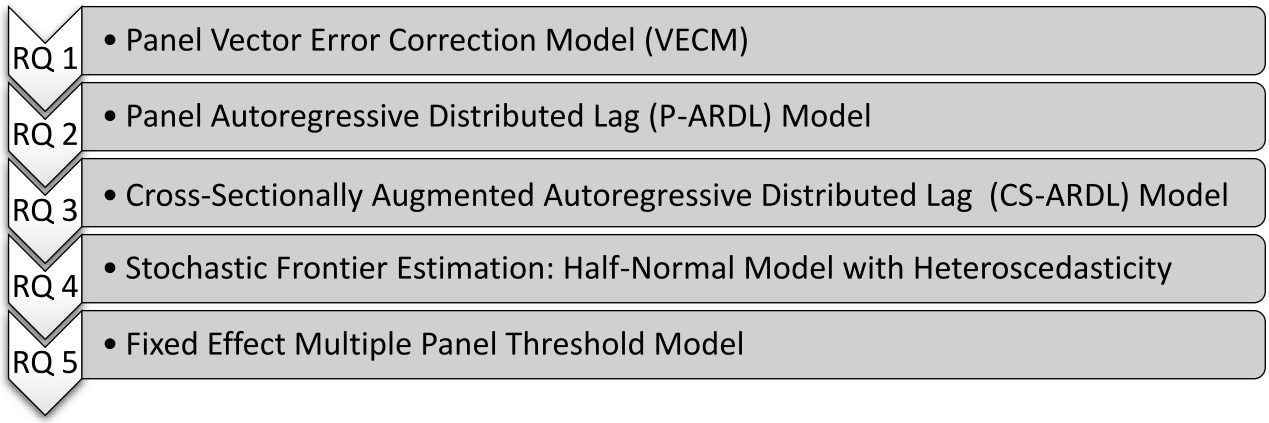
- Hypothesis 1a: ESC investments by banks are responsible for high concentration in the lending and deposit segments of the Australian banking market.
- Hypothesis 2a: ESC investments influence the cost and profit efficiencies of Australian banks.
- Hypothesis 3a: ESC investments influence E.U. banks' cost and profit efficiencies.
- Hypothesis 3b: Different ESC variables affect the performance of banks differently.
- Hypothesis 4a: The relationship between bank profitability and IT sunk cost investments is non-monotonic.

1.8 Research Methodology

Given the research framework of the objectives, the overall research is divided into two major sub-studies. The first examines the top nine Australian banks from 2000 to 2019, collectively representing 84 per cent of Australia's banking assets. The second explores a larger sample of 34 banks from the E.U. banking market from 2009 to 2018.[17]

Figure 1.4 provides a synopsis of the primary econometric technique used to address each research question.

Figure 1.4: Econometric Tools Utilised to Address Research Questions



Source: Author's construct.

The framework begins with an analysis of the Australian banking market and examines the influence of different ESC investments on banks' market share. The study first utilises data from APRA to manually derive the market share of each sample bank in the lending and deposit segments separately. Next, the study investigates the impact of three ESC investments – advertising, branching, and technology – on the derived market shares after controlling for relevant factors using the Panel-VECM approach.

[17] The empirical models tested in the study require balanced panel datasets, due to which the sample size and period for the E.U. banks were pruned and finally assessed for 2009 to 2018.

To examine RQ 2: the influence of ESC investments on the performance of Australian banks, first, sample banks' cost and profit efficiency scores were calculated using the stochastic frontier analysis (SFA) approach, following Hoang et al. (2020). The study utilises Pesaran, Shin, and Smith's (1999) P-ARDL approach. Finally, the study also employs Chudik, Mohaddes, & Pesaran's (2013) CS-ARDL model as a robustness test to address any potential error arising from cross-sectional dependence.

To assess RQ 3: the influence of ESC investments on the performance of E.U. banks, first, sample E.U. banks' cost and profit efficiencies were calculated using the SFA approach. Then the study employs Chudik and Pesaran's (2015) CS-ARDL approach. Additionally, the study uses Kumbhakar et al.'s (2015) half-normal model with heteroscedasticity and uncovers the impact of different ESC investments on the performance of E.U. banks.

Finally, to decode the paradox of technology for banks' profitability (RQ 4), the study utilises the fixed-effect panel threshold model proposed by Hansen (2000). Hansen (1996) noted that regression functions may not be identical across all observations in a sample and may fall into discrete categories. Hansen's (2000) approach splits individual observations into classes based on the value of the observed variable and describes the jumping character or structural break in the relationship between variables (Wang, 2015). The study employs Hansen's (1999, 2000) estimation technique to examine and model the non-monotonic relationship between IT sunk cost investments and E.U. bank profitability.

Besides the empirical techniques outlined above, the study has employed various panel Granger causality tests, fully modified ordinary least square (FMOLS) estimations, principal component analysis (PCA), cross-section dependence test and translog cost function, as per the analysis requirements. Each empirical chapter details the utility and application of these tests.

1.9 Contribution of the Study

The present study integrates the theoretical framework Sutton (1991) offered with well-established banking theories to provide an enhanced understanding of banking market concentration. The following section discusses the main contributions of the study.

i) First, the Australian banking sector has some unique characteristics. Besides observing high concentration, it is exceptionally resilient to economic shocks (Hoang et al., 2020), making it an ideal market for examining Sutton's theory. However, the focus of the researchers so far has been the U.S. banking market, and smaller market economies like Australia have remained primarily ignored. Thus, the analysis of the Australian banking market outlines the operation of bankers' endogenous strategies to corner market share in smaller advanced economies and addresses a significant void in the banking literature.

ii) Prior studies examining the operation of Sutton's ESC theory in the banking industry do not discriminate between the two primary services offered by banks, i.e. deposit and lending. However, banks' ESC investments may influence depositors and borrowers differently (see Cohen & Mazzeo, 2010). The present study examined the impact of ESC investments on the market share of Australian banks in the lending and deposit segments separately and made some important revelations. The research thus extends the banking literature and offers bankers new insights to formulate strategies to manage market share in the two segments and improve the efficacy of their ESC investments.

iii) Notably, the literature extensively debates the effect of industry concentration on firms' behaviour (conduct) by analysing their performance (Williams, 2003). ESC investments consume significant firm resources (Senyuta & Žigić, 2016) and are a critical tool enabling banks to gain market power and navigate concentration in the sector (Dick, 2007). Assessing the impact of ESC investments on the cost and profit efficiencies of the banks, the present study maps managerial biases in selecting such critical investments in quality. Thus, contributing to the literature on behavioural accounting and finance and extending knowledge about the managerial motivation behind acquiring quality.

iv) The study identifies the importance of IT in modern banking and addresses a longstanding issue concerning the productivity paradox stemming from massive IT investments (see Solow, 1987). Prior studies (e.g. Gupta, Raychaudhuri, & Haldar, 2018; Ho & Mallick, 2010; Prasad & Harker, 1997) assessing the issue assume a linear relationship between IT investments and firm performance. However, banks may select strategic sunk cost investments in IT in isolation from their competitors. Due to this heterogeneity, the structural relationship between banks' IT investments and profitability may differ. Employing Hansen's (1999) panel threshold model, the study establishes that the relationship between IT ESC investments and bank profitability is non-monotonic. Thus, the study explains why researchers present contradicting results even when analysing the same banking markets and offers new insights into the issue.

1.10 Structure of the Thesis

Figure 1.5 outlines the structure of the thesis. The thesis comprises six (6) chapters and follows a simple format. First, after the introduction chapter (Chapter 1), the following two chapters empirically explore the operation of ESC in the Australian banking market. The research then evaluates the operation of ESC in the E.U. banking market in Chapter 4. In Chapter 5, the study explores the role of IT sunk cost investments on E.U. banking profitability through the innovative threshold approach. Finally, Chapter 6 concludes the findings of the research.

Figure 1.5: Structure of the Thesis

Endogenous Sunk Cost Competition in the Banking Industry					
Chapter 1: Introduction	**Chapter 2:** The Role of Endogenous Sunk Cost Investments in Shaping the Structure of the Australian Banking Market	**Chapter 3:** Mapping Managerial Biases in Choosing Endogenous Sunk Cost (ESC) Investments	**Chapter 4:** What Drives Endogenous Sunk Cost Investments in the European Banking Industry?	**Chapter 5:** Understanding the Paradox of Technology for Banks' Profitability: The Threshold Effect Approach	**Chapter 6:** Conclusion

Source: Author's construct.

Chapter 1, the introductory chapter, offers an overview of concentration in the banking industry and the associated theories, which present contradicting arguments. Then, after identifying the research gaps, the chapter underpins the principal theoretical framework that navigates the entire research. Further, the chapter outlines the study's research questions, objectives, and hypothesis. Finally, the chapter introduces readers to the methodologies employed to address outlined research questions and highlights the study's contribution and thesis structure.

Chapter 2 explores the role of ESC investments in shaping the structure of the Australian banking market. The chapter first reviews the literature on non-price competition in banking, establishing branching, advertising, and IT as the relevant ESC factors for the banking industry. Further, the chapter develops an econometric framework controlling for various bank-specific, industry-specific, and macroeconomic factors to estimate the influence of each ESC variable (advertising, branching, and IT) on the market share of Australian banks in the lending and deposit segments individually. Finally, the chapter discusses and explains how each ESC factor influences Australian banks' market share in the two banking services domains.

Chapter 3 investigates managerial biases in selecting ESC investments by analysing Australian banks' cost and profit efficiencies. The chapter extensively reviews the efficiency literature concerning the Australian banking market and uses SFA to calculate the efficiency of each sample bank. Subsequently, the study utilises the P-ARDL approach to assess the relationship. In addition, to overcome the potential problem arising from cross-sectional dependence, the chapter employs the CS-ARDL technique for robustness check.

Chapter 4 extends the research beyond Australia and investigates the drivers of ESC investments in the E.U. banking market. After reviewing the European banking literature on market concentration and performance, the chapter calculates the efficiency of the sample banks using the SFA approach. It then estimates the influence of ESC investments on the cost and profit efficiencies of the E.U. banks using the CS-ARDL approach. In addition, to overcome the potential bias in the two-step approach (see Wang & Schmidt, 2002), the chapter employs a translog half-normal model with heteroscedasticity, as proposed by Kumbhakar et al. (2015), to supplement the primary results.

Chapter 5 attempts to uncover the paradox of technology for bank profitability using the threshold effect. First, the chapter reviews the literature concerning the Solow paradox in the banking sector. After that, the chapter develops a microeconomic framework based on Hansen's (1999, 2000) fixed-effect panel threshold model and establishes a non-monotonic relationship between IT investments and bank profitability. The study also tests the relationship between IT sunk cost investments and other accounting measures of bank performance, presenting new insight into the issue.

Chapter 6, the final chapter, summarises findings, the practical and theoretical implications of these findings, and recommendations. Additionally, the chapter highlights some significant features of banking markets in Australia and the E.U. Finally, it concludes with a discussion on the limitation of the study and directions for future research.

CHAPTER 2: The Role of Endogenous Sunk Cost Investments in Shaping the Australian Banking Market Structure

The Australian banking sector has persistently demonstrated high concentration levels, and even after several regulatory measures and policy actions, its market structure remains resilient. Chapter 2 investigates Sutton's notion of Endogenous Sunk Cost investment in the context of the Australian banking industry and attempts to unravel the dynamics of competition and concentration within the sector.

2.1 Introduction

Following the Great Depression of the 1930s, and subsequent World War II, the banking sector in Australia became extremely concentrated (Wright, 1999, p. 18). The regulators were content with a consolidated banking market structure and promoted it – as evident from the Royal Commission's (1937) final recommendations.[18] However, after decades of stability, since the 1970s, a pro-competition view emerged globally, suggesting that excessive control fostered stability in the banking sector at the expense of productivity and efficiency (Vives, 2016). Following global trends, in 1979, the Australian Federal Government tasked the Campbell committee to review regulations and make policy recommendations to improve the overall functioning of the financial system (Edwards & Valentine, 1998). In line with the increasing dominance of the free market paradigm, it is not surprising that the committee submitted that "…the most efficient way to organise economic activity is through a competitive market system

[18] Prominent measures undertaken following the recommendations from the Royal Commission included the introduction of licensing provisions – which prohibited "carrying on the business of a bank" by any organisation without prior authorisation from the Commonwealth Treasurer; initiation of variable primary reserve requirement – to control the volume of credit; and implementation of numerous reporting requirements – for greater transparency (Edwards & Valentine, 1998).

which is subject to a minimum of regulation and government intervention" (Campbell, 1981, p. 1).

The recommendations of the Campbell (1981) committee[19] and the subsequent Wallis (1997) report[20] made a significant shift in regulatory stance, favouring competition in the banking sector. Subsequently, regulators introduced several reforms to lower the concentration level in the banking sector by encouraging new firms to set up banking operations in Australia.

A predictable consequence of reduced barriers to entry, alongside the rapid growth of the market[21] in which banks offer homogeneous products, is that it must witness an increase in the number of banking firms and a decline in the level of market concentration (Dick, 2007; Hubbard & Mazzeo, 2017; VanHoose, 2017, p. 71). However, as noted by the 2014 Financial System Inquiry (Murray et al., 2014), and subsequently by the recent Productivity Commission (2018), the Australian banking markets remain highly concentrated, even after decades of regulatory efforts. The Herfindahl–Hirschman index (HHI),[22] a standard measure of market concentration, confirms the trend. Notably, contrary to the predictions of standard economic theories, HHI in the deposit (lending) segment increased from 1,179.76 (1,226.47) in 2000 to 1,496.07 (1,579.90) in 2019, even though the number of registered ADIs almost doubled during the period (APRA, 2019).

Fundamentally, a firm can increase its market share through the competitive pricing of products. However, service competition influences the market structure of the Australian

[19] Some of the prominent recommendations of the Campbell committee later implemented included: removal of ceilings on deposit and loan rates; permitting new banks, including foreign-owned entities, to enter the Australian banking industry; deregulation of the foreign exchange market; and relinquishment of direct monetary controls and reliance on interest rates as the principal instrument of monetary policy (Edwards & Valentine, 1998).

[20] Some of the prominent recommendations of the Wallis committee were: i) the removal of industry-specific criteria for participation in different markets; ii) neutral regulatory treatment of competitors from diverse institutional sectors; iii) single market conduct and disclosure regulator for the financial industry; and iv) a single prudential regulator (the Australian Prudential Regulation Commission – APRC) separate from the Reserve Bank of Australia (Quigley, 1997).

[21] Total loans and advances swelled from approximately A$ 487.7 billion in 2000 to close to A$ 2.7 trillion in 2019, and total deposits multiplied from about A$ 407.35 billion in 2000 to close to A$ 2.23 trillion in 2019.

[22] Please refer to section 3.3 (Chapter 3) for a brief explanation on the calculation of HHI.

banking sector and not price competition (Productivity Commission, 2018, p. 97). Further, an inquiry into mortgage pricing by ACCC (2018) concludes that Australian banks do not compete on prices to gain market share. Therefore, a critical empirical question is: How do Australian banks beat the competition and maintain their respective market share without engaging in price rivalry?

Sutton's (1991) theory of ESC investment can be a valuable source to untangle the mystery behind the observed market power and thus concentrated market structure of the Australian banking industry. The central idea of Sutton's theory of ESC is that when firms experience tougher competition, they will incur more significant investments in fixed ESC. Sutton (1991) suggests that by doing so, the incumbent firms hope to shift consumer demand and gain market share by offering superior quality, i.e. their focus shifts from better pricing to better services. Consequently, concentration in the market will be higher in industries where incumbent firms can improve the consumers' "willingness to pay" through fixed investments in quality attributes of a homogeneous product *(please refer to Chapter 1 for an analysis of the functioning of Sutton's ESC theory).*

Following the recommendations of the Campbell (1981) committee and the Wallis (1997) report, regulators introduced several reforms in the banking market, making it much more accessible for foreign banks and new participants aspiring to set up banking operations in Australia. Therefore, to protect (and gain) market share, the incumbent bank may use ESC investments as a strategic tool, improving the quality of their product offering rather than engaging in price rivalry. The present study aims to evaluate whether Sutton's (1991) theory of ESC investments explains the concentrated structure of the Australian banking market.

Following Dumrongrittikul and Anderson (2016), and Hondroyiannis and Papaoikonomou (2020), the research utilises a panel vector error correction model with exogenous variables

(VECMX model) to empirically assess whether Sutton's notion of ESC applies to the Australian banking market. The model treats all variables of interest as endogenous and interdependent, both in a dynamic and static sense, and allows the inclusion of exogenous variables in the estimation (Canova & Ciccarelli, 2013, p. 6). Thus, the models provide a comprehensive analysis alongside addressing any endogeneity issues. Precisely, the study evaluates the impact of ESC investments on the market share of sample banks in the deposit and lending markets separately, after controlling for relevant industry- and market-specific factors.

The present analysis makes three critical contributions. First, considering the outcomes of recent inquiries of the Australian banking sector (ACCC, 2018; Murray et al., 2014; Productivity Commission, 2018), it is evident that regulators are not satisfied with the current structure of the industry. The study identifies factors driving concentration in the Australian banking market, which can help in appropriate policy action to achieve greater competition – as desired by regulators since the 1980s. Second, to the best of my knowledge, Sutton's ESC theory has never been tested before in the Australian banking market. The market observes a relatively high concentration compared to its global peers (Hoang et al., 2020). The analysis thus offers a nuanced evaluation of Sutton's theory's operation in an oligopolistic banking market. Finally, competition may shape differently in the deposit and lending segments. The present research evaluates the impact of ESC investments of Australian banks on their respective market share in the lending and deposit markets separately. It allows mapping of depositor and borrower responses to different forms of ESC investments of sample banks individually, which has never been assessed before.

The organisation of the rest of the chapter is as follows: Section 2.2 will review the critical literature, outline relevant ESC factors and industry- and market-specific variable(s) vital to the analysis. Section 2.3 describes and defines the study's data, source, and characteristics.

Section 2.4 details the empirical model employed in the research and interprets the results. Finally, section 2.5 concludes.

2.2 Literature Review

Conventional entry models predict that an increase in the market size will create opportunities for new firms to enter and gain sufficient profits, reducing market concentration (see Belleflamme, 2010; Shiman, 2008). However, the central notion of Sutton's (1991) theory is that in an ESC industry, an increase in the market size cannot lead to a fragmented market structure; rather, it will trigger a competitive escalation in ESC outlays – "thus offsetting the tendency toward fragmentation" (p. 12). A handful of studies validate Sutton's notion in the banking sector (for example, Cerasi, Chizzolini, & Ivaldi, 1998, 2002; Cohen & Mazzeo, 2010; Dick, 2007; Jain & Gangopadhyay, 2020), focusing mainly on the U.S. or European markets.

For a comprehensive analysis of Sutton's notion in the context of the Australian banking market, it is essential to analyse the impact of ESC investments on banks' market share after controlling for other factors that shape the banking market structure. Accordingly, this section reviews relevant banking literature to identify the most pertinent endogenous and exogenous factors critical for the analysis.

2.2.1 Endogenous sunk cost (ESC) investments

Branching

As depositors are sensitive to the convenience of having nearby banking offices and a more extensive physical network, researchers have identified branching as one of the critical quality attributes that attract depositors (see Cohen & Mazzeo, 2004; Iftekhar & Stephen, 1997; White, 1976). According to Carlson and Mitchener (2006), branch banking raised competition during strict pricing regulations in the 1920s and 1930s, resulting in increased concentration in the

U.S. banking market. However, as noted by Dick (2006), branching remained a critical source of non-price competition in the U.S. following the deregulation of the banking sector. As a result, U.S. banks significantly expanded their branching network, increasing their operating costs and negating any gains from increases in revenues from additional branches; however, it allowed incumbent banks to maintain their market share. The author highlights that contrary to the regulators' expectations, the branching reforms (which aimed at increasing competition in the banking market) had no impact on the banks' market structure. In a recent analysis of the U.S. banking market, underpinning the perceived importance of branching in modern banking, Kuehn (2020) found that banks expand their branching network in response to an increase in the branch network size of their competitors in a bid to protect their market share.

In an analysis of the E.U. banking market, Cerasi et al. (1998, 2002) investigated the branching behaviour of banks in the E.U. following the deregulation of the banking sector in the unified economic region. The authors concluded that incumbent banks increase their branching investments to compete for clients following tougher price competition. In an analysis of the Norwegian banking sector, Kim and Vale (2001) empirically established that branching has a significant, positive effect on the bank's share in the loan market. The authors found that an additional branch, on average, increases the net market share of a Norwegian bank by 9.4 per cent in the lending segment (p. 1599). Analysing the Hungarian banking market, Temesvary (2015) found that banks with extensive branching networks exercise market power in the lending segment. However, in an analysis of the Italian banking market, Degl'Innocenti, Mishra, and Wolfe (2018) found contradictory results.

Some recent studies establish branching as a critical endogenous strategy in developing economies. For instance, Zhang, Arora, and Colombage (2021) found that the size of the population and deposits influence the branching strategy of Indian banks; a finding similar to that of Dick (2007, 2008). Furthermore, in the Australian banking market context, the

Productivity Commission (2018) concluded that extensive geographical reach (branch network) contributes to major banks' brand image, attracting consumers.

Advertising

Initial studies investigating the relationship between advertising intensity and market concentration reject the hypothesis that advertising is an ESC for the banking sector. For instance, Lapp (1976) suggests that the banking market structure was controlled exogenously due to strict regulations, and the causality ran from market structure to advertising and not vice-versa. On similar lines, Kohers and Simpson (1981) established an inverse relationship between advertising intensity and market concentration, claiming that dominant players would advertise less in a highly concentrated market. However, researchers found contradicting results in subsequent studies, mainly those that analysed data from the post-deregulation era. For instance, Pinho (2000) investigated non-price instruments in the Portuguese banking market, where new banks chartered post deregulation made affirmative use of advertising to gain market share. Researching thrift institutions in the U.S. from 1994 to 2000, DeYoung and Örs (2004) and Örs (2006) found a positive relationship between market concentration and advertising outlays. Using advertising intensity as the relevant variable, Dick (2007) suggests that dominant banks advertise 35 per cent more than their fringe counterparts in the U.S. banking market. In an analysis of Spanish banking firms, Martín-Oliver and Salas-Fumás (2008) concluded that "advertising capital increases the demand for loans, and the supply of deposits" (p. 251).

In recent studies, scholars have extensively analysed the advertising strategies of banks in developing markets. For instance, analysing the Turkish banking market, Amoako, Anabila, Asare Effah, and Kumi (2017) found that banks allocate considerable amounts in their marketing budgets to acquire new and service existing customers. In a qualitative analysis of

Ghana's banking industry, Amoako et al. (2017) established a significant positive relationship between advertising, customer loyalty, and brand preference. Analysing the Indian banking market, Mulchandani, Mulchandani, and Attri (2019) highlight the problems associated with product differentiation in the banking industry, as any new feature introduced is quickly imitated by competitors. Thus, authors see advertising as an essential tool in the value-creation process that allows banks to develop long-term relationships with their customers.

Loveland, Smith, and Smith (2019) suggest that advertising is a powerful tool to improve consumer perception. As the brand image is a critical driver of consumers' perception and preference in Australia (Productivity Commission, 2018), seemingly, advertising is a crucial ESC investment that is likely to influence the market share of Australian banks.

Information technology

The importance of IT in modern banking is evident from the fact that top global bankers often cite their business as a synonym for a technology company[23] (Pierri & Timmer, 2021). In addition, intensified competition in the sector has urged banks to adopt cost-saving technologies to remain competitive (Beccalli, 2007; Jain & Gangopadhyay, 2020). Further, IT enables banks to customise financial products, thereby enhancing customer experience and strengthening their relationship (Marinč, 2013). However, it is critical to note that some early studies failed to establish any affirmative relationship between endogenous IT strategies of banks and their impact on customers (see Karakostas, Kardaras, & Papathanassiou, 2005; Liebach Lüneborg & Flohr Nielsen, 2003).

Nonetheless, later studies have presented contradictory results. For instance, using a novel dataset on IT services by all 457 savings banks in Germany, Koetter and Noth (2013)

[23] Michael Corbat (CEO Citibank, 2014): "We see ourselves as a technology company with a banking licence."
Marianne Lake (CFO JPMorgan Chase, 2016): "We are a technology company."
Ralph Hamers (CEO ING, 2017): "We want to be a tech company with a banking licence."

investigated the impact of IT on bank output and market power. Similarly, Hughes and Mester (2013) studied IT investments of 842 top-tier bank-holding companies in the U.S. The authors found that banks derive scale economies from technological advantages and are an "important driver of bank's increasing size" and, thus, market share (p. 584).

Few studies investigate the influence of technology on the Australian banking market; however, there are some important revelations. For instance, citing survey results, Jones (2002) claimed that "Australians are sophisticated when it comes to embracing internet banking technology." The author found that in contrast to the U.S. and the U.K., internet-enabled banking services' penetration rate was relatively high in Australia, primarily because of the geographic disbursement of the population (Jones, 2002). In a qualitative analysis of the Australian banking sector, Heaney (2007) found that customers accessing their bank accounts using the internet perceive their banks as providing higher-quality services. Thus, IT investments could be a relevant endogenous factor driving concentration in the Australian banking market.

2.2.2 Industry-specific factors

Applying Sutton's notion requires a joint analysis of the "toughness of price competition" and endogenous quality competition in an industry (Bresnahan, 1992; Dick, 2007). After summarising the literature on the relevant ESC investments that drive concentration in the banking market, this section identifies industry-specific factors pertinent to the Australian banking market structure analysis.

Market size

Standard economic models suggest that an increase in the market size will create opportunities for new firms to enter and gain sufficient profits, reducing market concentration (see

Belleflamme, 2010; Shiman, 2008). Thus, an increase in the size of the banking market can entice new firms to enter the market due to available economic profits. However, if the concentration in the Australian banking market is driven endogenously by banks, the market expansion will not affect the market structure (Sutton, 1991).

Regulatory capital requirements

The regulatory capital requirements aid the market power of large incumbent banks, primarily through two regulations. First, APRA has accredited the four major banks (along with Macquarie and ING) to use internal ratings-based (IRB) models, which allows them to self-determine their risk weights for credit exposure. IRB risk weights allow accredited banks to use a much smaller portion of equity funding for mortgages than their fringe counterparts (Murray et al., 2014), hence aiding their competitiveness in the lending market. Second, as major banks are required to hold additional capital, while it increases their costs, it also allows them to derive better credit ratings and access cheaper funds, aiding their competitiveness in the deposit market (Productivity Commission, 2018).

As changes in the capital structure may influence banks' market share in both lending and deposit segments, it is an important factor to account for in a comprehensive analysis of the influence of banks' ESC investments on banking market concentration.

Exogenous setup costs

It is critical to analyse the mandatory setup cost for a new firm to participate in the market, i.e. the minimum cost a firm must incur to obtain a banking licence in Australia. In effect, for industries in which firms offer homogeneous products (like banking), the equilibrium concentration level would fall with the decline in the setup cost (Sutton, 1991). Conversely, high setup costs will restrict participation on the one hand, and stall exits on the other, impacting the market structure inexplicably.

Analysing the U.S. banking sector, Dick (2007) outlined exogenous costs to average around $7 million and a processing time of 7 months (p. 61) for a new firm to set up a bank. In Australia, APRA allows firms to operate as a "Restricted ADI", which requires a minimum capital of $3 million and an additional resolution reserve of $1 million. However, a firm looking to operate as an unrestricted ADI requires a minimum capital of at least $15 million (APRA, 2021). As there have been changes over time in capital requirements for firms to be admitted as registered ADIs, a factor determined by regulators, it is crucial to evaluate its implications on the market share of incumbent banks.

Toughness of price

The toughness of price is an essential condition outlined by Sutton (1991), necessary for the operation of his ESC theory. The underlying intuition is that, on the one hand, tougher price competition will make the market unattractive for new participants to enter; on the other hand, it will fade economic profits fostering exits (Shiman, 2008). As market concentration rises with the toughness of price competition, controlling the element's influence is critical to precisely evaluate the impact of banks' ESC investments on their respective market share.

2.2.3 Bank-specific factors

Bank size

According to the Productivity Commission (2018), consumers perceive major banks as being "too big to fail", and that the government will step in to save the institution should the need arise. It is important to note that the government's Financial Claims Scheme insures depositors at all ADIs alike; nonetheless, it is a little-known fact, and consumers prefer banking with larger institutions. Scholars have investigated consumer perception of larger banks to be safer in several banking markets worldwide (see VanHoose, 2017; Vives, 2016). Bank size is an exogenous factor as the management cannot endogenously control it. Controlling its effect on market share in lending and deposits will allow a precise estimation of the influence of banks' ESC investments.

2.3 Data and Definition of Variables

To empirically examine the influence of ESC investments on concentration in the Australian banking market, the study analyses an unbalanced panel of nine Australian banks from 2000 to 2019. The sample used in the present study is similar to previous prominent studies on the Australian banking industry by Vu and Turnell (2011) and Moradi-Motlagh and Babacan (2015). The sample banks collectively hold 84 per cent of Australia's banking assets (as of 30th June 2019), thus reflecting the broader competition and concentration trend in the Australian banking market.

Depending upon availability, I have sourced data from multiple sources. Table 2.1 defines each variable of interest and its source(s).

Following the banking literature, the present research investigates the impact of three ESC investments of sample banks, namely: branching (Z_B), advertising (Z_A), and technology (Z_T) on their respective market share in the lending (MSL) and deposit (MSD) segments separately. The empirical test controls for the effect of the other factor – market size (MKT_SIZE) – by considering Australia's total resident banking assets in each period. Further, exogenous setup cost (EXO)[24] is proxied into the estimation through the total assets of the smallest ADI incorporated in Australia in terms of deposits in each year of observation. At the same time, the model factors the toughness of price into the analysis through the Lerner Index ($LERNER$),

[24] An exact exogenous setup cost is difficult to determine for Australia for two reasons. First, in an email response, APRA confirmed non-availability of data. Second, there are different categories of ADIs, making it difficult to assess a standard entry cost for a firm aspiring to set up a bank in Australia. To overcome the issue, I have used the total assets of the smallest registered ADI in each sample year – which is a close proxy of *toughness of entry*.

which captures the essence of pricing power by measuring the disparity between price and marginal costs as a percentage of the price (Hoang et al., 2020).

Table 2.1: Description of the Variables of Interest Utilised in the Empirical Analysis

Variables	Definitions	Data Source
MSL	Natural logarithm of market share of each sample bank in the lending market – calculated manually from the Monthly Banking Statistics available from APRA[17]	APRA
MSD	Natural logarithm of market share of each sample bank in the deposit market – calculated manually from the Monthly Banking Statistics available from APRA[25]	APRA
Z_B	Natural logarithm of expenses related to branching – includes depreciation charged to fixed assets, lease rentals, and other operating expenses	FitchConnect and annual reports
Z_A	Natural logarithm of expenses related to advertising and marketing	DataStream and annual reports
Z_T	Natural logarithm of expenses incurred on information technology – includes costs related to data communication, depreciation, and amortisation of software and hardware assets held by the entity, cost of software licences, cost of IT-related services outsourced, operating leases associated with IT and other IT expenses	Annual reports
EXO	Natural logarithm of the total resident assets of the smallest ADI in terms of deposits in each observation year	APRA
LERNER	Calculated following Hoang et al. (2020). (Refer to Appendix 3 for details)	-
MKT_SIZE	Natural logarithm of total resident banking assets in Australia	APRA
BANK_SIZE	Natural logarithm of total assets of each sample bank	DataStream and annual reports
REGU	Natural logarithm of total equity to total assets of each sample bank	DataStream and annual reports

Following the findings of the Productivity Commission (2018), two additional control variables are modelled into the estimation to control the effect of changes in the regulatory capital

[25] The data available from the APRA portal dates back to 2002. Upon request, the APRA Data Analytics and Insights team provided data for the years 2000 and 2001, for which I would like to thank the regulator's statistical division.

requirements of banks (REGU) and consumer perception and preference to deal with larger banks (BANK_SIZE).

Table 2.2 presents the descriptive statistics of the data.

Table 2.2: Descriptive Statistics

Variables	Mean	Median	Maximum	Minimum	Std. Dev.	Obs.
MSL	1.249	0.878	3.212	-3.186	1.844	172
MSD	1.336	0.967	3.219	-2.996	1.721	172
Z_B	4.710	4.796	7.066	0.501	1.883	172
Z_A	3.763	3.912	6.258	-0.812	1.839	167
Z_T	5.045	4.852	7.749	0.267	2.029	172
EXO	4.512	4.611	5.375	3.091	0.658	172
LERNER	0.126	0.127	0.422	-0.600	0.140	172
MKT_SIZE	14.448	14.691	15.160	0.693	1.181	172
BANK_SIZE	11.466	11.893	13.796	6.310	1.986	172
REGU	-2.729	-2.747	-1.885	-3.235	0.245	172

Note: The abbreviations MSL and MSD stand for market share in the lending and deposit segments of each sample bank. Z_B, Z_A, and Z_T denote the sample banks' ESC investments: branching, advertising, and technology, respectively. MKT_SIZE: the size of the market; EXO: the exogenous setup cost; $LERNER$: Lerner Index; $BANK\_SIZE$: the size of each sample bank in terms of total assets; and, finally, $REGU$: regulatory changes to the capital structure are the control variables.

These summary statistics are based on the natural logs of the variables, as utilised in the analysis. Notably, there are a few missing observations for the advertising data due to non-availability.

2.4 Methodology and Results

For a precise examination of the effect of endogenous factors on the market share of sample banks, a comprehensive model must account for exogenous factors. A vector error correction model (VECM) is an established approach for analysing short-term dynamics and long-term cointegrating relationships among relevant variables (Engle & Granger, 1987). A VECM model can be expressed in its equivalent representation with a vector of exogenous factors as a VECMX (Dumrongrittikul & Anderson, 2016; Hondroyiannis & Papaoikonomou, 2020).

The model adequately addresses endogeneity concerns (Hondroyiannis & Papaoikonomou, 2020), which is critical to the current research, given that it is unlikely that one ESC investment decision would be independent of another. Considering the attributes of the panel VECMX approach, it is the most suitable technique for the current analysis.

What follows is a step-by-step development and analysis of the VECMX model.

2.4.1 Step 1: Panel unit root

One of the primary requirements for the Panel-VECM(X) Granger causality test is that the variables must be stationary and integrated of order one [i.e. I(1)] (Kumar Mandal & Madheswaran, 2010; Mahadevan & Asafu-Adjaye, 2007). There are many techniques to examine unit roots in a panel dataset. However, through a large-scale Monte Carlo stimulation, Hlouskova and Wagner (2006) established that Breitung's (2000) panel unit root test offers the highest power and most negligible distortions among all other options available. Thus, following Breitung (2000), the present study examines unit root using the below form:

$$y_{it} = \alpha_{it} + \sum_{k=1}^{p+1} \beta_{ik} X_{i,t-k} + \varepsilon_t \tag{2.1}$$

The Breitung (2000) test examines the null hypothesis[26] that the process is a difference stationary, while the alternative hypothesis[27] assumes that the panel series is stationary for all i. Breitung (2000) uses the following transformed vectors to construct the test statistic (Kumar Mandal & Madheswaran, 2010):

$$\lambda_B = \frac{\sum_{i=1}^{N} \sigma_i^{-2} y_i^{*/} x_i^{*/}}{\sqrt{\sum_{i=1}^{N} \sigma_i^{-2} X_i^{*/} A^{/} A X_i^{*}}} \tag{2.2}$$

[26] $H_0: \sum_{k=1}^{p+1} \beta_{ik} - 1 = 0$
[27] $H_1: \sum_{k=1}^{p+1} \beta_{ik} - 1 < 0$

Table 2.3 outlines the results of the Breitung (2000) panel unit root test.

Table 2.3: Panel Unit Root Test Results

Variables	**Breitung's (2000) t-test**	
	Levels	First difference
Explanatory variables		
MSL	0.028	-1.743*
MSD	0.096	-3.188*
Endogenous choice variables		
Z_B	1.477	-3.077*
Z_A	0.014	-5.289*
Z_T	-0.137	-2.594*
Exogenous control variables		
EXO	-0.752	-5.913*
LERNER	-1.481	-3.176*
MKT_SIZE	2.817	-7.130*
BANK_SIZE	2.260	-1.451*
REGU	-1.308	-5.186*

Note: Unit root test was performed with individual trends and intercepts for each series. The optimal lag length is derived using the Schwarz information criterion (SIC). * denotes statistical significance at the 5% level. The abbreviations MSL and MSD stand for market share in the lending and deposit segments of each sample bank. Z_B, Z_A, and Z_T, denote the sample banks' ESC investments: branching, advertising, and technology, respectively. MKT_SIZE: the size of the market; EXO: the exogenous setup cost; $LERNER$: Lerner Index; BANK_SIZE: the size of each sample bank in terms of total assets; and, finally, REGU: regulatory changes to the capital structure are the control variables.

The test statistics in Table 2.3 for the explanatory variables: market shares in lending (MSL) and deposit (MSD) segments; ESC variables – branching (Z_B), advertising (Z_A), and IT (Z_T); and control variables – entry cost (EXO), the toughness of price (LERNER), market size (MKT_SIZE), bank size (BANK_SIZE) and (REGU) are insignificant at levels, implying that each variable is panel non-stationary. However, when applied to the first difference of the variables, the panel unit root test rejected the null hypothesis of unit root at a 5 per cent significance level.

2.4.2 Step 2: Panel cointegration

After establishing that the variables of interest are integrated of order one in step 1, the study utilises the panel cointegration test in step 2 to determine the panel Granger causality test strategy and model specification. Suppose the test results indicate cointegration among variables. It will imply that the variables considered in a model co-move over time, and any short-run deviation corrects in the long run (Engle & Granger, 1987; Stock & Watson, 1993). The analysis will thus proceed with the P-VECM(X) framework.[28]

Following Hondroyiannis and Papaoikonomou (2020), and Shahiduzzaman and Alam (2012), the present study utilises the Johansen cointegration technique (Johansen, 1991) to estimate the long-run relationship between ESC factors and the market share of sample banks. The procedure estimates the cointegration rank r using the maximum likelihood, and the cointegration rank is determined using the trace (λ_{trace}) and maximum eigenvalue ($\lambda_{\max}$) test statistics (Johansen, 1988; Stock & Watson, 1988). The comparative advantage of Johansen's procedure over other available cointegration techniques is that it can provide independent estimates of the multiple cointegrating vectors (Shahiduzzaman & Alam, 2012). Additionally, the study utilises the Kao (1999) test to confirm cointegration. The Kao test assumes a homogenous or a common cointegrating vector (Mahembe & Odhiambo, 2019).

Both Johansen's (1991) and Kao's (1999) cointegration techniques test the null hypothesis of no cointegration. Tables 2.4 and 2.5 below report the results of panel cointegration.

[28] Conversely, if the test results suggest that the variables lack a long-run relationship, it will imply that the variables tend to move randomly from each other (Granger, 1988). Causality among non-cointegrating variables is then estimated using a panel vector autoregressive (VAR) model.

Table 2.4: Panel Cointegration Test Results – Johansen (1991)

Number of cointegrating equations	Trace test	Critical value	Max-Eigen statistic	Critical value
r=0	78.01***	69.82	45.47***	33.88
r>1	32.54	47.86	20.38	27.58

Note: Optimal lag length for the Johansen test was chosen as 1 (one), as prescribed by the SIC. ***,**,*****: denotes statistical significance at 10%, 5%, and 1% respectively.

Table 2.5: Panel Cointegration Test Results – Kao (1999)

Dependent variable	t-Statistic
MSD (Model-1)	-5.43***
MSL (Model-2)	-2.99***

Note: *,**,**: denotes statistical significance at 10%, 5%, and 1% respectively. Automatic lag length selection based on SIC. The abbreviations MSL and MSD stand for market share in the lending and deposit segment of each sample bank.

Tables 2.4 and 2.5 illustrate that both tests reject the null hypothesis of no cointegration. Thus, one can infer that a co-movement exists among MSL, MSD, and ESC investments in the presence of exogenous elements.

2.4.3 Step 3: Testing for causality

After establishing the order of integration and confirming cointegration among variables (in steps 1 and 2), the study proceeds with assessing the panel VECMX model to detect causality in step 3. Similar to P-VECM, the study concludes with panel VECMX estimation in two stages.

In the first stage, the long-run relationship is estimated for the two models, using the following forms:

Model-1

$$\mathrm{MSD}_{it} = \alpha_{it} + \delta_{it}t + \gamma_{1i}Z_{B_{it}} + \gamma_{2i}Z_{A_{it}} + \gamma_{3i}Z_{T_{it}} + \gamma_{4i}\mathrm{MSL}_{it} + \varphi_{1i}\mathrm{EXO}_{it} + \varphi_{2i}\mathrm{LERNER}_{it} + \varphi_{3i}\mathrm{MKT\_SIZE}_{it} + \varphi_{4i}\mathrm{BANK\_SIZE}_{it} + \varphi_{5i}\mathrm{REGU}_{it} + \varepsilon_{it}, \quad (2.3)$$

Model-2

$$\mathrm{MSL}_{it} = \alpha_{it} + \delta_{it}t + \gamma_{1i}Z_{B_{it}} + \gamma_{2i}Z_{A_{it}} + \gamma_{3i}Z_{T_{it}} + \gamma_{4i}\mathrm{MSD}_{it} + \varphi_{1i}\mathrm{EXO}_{it} + \varphi_{2i}\mathrm{LERNER}_{it} + \varphi_{3i}\mathrm{MKT\_SIZE}_{it} + \varphi_{4i}\mathrm{BANK\_SIZE}_{it} + \varphi_{5i}\mathrm{REGU}_{it} + \varepsilon_{it}, \quad (2.4)$$

Model 1 (Model 2) in eq. 2.3 (eq. 2.4) assesses the long-run causal relationship between ESC investments and the sample bank's MSD (MSL). It is important to note that MSL (MSD) is included in the model as an endogenous variable, impacting the market share of sample banks in the deposit (lending) segment.

The models specified above control for the effects of four industry-specific factors. First, according to traditional models of entry, the existence of higher exogenous setup costs creates an upper bound on the number of firms that can profitably enter the market (Shiman, 2008). EXO captures the effect of changing capital requirements for new firms to set up banking operations in Australia. Second, the toughness of price competition, which impacts the attractiveness of a market for new participants to enter and operate, is captured through the LERNER. It measures a firm's pricing power by relating its price to marginal cost. A tougher price competition, i.e. a lower price–cost margin, will discourage new entrants and vice-versa (see Shiman, 2008). Third, as market expansion encourages new firms to enter and operate profitably (see Belleflamme, 2010), the MKT_SIZE controls the effect of increase in market size on the competition. Finally, according to the Productivity Commission (2018), changes in REGU influence the ability of Australian banks to compete in lending and deposit segments. The model uses REGU to account for changes in capital requirements in both models.

Additionally, following the findings of the Productivity Commission (2018), the empirical estimation also includes a firm-specific control variable to capture the effect of consumer preference for bigger banks (BANK_SIZE).

In the subsequent step, the panel Granger causality models with dynamic error correction are estimated as below:

Model-1

$$\begin{aligned}\Delta \mathrm{MSD_{it}} = {} & \theta_{1j} + \lambda_{1i}\mathrm{ECT_{it-1}} + \sum_{k}\theta_{11ik}\,\Delta \mathrm{MSD_{it-k}} + \sum_{k}\theta_{12ik}\,\Delta \mathrm{Z_{B_{it-k}}} + \sum_{k}\theta_{13ik}\,\Delta \mathrm{Z_{A_{it-k}}} \\ & + \sum_{k}\theta_{14ik}\,\Delta \mathrm{Z_{T_{it-k}}} + \sum_{k}\theta_{15ik}\,\Delta \mathrm{MSL_{it-k}} + \sum_{k}\partial_{11ik}\,\mathrm{EXO_{it-k}} \\ & + \sum_{k}\partial_{12ik}\,\mathrm{LERNER_{it-k}} + \sum_{k}\partial_{13ik}\,\mathrm{MKT\_SIZE_{it-k}} \\ & + \sum_{k}\partial_{14ik}\,\mathrm{BANK\_SIZE_{it-k}} + \sum_{k}\partial_{15ik}\,\mathrm{REGU_{it-k}} + \mu_{1it} \qquad (2.5)\end{aligned}$$

Model-2

$$\begin{aligned}\Delta \mathrm{MSL_{it}} = {} & \theta_{1j} + \lambda_{1i}\mathrm{ECT_{it-1}} + \sum_{k}\theta_{11ik}\,\Delta \mathrm{MSL_{it-k}} + \sum_{k}\theta_{12ik}\,\Delta \mathrm{Z_{B_{it-k}}} + \sum_{k}\theta_{13ik}\,\Delta \mathrm{Z_{A_{it-k}}} \\ & + \sum_{k}\theta_{14ik}\,\Delta \mathrm{Z_{T_{it-k}}} + \sum_{k}\theta_{15ik}\,\Delta \mathrm{MSD_{it-k}} + \sum_{k}\partial_{11ik}\,\mathrm{EXO_{it-k}} \\ & + \sum_{k}\partial_{12ik}\,\mathrm{LERNER_{it-k}} + \sum_{k}\partial_{13ik}\,\mathrm{MKT\_SIZE_{it-k}} \\ & + \sum_{k}\partial_{14ik}\,\mathrm{BANK\_SIZE_{it-k}} + \sum_{k}\partial_{15ik}\,\mathrm{REGU_{it-k}} + \mu_{1it} \qquad (2.6)\end{aligned}$$

In the above models, (eq. 2.5 and 2.6) Δ denotes the first difference, and k is the lag length.[29] Further, ECT represents the error correction term, and λ is the speed of adjustment, i.e. how fast deviations from the long-run equilibrium are eliminated following changes in each variable (Mehrara, 2007).

Table 2.6 below outlines the long-run causality inferred from Model-1 – market share in the deposit segment (MSD), and Model-2 – market share in the lending segment (MSL).

Table 2.6: Panel Granger Causality Test Results (Long Run)

Model	**Dependent variable**	**ECT**	**ECT, ΔZ_B**	**ECT, ΔZ_A**	**ECT, ΔZ_T**	**ECT ΔMSD**	**ECT ΔMSL**
Model-1	ΔMSD	-0.23***	0.12	-0.07	-0.03	-	0.08
Model-2	ΔMSL	-0.05	-0.06*	-0.04	0.01	0.13***	-

Note: *,**,**: denotes statistical significance at 10%, 5%, and 1% respectively. Δ denotes the first difference of variables of interest. The abbreviations MSL and MSD stand for market share in the lending and deposit segments of each sample bank. Z_B, Z_A, and Z_T denote the sample banks' ESC investments: branching, advertising, and IT, respectively.

Long-term causality is confirmed if the derived ECT coefficient is negative and statistically significant (Hondroyiannis & Papaoikonomou, 2020). The ECT derived for Model-1 (in Table 2.6 above), which evaluates MSD, is negative and statistically significant, suggesting a long-run unidirectional causal relationship from ESC investments ($Z_B, Z_A,$ and Z_T) and MSL to MSD. Further, the coefficient indicates that any deviation from the long-run trajectory automatically corrects in the subsequent period at an adjustment speed of 23 per cent.

However, the P-VECM results for Model-2, which evaluates MSL, are very different from those of Model-1. The derived ECT for Model-2 is negative but not statistically significant, indicating that ESC investments do not cause MSL in the long run. Interestingly, the system detects long-run unidirectional causality for (Z_B), indicating that branching investments of sample banks, in the long run, are influenced by MSL, MSD, Z_A, and Z_T.

[29] Chosen as one (1) for all models (as determined by SIC under the unrestricted panel VAR model).

Following the broad literature, the study derives the short-run causal effects through the Wald χ^2 test statistic (see Hondroyiannis & Papaoikonomou, 2020; Mahembe & Odhiambo, 2019; Wang, Zhou, Zhou, & Wang, 2011).[30] The results from the Wald χ^2 test in Table 2.7 below suggests:

- Short-run unidirectional causal relationship from ΔMSD and ΔMSL to ΔZ_A ($\Delta MSD \rightarrow \Delta Z_A$) and ($\Delta MSL \rightarrow \Delta Z_A$) is detected by the system, suggesting that banks' market share in both deposit and lending segment Granger causes advertising investments in the short run.
- Short-run unidirectional causal relationship from ΔZ_A and ΔMSL to ΔZ_T ($\Delta Z_A \rightarrow \Delta Z_T$) and ($\Delta MSL \rightarrow \Delta Z_T$) is detected by the models, suggesting that advertising expenditure and market share in lending Granger causes IT investments of sample banks in the short run.
- Finally, unidirectional causality is detected ΔMSD to ΔMSL ($\Delta MSD \rightarrow \Delta MSL$), suggesting that, in the short run, an increase in the market share in the deposit segment, Granger causes market share in the lending segment.

Table 2.7: Panel Granger Causality Test Results (Short Run)

Dependent variable	Direction of causality/explanatory variables **χ^2 statistics**				
	ΔMSD	ΔZ_B	ΔZ_A	ΔZ_T	ΔMSL
ΔMSD	-	1.03	1.15	1.11	2.59
ΔZ_B	0.19	-	2.11	0.03	0.08
ΔZ_A	6.50**	0.00	-	0.14	9.66***
ΔZ_T	1.44	0.26	5.13**	-	4.35**
ΔMSL	3.69*	1.90	0.06	1.36	-

Note: *,**,*: denotes statistical significance at 10%, 5%, and 1% respectively. Δ denotes the first difference of variables of interest. The abbreviations MSL and MSD stand for market share in the lending and deposit segment of each sample bank. Z_B, Z_A, and Z_T denote the sample banks' ESC investments: branching, advertising, and IT, respectively.

[30] The short-run causality (for example) between ΔMSD and ΔZ_B can be determined by testing $\theta_{12ik} = 0$ in eq. 2.5. If the null hypothesis is rejected, one will interpret that the Granger causality runs from ΔZ_B to ΔMSL (Wang et al., 2011).

2.4.4 Step 4: Estimating elasticities

For a meaningful interpretation of the causality results in section 2.3.3, it is crucial to analyse the elasticity coefficients. Thus, following Hondroyiannis and Papaoikonomou (2020); Kumar Mandal and Madheswaran (2010); Pedroni (2001), the present study utilises fully modified ordinary least square (FMOLS) estimation for the heterogeneous cointegrated panel to estimate long-run elasticity coefficients for the two model(s). FMOLS is a suitable approach that addresses the endogeneity problem and offers an unbiased estimate of the coefficients, interpreted as long-run elasticities. Notably, as all the variables of interest in the estimation are in their natural logarithmic form, the coefficient of the independent variables are read as long-run elasticities (Kumar Mandal & Madheswaran, 2010).

Table 2.8 below outlines the FMOLS estimates.

Table 2.8: Fully Modified OLS Estimates (Long-Run Elasticities)

Model	**Dependent variable**	$\mathbf{Z_B}$	$\mathbf{Z_A}$	$\mathbf{Z_T}$	**MSD**	**MSL**
Model-1	MSD	0.39***	0.08***	-0.00	-	0.41***
Model-2	MSL	-0.31***	-0.18***	-0.00	0.44***	-

Note: *,**,**: denotes statistical significance at 10%, 5%, and 1% respectively. The abbreviations MSL and MSD stand for market share in each sample bank's lending and deposit segment. Z_B, Z_A, and Z_T denote the sample banks' ESC investments: branching, advertising, and technology, respectively.

The elasticity coefficients for branching in Table 2.8 suggest that, in the long run, a 1 per cent change in Z_B results in a 0.39 per cent increase in MSD. According to Cohen and Mazzeo (2010), depository institutions add branches in response to competitive pressure to retain and gain market share. The Productivity Commission (2018) suggests that established presence (branching reach) contributes to the brand recognition of banks and the perception that they are safe. The results for Model-1 confirm that Z_B is a relevant source of concentration in the Australian deposit market, endorsing the views of the Productivity Commission (2018).

However, the results indicate that, in the long run, the branching quality of the lender does not influence the decision of Australian borrowers. Results suggest that a percentage increase in branching is associated with a 0.31 per cent decrease in MSL. The results for Model-2 are in line with the findings of Degl'Innocenti et al. (2018). According to the authors, branching enhanced banks' market power in the deposit segment but adversely impacted it in the lending segment. Further, the Productivity Commission (2018, p.79) noted that Australian households who conventionally relied on their local branch to obtain a loan are now increasingly turning to brokers, thus diminishing the importance of banks' physical presence in the lending segment.

The elasticity coefficients for advertising in Table 2.8 suggest that, in the long run, a 1 per cent increase in Z_A improves sample banks' MSD by 0.08 per cent. The results partially support the findings of Martín-Oliver and Salas-Fumás (2008). In their analysis of the Spanish banking market, the authors found that advertising positively influences demand for banking services. They noted that advertising improves demand for deposit services twice as much as that for loans. However, notably, Z_A adversely impacts MSL of Australian banks, and a percentage increase is associated with a decline of 0.18 per cent in MSL. In Australia, advertising by lenders is ineffective since they cannot precisely communicate any competitive price to potential borrowers. The *National Consumer Credit Protection (NCCP) Act 2009* mandates lenders to advertise a comparison rate that includes fees and other charges apart from the base interest rate to allow potential borrowers to compare products from different lenders easily. As comparison rates are calculated based on standard variable rates, which does not apply to more than 90 per cent of the customers (Productivity Commission, 2018), advertising by lenders is ineffective in attracting potential borrowers. Banks' advertising outlays possibly push their costs, enabling lenders with lower marketing costs to price loans competitively and gain market share.

Australian banks are among the biggest spenders on IT in the developed world. According to analyst estimates, the combined IT budget for Australian banks is closer to between 15 per cent to 23 per cent of costs; far higher than their American or European counterparts (RFi Group, 2017). However, the results indicate that IT investments do not impact MSL or MSD. A longstanding theoretical claim in literature asserts that adopting IT will offer benefits in terms of better product quality and increased value to customers. However, the economic rents and value realised from these benefits will not last long due to the high imitability of IT (Carr & Carr, 2004). The insignificant and negligible coefficients in Table 2.8 suggest that Australian banks cannot create meaningful product differentiation through their IT investments. Hence, it does not impact depositors' (borrowers') preference and thus MSD (MSL).

Table 2.9 below presents the short-run elasticities for the two models of interest:

Table 2.9: Short-Run Elasticity Estimates

Dependent variable (DV)	***Explanatory variables***					
	$\Delta \mathbf{DV_{t-1}}$	$\Delta \mathbf{Z_B}$	$\Delta \mathbf{Z_A}$	$\Delta \mathbf{Z_T}$	$\Delta \mathbf{MSD}$	$\Delta \mathbf{MSL}$
ΔMSD	-0.01	0.08	0.04	-0.06	-	0.14
ΔZ_B	-0.04	-	0.06	0.01	-0.03	0.05
ΔZ_A	-0.43***	-0.00	-	0.05	0.56**	-0.60***
ΔZ_T	-0.07	-0.06	0.13**	-	-0.18	0.28**
ΔMSL	0.23**	0.12	0.01	-0.07	-0.21*	

Note: *,**,**: denotes statistical significance at 10%, 5%, and 1% respectively. Δ denotes the first difference of variables of interest. The abbreviations MSL and MSD stand for market share in the lending and deposit segments of each sample bank. Z_B, Z_A, and Z_T denote the sample banks' ESC investments: branching, advertising, and IT, respectively.

Finally, the models detect a significant impact of MSL (MSD) on MSD (MSL). In Model-1 (Model-2), a 1 per cent increase in MSL (MSD) is associated with a 0.41 (0.44) per cent increase in MSD (MSL). The results substantiate the findings of the Productivity Commission (2018), which notes low switching in the Australian banking market, and attributing it to consumer inertia.

Estimates in Table 2.9, in conjunction with the Granger causality results in Table 2.7, indicate no causal relationship between MSD and other variables of interest in the short run. While Model-2, although at a significance level of 10 per cent, suggests that, in the short run, a 1 per cent increase in MSD is associated with a 0.21 per cent decline in MSL.

The system also detected short-run causality running from MSL and MSD to Z_A (refer to Table 2.7). The elasticity estimates in Table 2.9 suggest that a 1 per cent increase in MSD pushes the advertising expense of sample banks by 0.56 per cent, while a percentage increase in MSL causes a decline in advertising spending to the tune of 0.60 per cent. The short-run results are similar to long-run elasticity estimates (refer to Table 2.8) and confirm that Australian banks derive value from advertising in the form of an increase in MSD. Still, due to NCCP's mandate on comparison rates, they cannot communicate with potential borrowers effectively, which adversely impacts their MSL.

The panel Granger results (in Table 2.7) indicated a unidirectional causality running from MSL to Z_T. Results in Table 2.9 indicate a 1 per cent increase in MSL is associated with a 0.28 per cent increase in IT spending. According to the Australian Securities and Investments Commissions' (ASIC, 2014) responsible lending guideline (RG209.2), lenders must ensure that the credit contract is "not unsuitable" for the loan applicant and the borrower will be able to meet their payment obligations. Since manual assessment of loan applications is time consuming and labour intensive, lenders in Australia are increasingly turning to technology-driven automated loan processing (Grant & Deer, 2020). The short-run causality from MSL to Z_T suggests that banks incur higher technology spending to meet regulatory requirements when their market share in lending increases. The system also detected a unidirectional causality running from Z_A to Z_T, indicating that a 1 per cent increase in advertising causes a 0.13 per cent increase in IT.

Table 2.10 below outlines the elasticities of the exogenous variables investigated in the primary models (eq. 2.3–2.6).

Table 2.10: Elasticity Estimates for Industry and Firm-Specific Factors

Model	**Dependent variable**	**MKT_SIZE**	**REGU**	**EXO**	**LERNER**	**BNK_SIZE**
Model-1	MSD	0.00	-0.08	-0.01	-0.25**	-0.01**
Model-2	MSL	0.00	0.12*	-0.01	-0.17	0.00

Note:* *,**,**: denotes statistical significance at 10%, 5%, and 1% respectively. The abbreviations MSL and MSD stand for market share in the lending and deposit segment of each sample bank. MKT_SIZE: the size of the market; EXO: the exogenous setup cost; $LERNER$: Lerner Index; BANK_SIZE: the size of each sample bank in terms of total assets; and, finally, REGU: regulatory changes to the capital structure.

The system indicates that LERNER and BNK_SIZE are the two industry-specific factors of statistical relevance in the evaluation of MSD. Results in Table 2.10 suggest that a 1 per cent increase in LERNER adversely impacts sample banks' MSD by 0.25 per cent. The results align with the expectations, indicating that when banks exercise pricing power (by expanding their price–cost margin), they lose MSD. At the same time, a percentage increase in the bank size mildly reduces MSD by 0.01 per cent.

For MSL, the system indicates that REGU, which captures the impact of regulatory capital requirements (proxied by the ratio of total equity to total assets), is the only relevant factor of statistical significance. A 1 per cent increase in REGU is associated with a 0.12 per cent increase in MSL, supporting the widespread view that better-capitalised banks observe sustained loan growth (see Brei, Gambacorta, & von Peter, 2013).

2.4.5 Robustness check

The primary model(s) assessed in the study does not consider macroeconomic factors. Different banks may observe varying degrees of "macroeconomic sensitivity", which impacts their operational risk at the firm level (Abdymomunov, Curti, & Mihov, 2020). Thus, the study tests an alternative panel VECMX model as a robustness check. The alternative models – Model-1^{a} (Model-2^{a}) – examine the impact of ESC investments on MSD (MSL) after controlling for critical macroeconomic factors identified by banking literature: gross domestic product growth (GDPG) (see Athanasoglou et al., 2008; Trujillo-Ponce, 2013); market capitalisation (MCAP); inflation rate (INF) (see Perry, 1992; Revell, 1979) and population (POP) (see Dick, 2007; Dick, 2008); and cash rate (RATE) (see Holland, Liu, Roca, & Salisu, 2020). The study sourced data for macroeconomic variables from the World Bank.

Eq. 2.7 and eq. 2.8 below outline the alternative models:

Model-1^{a}

$$\mathrm{MSD_{it}} = \alpha_{it} + \delta_{it}t + \gamma_{1i}Z_{B_{it}} + \gamma_{2i}Z_{A_{it}} + \gamma_{3i}Z_{T_{it}} + \gamma_{4i}\mathrm{MSL_{it}} + \varphi_{1i}\mathrm{GDPG_{it}} + \varphi_{2i}\mathrm{MCAP_{it}} + \varphi_{3i}\mathrm{INF_{it}} + \varphi_{4i}\mathrm{POP_{it}} + \varphi_{5i}\mathrm{RATE_{it}} + \varepsilon_{it}, \tag{2.7}$$

Model-2^{a}

$$\mathrm{MSL_{it}} = \alpha_{it} + \delta_{it}t + \gamma_{1i}Z_{B_{it}} + \gamma_{2i}Z_{A_{it}} + \gamma_{3i}Z_{T_{it}} + \gamma_{4i}\mathrm{MSL_{it}} + \varphi_{1i}\mathrm{GDPG_{it}} + \varphi_{2i}\mathrm{MCAP_{it}} + \varphi_{3i}\mathrm{INF_{it}} + \varphi_{4i}\mathrm{POP_{it}} + \varphi_{5i}\mathrm{RATE_{it}} + \varepsilon_{it}, \tag{2.7}$$

2.4.5.1 Long-run causalities

Table 2.11 below illustrates the long-run causality results inferred from Model-1^{a} – market share in the deposit segment (MSD) – and Model-2^{a} – market share in the lending segment (MSL).

Table 2.11: Panel Granger Causality Test Results (Long Run) – Alternative Models

Model	Dependent variable	ECT	ECT, ΔZ_B	ECT, ΔZ_A	ECT, ΔZ_T	ECT ΔMSD	ECT ΔMSL
Model-1^{a}	ΔMSD	-0.07**	0.06**	0.09	0.11***	-	-0.01
Model-2^{a}	ΔMSL	-0.0003	0.002**	0.003	0.003***	-0.002**	-

Note:* *,**,**: denotes statistical significance at 10%, 5%, and 1% respectively. Δ denotes the first difference of variables of interest. The abbreviations MSL and MSD stand for market share in the lending and deposit segments of each sample bank. Z_B, Z_A, and Z_T denote the sample banks' ESC investments: branching, advertising, and technology, respectively.

A long-run causality is determined if the ECT is negative and statistically significant (Hondroyiannis & Papaoikonomou, 2020). The results of the alternative model (Model-1^{a}) in Table 2.11 confirms a long-run unidirectional causality running from ESC investments to MSD. This is in accordance with the primary model (Model-1, Table 2.6). Further, the alternative model (Model-2^{a}) also confirms that ESC investments do not Granger cause MSL.

2.4.5.2 Short-run causalities

The short-run Granger results (in Table 2.12 below) for the alternative models confirm the findings of the primary model, indicating causality running from MSL and MSD to ΔZ_A. Further, the models also inveterate a unidirectional short-run causality running from ($\Delta Z_A \rightarrow \Delta Z_T$). However, there are also some notable deviations. First, controlling macroeconomic factors result in a bi-directional causal relationship between MSD and MSL

(MSD ↔ MSL) in the short run. Second, the alternative models do not detect any short-run causality running from MSL to ΔZ_T, as seen in the primary model (refer to Table 2.7).

Table 2.12 below illustrates the short-run causality results inferred from the alternative models.

Table 2.12: Panel Granger Causality Test Results (Short Run) – Alternative Models

Dependent variable	Direction of causality/explanatory variables **χ^2 statistics**				
	ΔMSD	ΔZ_B	ΔZ_A	ΔZ_T	ΔMSL
ΔMSD	-	0.30	1.20	1.32	5.20**
ΔZ_B	0.43	-	3.65*	0.29	0.16
ΔZ_A	6.27**	0.50	-	1.11	9.00***
ΔZ_T	0.44	1.61	9.27***	-	2.10
ΔMSL	3.24*	4.10*	0.0003	1.61	-

Note:* *,**,**: denotes statistical significance at 10%, 5%, and 1% respectively. Δ denotes the first difference of variables of interest. The abbreviations MSL and MSD stand for market share in the lending and deposit segments of each sample bank. Z_B, Z_A, and Z_T denote the sample banks' ESC investments: branching, advertising, and IT, respectively.

2.4.5.3 Long-run elasticities

It is crucial to evaluate elasticity coefficients for a meaningful interpretation of the results. Table 2.13 below presents the FMOLS results, outlining the long-run elasticities of the alternative models.

Table 2.13: Fully Modified OLS Estimates (Long-Run Elasticities) – Alternative Models

Model	**Dependent variable**	**Z_B**	**Z_A**	**Z_T**	**MSD**	**MSL**
Model-1^a	MSD	0.28***	0.05***	0.05**	-	0.49***
Model-2^a	MSL	-0.01	-0.10***	-0.00	0.76***	-

Note:* *,**,**: denotes statistical significance at 10%, 5%, and 1% respectively. The abbreviations MSL and MSD stand for market share in the lending and deposit segments of each sample bank.

The alternative model, Model-1^a suggests that all three ESC investments positively impact MSD in the long run. Precisely, a 1 per cent increase in Z_B improves MSD by 0.28 per cent, and a percentage increase in both Z_A and Z_T improves MSD by 0.05 per cent. Nonetheless, Model-2[a] suggests that, though negatively, advertising (Z_A) is the only ESC investment of statistical relevance in evaluating MSL. A 1 per cent increase in advertising is associated with a 0.10 per cent decline in MSL.

2.4.5.4 Short-run elasticities

To fully understand the implications of causality, evaluating the elasticities of variables of interest is critical. The short-run estimates (in Table 2.14 below) of the alternative models, in conjunction with the causality results in Table 2.12, suggest that a 1 per cent increase in MSL (MSD) is associated with a 0.21 (0.20) per cent increase (decrease) in MSD (MSL) in the short run. The elasticity coefficient and causality results confirm the primary results, indicating that a percentage increase in MSD (MSL) is associated with a 0.56 (0.60) increase (decrease) in ΔZ_A. Additionally, a 1 per cent increase in ΔZ_A is also associated with a 0.17 per cent increase in ΔZ_T. Notably, the results suggest that, in the short run, a percentage increase in branching results in a 0.18 per cent increase in MSL.

Table 2.14 below outlines the short-run elasticities for the alternative models:

Table 2.14: Short-run Elasticity Estimates – Alternative Models

Dependent variable (DV)	**Explanatory variables**					
	$\Delta \mathbf{DV_{t-1}}$	$\Delta \mathbf{Z_B}$	$\Delta \mathbf{Z_A}$	$\Delta \mathbf{Z_T}$	**ΔMSD**	**ΔMSL**
ΔMSD	-0.07	0.04	0.04	-0.06	-	0.21**
ΔZ_B	-0.07	-	0.08*	0.03	0.07	-0.04
ΔZ_A	-0.36***	-0.13	-	0.13	0.56**	-0.60***
ΔZ_T	-0.04	-0.15	0.17***	-	-0.11	0.19
ΔMSL	0.26***	0.18**	0.00	-0.08	-0.20*	-

Note:* *,**,**: denotes statistical significance at 10%, 5%, and 1% respectively. Δ denotes the first difference of variables of interest. The abbreviations MSL and MSD stand for market share in the lending and deposit segments of each sample bank. Z_B, Z_A, and Z_T denote the sample banks' ESC investments: branching, advertising, IT, respectively.

2.4.5.5 Elasticity estimates of macroeconomic factors

Finally, Table 2.15 illustrates the elasticity results of the exogenous factors examined in the alternative models.

Table 2.15: Elasticity Estimates for Macroeconomic Variables – Alternative Models

Model	Dependent variable	GDPG	MCAP	INF	POP	RATE
Model-1[a]	MSD	-0.09*	-0.04	0.01	-0.62**	-0.04
Model-2[a]	MSL	-0.01	0.03	-0.34	-0.001	-0.05

Note:* *,**,**: denotes statistical significance at 10%, 5%, and 1% respectively.

The results of the alternative Model-1[a] suggest that GDPG and POP are the two macroeconomic factors of statistical relevance in the analysis of MSD. The results indicate that a 1 per cent increase in GDPG (POP) is associated with a 0.09 (0.62) per cent decline in MSD. According to Dick (2007, 2008), an improvement in GDPG reflects economic expansion, while an increase in population demonstrates the size of the domestic banking market. Notably, as an increase in the market size or economic activity can entice new firms to enter due to available economic profits, it is likely to impact the market share of incumbent banks adversely.

For Model-2[a], the results suggest that none of the macroeconomic variables are of statistical significance in the evaluation of MSL.

Overall, the findings of the alternative model support the primary results, suggesting that while ESC investments influence concentration in the deposit segment, they do not impact concentration in the lending segment.

2.5 Conclusion

Since the early 1980s, regulators in Australia have formulated several policies to introduce greater competition in the banking sector; however, these measures proved largely ineffective, and incumbent banks have successfully ring-fenced their market share against competitive headwinds. Concentration in the Australian banking sector is a matter of active policy debate and regulatory concern, as is evident from some recent inquiries and reports (see ACCC, 2018; Murray et al., 2014; Productivity Commission, 2018). Relying on the well-established theory of ESC competition of Sutton (1991), the study presents some valuable insights into the dynamics of the concentration observed in the Australian banking market. The results suggest that ESC investments shape concentration in the deposit segment (MSD) but not in the lending segment (MSL).

The empirical analysis confirms that a positive long-run unidirectional causal relationship runs from ESC investments to MSD. However, results indicate no direct causal relationship between banks' ESC investments and MSL. In other words, the results suggest that depositors derive value from specific endogenous features of a bank – allowing them to create product differentiation and maintain and gain market share in the deposit segment. But, seemingly, consumers' borrowing decisions are not influenced by the quality banks indicate through ESC outlays. The results highlight the complexities of competition in the Australian banking market. Banks compete for deposits on non-price quality dimensions but cannot rely on them to gain market share in the lending segment.

Then what explains the high concentration in the lending market?

First, results indicate that MSD has a strong influence on MSL. Banks use ESC to increase their market share in the deposit segment, which allows them to bring down their cost of funding – the most significant expense for lenders operating in the Australian financial system

(Productivity Commission, 2018). Apparently, lower funding costs allow major banks to price their lending products competitively and gain market share in the lending segment.

Second, the Productivity Commission (2018) highlights the role of mortgage brokers in the Australian lending market, which, as of December 2017, accounted for 54 per cent of the total new home loans originating in Australia. As there are no direct costs to the consumer in engaging a mortgage broker, borrowers increasingly choose brokers over direct contact with lenders to deal with the "intimidatingly complex and confusing nature of the home loan market" (p. 31). It is noteworthy that while there are many brokers,[31] 61 per cent of them operate under only 13 aggregators. As major banks often wholly or partly own major aggregators,[32] they indirectly exercise market power in the lending segment, resulting in concentration. As brokers are paid for each loan successfully settled, commissions are a variable cost for banks (Productivity Commission, 2018, p. 313) and thus do not constitute ESC.

The present study provides a nuanced picture of competition and concentration issues in an oligopolistic market and further substantiates the findings of the Productivity Commission (2018). While ESC pushes concentration in the deposit segment, relationship lending fostered by consumer inertia enables major Australian banks to exercise market power through brokers in the lending segment. Further, banks with high MSD have lower funding costs, which allows them to price out their fringe counterparts.

[31] As mortgage brokers can operate as credit representatives rather than a direct licensee, the precise number of mortgage brokers operating in Australia is unknown. The Mortgage and Finance Association of Australia (MFAA) estimated 16,000 brokers operating in Australia as of March 2017, while the Finance Brokers Association of Australia (FBAA) claimed there are 22,000 brokers in Australia.

[32] Aussie Home Loans and Finconnect are wholly owned subsidiaries of CBA, which also has a 20 per cent share in Mortgage Choice. NAB has full ownership of three aggregators – Choice, FAST, and PLAN. Recently, NAB also acquired aggregator 86 400 in a $220 million deal. WBC owns close to 80 per cent of online mortgage broker Uno. Macquarie bank has stakes in Connective, Lendi, and Yellow Brick Road.

The present analysis suffers from two limitations. First, the study does not analyse the industry-specific, bank-specific, and macroeconomic factors in a single estimation. Second, due to data limitations, the model uses proxy variables to capture the effect of specific factors that affect market structures. However, the following chapters will address these issues using an alternative dataset and methodological approach.

According to the Productivity Commission (2018), major Australian banks reflect better cost efficiencies in contrast to their smaller rivals, which aids their competitiveness in the deposit (through better credit ratings) and lending segment (through lower funding costs). According to the efficient structure (ES) hypothesis, the intensity of market competition and market concentration may not necessarily be negatively related (VanHoose, 2017). The proponents of the ES hypothesis claim that efficient firms dominate the market not through market power but due to their better cost efficiencies. As a result, firms with better cost efficiencies can set lower loan prices and offer higher deposit rates, consequently seizing market share from their less-efficient rivals. The following chapter evaluates the role of ESC investments in influencing Australian banks' cost and profit efficiencies.

CHAPTER 3: Mapping Managerial Biases in Choosing Endogenous Sunk Cost (ESC) Investments

Chapter 2 established endogenous sunk cost (ESC) investments as a source of market concentration in the Australian banking sector. Different theories predict varying managerial conduct in a concentrated market, which reflects firm performance. Chapter 3 analyses the impact of ESC investments on bank performance and uncovers the managerial bias that drives critical ESC investment decisions.

3.1 Introduction

Sutton (1991) outlines ESC as specific investments managers endogenously choose to enhance the demand of their product and thus the market share of their firm. Chapter 2 established ESC investments as a critical concentration source in the Australian banking market. As ESC consumes considerable resources of a firm, it is essential to investigate what drives such massive outlays in product differentiation. The present research investigates the managerial conduct in choosing ESC investments in the Australian banking market through a detailed analysis of its impact on bank performance.

The literature extensively debates that concentrated industry structure affects firms' behaviour (conduct), which reflects in their observed performance (Williams, 2003). Three broad paradigms predict varying conduct in a concentrated market and its effect on bank performance: structure–conduct–performance (SCP), efficient structure (ES), and quiet life (QL) hypotheses.

The SCP framework, which originated from the works of Mason (1939) and Bain (1951), asserts that entry barriers allow firms to exercise market power and set prices less favourable to consumers, i.e. banks will set higher lending and lower deposit rates than in a perfectly competitive market. As greater market concentration enables banks to obtain larger profits, managers may strategically commit resources to improve their market share by raising barriers to entry (see Posner, 1975; Tullock, 1967). Notably, managers may choose to engage in *non-price predation* that injures rivals by raising their operational (or entry) costs to gain (and maintain) market share (see Scheffman & Higgins, 2003). Such behaviour will adversely impact banks' cost efficiencies; however, their profits would be higher as a result (Berger & Hannan, 1998). Suppose managers strategise to exploit the concentrated market structure of Australia to increase profitability (as expected by the SCP paradigm). Given the highly regulated nature of the Australian banking sector (Productivity Commission, 2018), managers would rely on ESC investments to raise barriers to entry, hurting their (and that of rivals') cost efficiencies but aiding their profit efficiencies.

The ES hypothesis challenges the explanation of the SCP paradigm. It suggests that firms with superior production technologies or management experience lower costs and reap higher profits (Demsetz, 1973). According to the ES theory, the intensity of market competition and market concentration may not necessarily be negatively related[33] (VanHoose, 2017). The proponents of the theory claim that efficient firms dominate the market not through market power but because of their better cost efficiencies, which allows them to set lower (higher) loan (deposit) rates and seize market share from their less-efficient rivals. Suppose competition-induced efficiency drives concentration in the Australian banking market (as predicted by the ES hypothesis). In that case, managers must rationally choose the optimal level of investments in ESC to improve their cost efficiencies, which will also translate into higher profit efficiencies.

[33] In contrast to the SCP paradigm, which assumes the intensity of the competition (i.e. how fiercely market participants would compete to acquire customers) would be low in highly concentrated markets, ES theory posits that efficient banks gain dominance in the market irrespective of intensity of competition (Shaffer, 2004).

An alternative view, the QL hypothesis, establishes that if a high level of market concentration enables banks to charge a price above competitive levels, the managers may consume part of the benefits of the higher prices for a "quiet life" (Berger & Hannan, 1998). The additional profits drawn through market power provide a "cushion" that allows managers to earn economic rents without making a meaningful effort of cost minimisation. Further, managers may engage in non-profit maximising behaviour to a greater degree in a concentrated market than under conditions of perfect competition (Hermalin, 1992). For example, they may demonstrate *expense-preference behaviour*, expanding inputs beyond optimal levels or pursuing *empire building*, which involves increasing firms' operations beyond optimal size – adversely affecting the cost and profit efficiencies of the bank. The Australian banking market is highly regulated (Productivity Commission, 2018), leaving little room for managers to use strategies to corner market share. As ESC investments are out of regulatory purview[34] and impact banks' market share, managers may opt to overinvest in ESC to pursue a quiet life. Consequently, their bank will observe an adverse effect of increasing ESC investments on their costs and profitability.

Alternatively, a commonly known phenomenon, the *arms race*, may influence managerial behaviour in selecting ESC investments. The military metaphor suggests that managers may engage in endless investments in strategies they perceive will offer strategic benefit; however, in the knowledge that any competitive advantage will only be short lived – as rivals will imitate in an effort to protect their market position (Brady & Targett, 1995). For example, if a bank starts a new branch, in expectation of enhancing its market share, then rivals may soon operate in the vicinity to protect their market share, possibly neglecting the financial viability of expanding their branch network. If a competitive escalation drives ESC investments in

[34] There are no regulatory restrictions on branching, advertising, and technology investments in Australia. Managers endogenously choose the level of investments in these quality attributes, considering their overall strategy.

response to rivals' strategies, none of the banks will gain. Such decisions would reflect the poor performance of banks.

Branching (Dick, 2006, 2007, 2008), advertising (Amoako et al., 2017; Martín-Oliver & Salas-Fumás, 2008), and technology (Beccalli, 2007; Ho & Mallick, 2010) are established forms of ESC investments in the banking industry that influence customers' "willingness to pay". The Productivity Commission (2018) suggests that geographic reach (branching) and brand recognition (advertising) affect consumer perception, while technology impacts the process of financial intermediation and thus influences concentration in the Australian banking market. As ESC investments consume substantial resources and are a critical firm-specific strategy that is instrumental in its market positioning (Senyuta & Žigić, 2016), it is essential to investigate its impact on banks' performance (efficiency) to understand what drives it.

In recent years, regulators have expressed concerns about competitive conduct and high concentration levels in the Australian financial system (see ACCC, 2018; Murray, Davis, Dunn, Hewson, & McNamee, 2014; Productivity Commission, 2018). However, suppose major banks retain and gain market share by improving their efficiency through investments in ESC, as expected under the ES hypothesis. Then, a concentrated market may not be detrimental, and regulatory concerns could be futile. However, if bankers are using ESC investments as a strategic tool[35] to facilitate a *quiet life* – or if such investments stem from an *arms race* – it must alarm the regulators. Such investments can potentially hurt the overall stability of the financial system in the long run. Thus, the primary motivation of the study is to analyse the impact of ESC investments on the efficiency of banks; to understand managerial

[35] In concentrated markets, managers are known to engage in *managerial leisure*, i.e., pursuing objectives other than profit maximisation. Expansion of the bank beyond the optimal size can help them seek additional remunerations and control greater resources of the organisation (Berger & Hannan, 1998; Jensen, 1986).

conduct in selecting service quality, which is a crucial driver of concentration in the Australian banking sector (Productivity Commission, 2018).

The present research makes three contributions. First, the importance of efficiency in the Australian banking system is evident from the estimates of Wallis' (1997) report, which suggests that a 10 per cent improvement in banking efficiency would translate into annual cost savings of $4 billion for the economy[36] (see Paul & Kourouche, 2008). Researchers have actively explored the efficiency of Australian banks in the context of various regulatory measures (Avkiran, 1999; Paul & Kourouche, 2008; Williams, 2003), economic and financial disruption (Moradi-Motlagh & Babacan, 2015; Vu & Turnell, 2011), mergers and acquisitions (Neal, 2004; Wu, 2008), and shareholder value (Hoang et al., 2020; Kirkwood & Nahm, 2006; Shamsuddin & Xiang, 2012), among other issues. However, none of these studies contemplates ESC investments' influence on bank efficiency, to the best of my knowledge. The present research addresses this gap in banking literature. Second, the study utilises panel autoregressive distributed lag (P-ARDL) models to investigate the impact of ESC investments on the cost and profit efficiencies of Australian banks. The technique can handle variables that are stationary and non-stationary (integrated of up to order one or even fractionally integrated) in a single estimation. Finally, following Erülgen, Rjoub, and Adalıer (2020), besides P-ARDL, the study employs the cross-sectionally augmented autoregressive distributed lag (CS-ARDL) model to address the potential cross-sectional dependence error (Chudik & Pesaran, 2015) and supplementing the primary results of the study.

Section 3.2 reviews critical literature on bank efficiency. Section 3.3 defines the variables of interest and briefly explains the data used in the present study, while section 3.4 briefly

[36] The economic impact of improved efficiency will be much more significant today, given the massive increase in the size of the banking assets since the Wallis (1997) report. The Australian financial industry's assets are about A$8.5 trillion, over four and a half times greater than the nominal GDP of the country (Moradi-Motlagh & Jubb, 2020)

introduces the P-ARDL and CS-ARDL approaches employed in the analysis and outlines the results. Finally, section 3.5 provides concluding comments.

3.2 Literature Review

Following the Campbell (1981) report, the Australian banking sector witnessed several reforms[37] that aimed at improving the efficiency of the financial system through increased competition. The pace of the deregulation process sped up following the Wallis (1997) inquiry, which outlined 115 recommendations for change, aimed at increasing competition in more areas of the financial system, attaining more efficient outcomes, and lowering costs for users. Among all recommendations, the most controversial was removing the *six-pillar* policy[38] (Wu, 2008). Notably, increased competition hurt the spreads between the standard variable mortgage rate and the official cash rate;[39] however, the decline in the interest rate spreads did not result in lower profitability for the sector (Shamsuddin & Xiang, 2012). The deregulation of the Australian banking market and its impact on the industry's competitive landscape interested many researchers in investigating the efficiency of the Australian banks.

In an early analysis, Walker (1998) investigated scale economies in the Australian banking sector using the fixed-effect version of the stochastic frontier analysis (SFA) technique. Analysing 12 banks for the period 1978 to 1990, the author documented varying results using different sample estimation approaches and concluded that there was no evidence of significant diseconomies of scale. Notably, the author concedes the limitation of the fixed-effect approach

[37] Some of the most prominent reforms regulators gradually introduced include: removal of interest rate ceilings on bank deposits; ending quantitative controls on the growth in banks' advances; allowing foreign banks to set up operations in Australia; and easing the process of establishing a new domestic bank (Avkiran, 1999; Kent, 1999).
[38] Announced in the late 1980s by Treasurer Paul Keating, the six-pillar policy restricted mergers among any of the four major banks (ANZ, CBA, NAB, and WBC) and the two largest insurance companies (AMP and National Mutual). The Wallis committee reported high intermediation costs to the users of the financial system and prompted efficiency benefits from mergers; i.e. through rationalisation of bank branches.
[39] Interest rate spreads fell from 4.25 per cent in 1993 to an average of approximately 1.80 per cent over the decade to December 2007, scaling back to 2.9 per cent by April 2010 (Shamsuddin & Xiang, 2012).

as it imposes a constant level of efficiency for each sample bank across the observed period. However, comparing individual cost efficiencies, Walker (1998) found smaller banks to be more cost efficient than their bigger rivals. In a subsequent analysis using data envelopment analysis (DEA), Avkiran (1999) studied the impact of mergers on the efficiency of Australian banks between 1986 and 1995. The author found a slow but steady increase in bank efficiencies during the deregulated period. Further, the study established that the acquiring banks were more efficient than the target bank but did not always maintain their pre-merger efficiency following the acquisition.

Following Avkiran (1999), using the DEA approach, Sathye (2001) analysed the efficiency of 29 Australian banks for a single year (1996). The author found that Australian banks operated with lower efficiency than banks in Europe and the U.S. Further, the study discovered that domestic banks were more efficient than foreign-owned banks. Sathye (2001) attributed the observed inefficiency in Australian banks to wasting of inputs (technical inefficiency) rather than selecting the wrong combination of inputs (allocative inefficiency), indicating the operation of the QL hypothesis. However, in a detailed analysis of the efficiency of domestic and foreign banks operating in Australia from 1988 to 2001, Sturm and Williams (2004) documented conflicting results. Using DEA, SFA, and Malmquist Indices (MI), the authors found foreign banks to be more efficient than their domestic counterparts; however, higher efficiency did not translate into superior profits. In addition, the study confirmed overall efficiency gains in the post-deregulation period due to increased competition. According to the authors, nationality effects become insignificant once firm-specific variables are introduced in the models.

Analysing the Australian banking sector from 1995 to 1999, Neal (2004) investigated X-efficiency and productivity change in Australian banking using DEA and MI. Disagreeing with the findings of Walker (1998), the study found that diseconomies of scale "set in very early" and, thus, contrary to the recommendations of the Wallis (1997) inquiry, suggested that mergers between banks must be discouraged. The study results found regional banks to be less efficient than other types of banks and supported the findings of Avkiran (1999), suggesting that more efficient banks took over less efficient banks. The research concluded that the overall performance of the banking sector had deteriorated by 1999 since 1995 – a period of high bank merger activity[40] and industry consolidation.

In a similar vein, Paul and Kourouche (2008) investigated the technical efficiencies of 10 Australian banks using the DEA approach. The authors found that the efficiency of Australian banks varied across firms and time. While the study detected the lowest efficiency among small banks, medium-sized banks outperformed both the small and large banks in terms of efficiency improvements. Notably, the study found that Australia and New Zealand Banking Group (ANZ) and the Westpac Banking Corporation (WBC) – two of the four major banks in Australia – operated at decreasing returns to scale. Differing from the Wallis (1997) report's recommendation, like Neal (2004), the study concluded that mergers between large banks could lead to a decline in industry-wide scale efficiency. According to the authors, as small banks operate at increasing returns to scale, consolidation between them must be encouraged. In a separate analysis, using the DEA approach, Wu (2008) investigated the *ex-post* efficiency performance of banks involved in mergers from 1983 to 2001. Like Neal (2004) and Paul and Kourouche (2008), the study confirmed that mergers among banks may cause much lower efficiency performance in the merging banks and the banking sector.

Using DEA, Kirkwood and Nahm (2006) analysed the cost efficiency of 10 Australian banks listed on the ASX between 1995 and 2002 and its impact on stock returns. The study concluded

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[40] Some of the prominent mergers during 1995 to 1999 include: i) Challenge bank with WBC in December 1995; ii) Bank of Melbourne with WBC in December 1997; iii) QIDC with Suncorp-Metway in 1998; iv) Bank of South Australia with Advance bank in 1995; v) Advance bank with St George Bank in 1997; vi) Bank of Western Australia with Bank of Scotland in 1995; vii) Mitsubishi Bank of Australia with Bank of Tokyo Australia Limited in 1996; and viii) Trust Bank with Colonial State bank in 1999.

that the major banks improved their efficiency in producing services and profits during the analysis period, while regional banks experienced minimal change in their efficiency of delivering services and a decline in their efficiency in producing profits. Notably, the results suggested that changes in efficiency impact shareholder return. Similarly, Shamsuddin and Xiang (2012) investigated the impact of technical, cost, and profit efficiencies on the market value of 10 publicly listed Australian banks using the SFA technique. The authors found that between 1985 and 2008, the technical, cost, and profit efficiencies of the Australian banks improved. In addition, the study found large banks attained higher levels of cost efficiencies but observed a lower level of technical efficiency than their smaller rivals. Further, using a fixed-effect panel regression model, the study found support for the findings of Kirkwood and Nahm (2006). It established that an improvement in the technical, cost, and profit efficiencies contributed to the market value of banks.

The Australian banking sector demonstrated exceptional resilience during the 2008 GFC.[41] Using the SFA approach, Vu and Turnell (2011) analysed Australian banks' cost and profit efficiencies from 1997 to 2009. They found that the banks observed higher cost and profit efficiencies before the crisis. However, the eight sample banks analysed in the study witnessed a decline in their profit efficiencies following the GFC, while their cost efficiencies remained intact. Additionally, the study found that major banks were less cost efficient but more profit efficient than their regional peers, implying that profit maximisation is the primary aim of the major banks (a sign of the operation of the SCP hypothesis). Analysing the factors responsible for shaping Australian banks' cost and profit efficiencies, the authors found loans to deposits and bank capitalisation were significant determinants.

[41] Post the GFC, none of the banks required government-funded bailout in Australia, nor were there any concerns pertaining to the solvency of any major Australian bank. Notably, the four major Australian banks globally ranked among the top 20 safest banks for 2009 (Vu & Turnell, 2011).

Using DEA, Moradi-Motlagh and Saleh (2014) established that the choice of variables plays a crucial role in determining the efficiency of Australian banks. Notably, the authors introduced *interest-income* over the *net-interest income* variable to estimate the core profit efficiency. Comparing the results, the authors found that only 23 per cent of bank-year observations were fully pure technical efficient, much lower than the 81 per cent reported by Paul and Kourouche (2008). The study concluded that small banks suffer from both scale and pure technical inefficiencies. Medium-sized banks operate at the most productive scale size. Major banks (except ANZ) operate under decreasing returns to scale. The results of the study offer support to the findings of Neal (2004), Wu (2008), and Paul and Kourouche (2008) that, contrary to the recommendation of the Wallis (1997) inquiry, mergers among major banks will intensify scale inefficiency in the Australian banking market.

Moradi-Motlagh and Babacan (2015) utilised the bootstrap DEA technique to individually investigate the efficiency of eight Australian banks over the period 2006–2012. Their results support the findings of Vu and Turnell (2011), indicating that the number of pure technical efficient banks dropped considerably during the GFC. Before the GFC, the number of pure technical efficient banks was highest in 2006. The authors also found that the pure technical efficiency of major banks started to return to the level before the GFC while the same is not true for smaller banks. Additionally, supporting the findings of Paul and Kourouche (2008), the authors suggest that small banks operate under increasing returns to scale, while larger banks operate under decreasing returns to scale. The authors concluded that mergers between larger banks must be shunned, while consolidation among smaller banks must be promoted.

Using a two-stage double-bootstrap DEA approach, Salim, Arjomandi, and Seufert (2016) explored the relationship between corporate governance and the efficiency of Australian banks between 1999 and 2013. The authors found that board size and committee meetings have a significant and positive impact on the efficiency of Australian banks. Notably, the study found no statistically significant effects of the GFC and larger shareholdings on the efficiency of Australian banks. Additionally, the study results supported the earlier findings that major Australian banks are more technically efficient than their regional peers.

In a recent analysis of the Australian banking industry, Hoang et al. (2020) investigated the impact of efficiency on the shareholder value of 73 ADIs over the 2000–2015 period. The authors utilised the SFA approach to estimate the efficiency scores of sample banks, and modelled its impact on four different measures of shareholder value: net interest margin (NIM); Tobin's q ratio; return on equity (RoE); and economic value-added ratio, using system GMM. The study tested the SCP and ES hypotheses after controlling for different bank-specific, industry-specific, and macroeconomic variables. It concluded that both hypotheses apply to diverse aspects of shareholder value[42] to varying degrees.

Moradi-Motlagh and Jubb (2020) innovatively utilised efficiency analysis to determine irresponsible lending in banking. The study investigated the legitimacy of concerns of the Royal Commission about the risk of bad debts by analysing the technical efficiency of six Australian banks over the period 2007–2016. The study concluded that bad and doubtful debts are the primary source of inefficiency in Australian banks, followed by the inefficient use of fixed assets and labour, respectively. The authors suggested that although Australian banks' efficiency has substantially improved since the GFC, it is still far from being fully efficient.

The banking literature review indicates that the research on efficiency is gradually evolving in Australia. Following the deregulation of the Australian banking sector and subsequent recommendations from the Wallis (1997) inquiry, the primary focus of the researchers was to explore scale efficiencies and mergers (see Avkiran, 1999; Neal, 2004; Paul & Kourouche,

[42] For Tobins' q and RoE, the authors found the ES as the valid hypothesis. For the economic value-added ratio, the authors determined SCP as the valid hypothesis. However, for NIM, the authors concluded that neither hypothesis could be applied.

2008; Walker, 1998; Wu, 2008). Later, the GFC captured the attention of researchers, and studies investigated the impact of the crisis on the efficiency of Australian banks (see Moradi-Motlagh & Babacan, 2015; Vu & Turnell, 2011). More recently, scholars are innovatively investigating bank efficiency to explore its relationship with corporate governance (Salim et al., 2016), shareholder value (Hoang et al., 2020), and loan quality (Moradi-Motlagh & Jubb, 2020) in Australia. This chapter investigates the influence of ESC investments on Australian banks' cost and profit efficiencies, aiming to uncover the managerial rationale driving these massive outlays. To the best of my knowledge, the present research is the first of its kind and will add value to banking literature.

3.3 Data and Definition of Variables

To empirically examine the influence of ESC investments on the efficiency of Australian banks, the study analyses an unbalanced panel of nine banks from 2000 to 2019.[43] The sample represents close to 84 per cent of total banking assets in Australia and is similar to prominent studies such as Vu and Turnell (2011), Moradi-Motlagh and Babacan (2015), and Moradi-Motlagh and Jubb (2020).

To understand managerial conduct in selecting the level of ESC investments, cost (CES) and profit (PES) efficiencies of sample banks are calculated using the SFA approach. The precise derivation of CES and PES is detailed in section 3.4.1. As noted in Chapter 2, banks' investments in ESC can be categorised into branching $(\mathrm{Z_B})$, advertising $(\mathrm{Z_A})$, and technology $(\mathrm{Z_T})$.

[43] Australia and New Zealand Banking Group (ANZ); Bank of Queensland (BoQ); Bendigo Bank (BEN); Bank of Sydney (BoS); Commonwealth Bank of Australia (CBA); ING Bank (ING); Macquarie Bank Limited (MBL); National Australian Bank (NAB); and Westpac Banking Corporation (WBC).

The study derives the variable ESC using principal component analysis (PCA), a commonly used dimension-reduction technique, to estimate the collective impact of highly correlated ESC investments and to overcome modelling challenges. Section 3.4.2 briefly explains the utility and application of the procedure.

The literature outlines various bank-specific, industry-specific, and macroeconomic variables that influence banks' efficiency. For a precise evaluation of the ESC on CES and PES of sample banks, the study controls for these influences. The set of bank-specific, industry-specific, and macroeconomic variables assessed in the estimation are discussed below.

Bank-specific factor: Capital strength (CS)

According to Berger (1995b), Demirgüç-Kunt and Huizinga (1999), Goddard, Molyneux, and Wilson (2004), and Hoang et al. (2020), well-capitalised banks are perceived as less risky. This is because they have access to cheaper fund sources, which improves their overall profitability. However, Vu and Turnell (2011) documented a negative and statistically significant impact of bank capitalisation on the profit efficiencies of Australian banks. Theoretically, a bank with greater capital strength signifies that it operates over-cautiously and possibly overlooks potentially profitable investment opportunities (Goddard et al., 2004). Considering the relevance of capital strength (CS) in determining bank cost and profit efficiency, the study utilises it as a bank-specific control variable.

Bank-specific factor: Liquidity (LDR)

LDR, measured as the ratio of loans to deposits (Hoang et al., 2020), is a critical bank-specific variable that assesses a bank's ability to transform interest-bearing deposits into interest-earning loans. Some studies consider higher LDR as a sign of greater efficiency in the process of financial intermediation (Vu & Turnell, 2011), while others see higher LDR as a warning of a poor ability of the bank to withstand bank runs (see Jordà, Richter, Schularick, & Taylor, 2020). In an analysis of Australian banks, Vu & Turnell (2011) found that banks with higher LDR observed improved cost and profit efficiencies. However, in a subsequent analysis, Hoang et al. (2020) found little evidence of LDR having any meaningful impact on the profitability of Australian banks. Given the relevance of LDR in assessing bank performance, the study incorporates the variables in empirical tests as a bank-specific control variable.

Bank-specific factor: Cost management (CM)

Maudos and Fernández de Guevara (2004) suggest that, considering the explanatory capacity (high statistical significance) of operating expenses in explaining banks' performance, ignoring it in models may result in omitted variable bias. Athanasoglou, Brissimis, and Delis (2008) suggest that competition impedes banks' abilities to pass increases in costs to their customers entirely; hence, cost management is a critical determinant of bank performance. Analysing Australian banks, Vu and Turnell (2011) suggest that banks with high operational costs signal management inefficiencies and are thus a crucial determinant of CES and PES. Following the broad banking literature, the study utilises cost management (CM) as the third bank-specific explanatory variable.

Industry-specific factor: Market concentration (HHI)

The level of competition in the market is a critical industry-specific determinant of bank performance, which researchers have widely investigated in the banking literature. The Herfindahl–Hirschman index (HHI) is the most commonly used structural measure of competition (Hoang et al., 2020). HHI is calculated by squaring the market share of each firm competing in the market and then summing the resulting numbers:

$$HHI = s_1^2 + s_2^2 + s_3^2 \dots \dots . + s_n^2$$

where s_1, s_2, $s_3 \ldots s_n$ is the market share of each sample bank. As HHI gives higher weight to the market share of larger banks, a higher (lower) HHI denotes higher (lower) market concentration, reflecting weaker (stronger) competition. The SCP hypothesis asserts that in concentrated markets (markets with higher HHI), banks will exercise market power in pricing products to improve their profits. Conversely, the ES theory expects increased HHI to be an outcome of improved efficiency (Berger, 1995a). The present study utilises HHI as the relevant industry-specific control variable that is likely to influence CES and PES.

Macroeconomic factor: GDP growth ($GDPG$)

Different studies have documented the impact of economic conditions on bank performance. Poor economic conditions may adversely affect the quality of loan portfolios held by banks, resulting in increased credit losses and provisioning and reduced bank performance. Conversely, improvements in the economy foster borrowers' solvency (improving the quality of loan books held by the banks) and push credit demand by households and commercial enterprises, positively influencing banks' performance (see Athanasoglou et al., 2008; Trujillo-Ponce, 2013). The present study utilises GDP growth (GDPG) as a relevant macroeconomic explanatory variable affecting bank performance.

Macroeconomic factor: Inflation (INF)

Revell (1979) was the first to document the relationship between inflation and bank performance. According to the author, the pace at which banks' wage costs and other operating expenses increased compared to inflation will affect their costs and profits. However, Perry (1992) claims that by accurately predicting and including inflation premiums in interest rates, banks can maintain the actual value of all assets and liabilities while the value of demand deposits and reserves shrinks. As a result, banks may observe a limited impact of inflation on their costs but a significantly positive impact on their profitability. Notably, Australia has adopted a policy of inflation targeting,[44] i.e. the RBA alters interest rates in response to inflationary trends in the economy (Holland et al., 2020). Thus, inflation is a critical macroeconomic control variable utilised to analyse bank costs and profit efficiencies.

Table 3.1 below defines each variable of interest and its source.

Table 3.1: Description of the Variables of Interest Utilised in the Empirical Analysis

Variables	Definitions	Data source
CES	Cost efficiency score of each sample bank. Detailed derivation in section 3.4.1	-
PES	Profit efficiency score of each sample bank. Detailed derivation in section 3.4.1	-
ESC	The main variable of interest represents the ESC investments of sample banks. Detailed derivation in section 3.4.2.	-
CS	The ratio of equity to total assets represents the capital strength of a bank	FitchConnect and annual reports
LDR	The ratio of loans to deposits denotes banks' ability to transform deposits into loans	FitchConnect and annual reports
CM	The ratio of non-interest expenses to total assets represents cost management at banks	FitchConnect and annual reports
HHI	Natural logarithm of Herfindahl–Hirschman index calculated from data on deposits for each ADI, published by APRA[45]	APRA
GDPG	Natural logarithm of GDP growth	World Bank
INF	Natural logarithm of the rate of inflation	World Bank

The present study investigates the impact of ESC on CES and PES of Australian banks. The econometric models utilised in the analysis control for bank-specific (CS, LDR, and CM), industry-specific (HHI), and macroeconomic factors (GDPG and INF).

[44] The inflation target set by the Reserve Bank of Australia is 2–3%. One of the main advantages of inflation-targeting-related monetary policy is that it is easily understood by the public and it is substantially transparent. Central banks in inflation-targeting regimes publicly announce changes in interest rates, and are, therefore, accountable to both the government and the public (Holland et al., 2020).

[45] The data available online on APRA's website starts from 2002. I would like to acknowledge the help of the Manager, External Data Reporting – Data Analytics and Insights (APRA) to avail access to relevant data for the years 2000 and 2001.

Table 3.2 below presents the descriptive statistics of the data.

Table 3.2: Descriptive Statistics

Variables	Mean	Maximum	Minimum	Std. Dev.	Obs.
CES	0.930	0.984	0.823	0.027	172
PES	0.710	0.981	0.002	0.179	172
ESC	7.23E-08	2.150	-3.960	1.705	166
CS	0.068	0.152	0.039	0.020	172
LDR	0.826	0.989	0.347	0.132	172
CM	0.112	0.519	0.003	0.085	172
HHI	7.226	7.395	6.973	0.140	172
GDPG	1.034	1.400	0.658	0.248	172
INF	0.891	1.495	0.245	0.352	172

Note: The abbreviations CES and PES stand for the cost and profit efficiencies of each sample bank. ESC denotes the sample banks' ESC investments. CS, LDR, and CM are bank-specific factors representing capital structure, loan-to-deposit ratio, and cost management. HHI is the industry-specific feature capturing the effect of concentration through the Herfindahl–Hirschman index. Finally, GDPG and INF are the two macroeconomic factors controlling the impact of GDP growth and inflation on bank performance.

Table 3.3 below outlines the correlation between variables of interest.

Table 3.3: Correlation Analysis

	CES	PES	ESC	CS	LDR	CM	lnHHI	lnGDP	lnINF
CES	1.000								
PES	-0.066	1.000							
ESC	-0.074	0.169	1.000						
CS	0.242	0.140	-0.542	1.000					
LDR	0.231	0.311	0.007	-0.016	1.000				
CM	-0.467	0.130	0.498	-0.328	-0.387	1.000			
HHI	0.113	0.133	0.101	0.313	-0.084	-0.245	1.000		
GDPG	-0.169	-0.005	-0.056	-0.095	0.034	0.161	-0.512	1.000	
INF	-0.073	-0.125	-0.053	-0.237	0.034	0.254	-0.582	0.225	1.000

Note: The abbreviations CES and PES stand for the cost and profit efficiencies of each sample bank. ESC denotes the sample banks' ESC investments. CS, LDR, and CM are bank-specific factors representing capital structure, loan-to-deposit ratio, and cost management. HHI is the industry-specific feature capturing the effect of concentration through the Herfindahl–Hirschman index. Finally, GDPG and INF are the two macroeconomic factors controlling the impact of GDP growth and inflation on bank performance.

3.4 Methodology and Results

The present study utilises a two-step empirical strategy to test and analyse the impact of ESC investments on bank efficiency. In the first step, the study employs the SFA approach to derive Australian banks' cost and profit efficiencies. Subsequently, the study analyses the influence of ESC investments on bank efficiencies through two-panel cointegration techniques: the P-ARDL approach and the CS-ARDL technique.

3.4.1 Estimating bank efficiency

There is a consensus that traditional accounting measures cannot capture performance improvements from investments in quality (ESC) because of difficulties quantifying various unobservable features. In a recent citation-based systematic review of banking literature, Ahmad, Naveed, Ahmad, and Butt (2020) undertook a content analysis of the top 100 banking papers related to efficiency, profitability, and performance. They found that 74 per cent of the studies employed frontier analysis (while the remaining 26 per cent used financial ratio analysis) to measure bank performance. As in the absence of a proper index, the evaluation of the impact of ESC investments on bank efficiencies may remain subtle; thus, the current study utilises a common frontier approach to derive sample banks' cost and profit efficiencies.

Ahmad et al. (2020) found SFA is the most widely used parametric[46] approach. In contrast, data envelopment analysis (DEA)[47] is the most commonly used non-parametric approach

[46] The main advantages of employing a parametric approach in frontier analysis vis-à-vis the non-parametric approach are: first, it can characterise frontier technology in a simple mathematical form; second, it accommodates non-constant returns to scale (Førsund, Lovell, & Schmidt, 1980).

[47] In a comprehensive analysis of different technical efficiency estimation approaches, Hjalmarsson, Kumbhakar, and Heshmati (1996) investigated cement plants in Columbia for the period 1968–1988. The authors highlight that the scale properties of the DEA model are somewhat "blurred" and it lacks a natural way to introduce technical change in the analysis. The authors outline various properties of the SF model, which makes it an appropriate choice for the analysis of technical efficiency. Further, SF models estimate average parameter values in the regression equation – due to which the calculated efficiencies are not very sensitive to significant data changes at the unit level (Avkiran, 2013, p. 176), making them an appropriate choice for the analysis of the banking sector.

applied in the frontier analysis of banks. Therefore, in line with the broad banking literature, the present study utilises the SFA approach to derive sample Australian banks' cost and profit efficiencies.

SFA models develop a *best-practice* frontier from the data and split deviations between observed and optimal choices into two parts. The first part represents the usual statistical noise, "such as luck, weather, machine breakdown, and other events beyond the control of the firm". The second part represents technical inefficiency, which captures a firm's inability to produce maximal output, given the inputs consumed (Schmidt & Sickles, 1984). However, banking being a service industry, defining inputs and outputs in a frontier analysis is relatively complex (Vu & Turnell, 2011). There is a lack of consensus about the definition of input and output variables in the banking literature (Minviel & Ben Bouheni, 2021), and authors have proposed different approaches in various banking studies. The following subsection briefly discusses these different approaches and outlines the variables of interest the current study utilises to estimate sample banks' cost and profit efficiencies.

3.4.1.1 Definition of input and output variables

There are four main approaches used in banking studies to select input and output variables to estimate efficiencies. First, Sealey Jr and Lindley (1977) proposed the intermediate approach (IA), which sees banks as intermediaries that collect deposits and transform them using labour and capital into loans and other assets, which yields interest and non-interest income for the banks. In other words, IA assumes banks to be mediators connecting savers and investors. Second, under the production approach (PA), banks are treated as the producer of services (Benston, 1965), which utilises labour and capital as inputs to produce loans and deposits as outputs. Third, Berger and Humphrey (1991, 1992) suggested the value-added approach (VA), which assumes anything adding value to a bank as output. VA asserts that all liabilities and assets of a bank have some output characteristics and treats employees, the premises, and fixed assets as inputs (Bhatia, Basu, Mitra, & Dash, 2018). Finally, proposed by Hancock (1986), the cost approach (CA) assumes all revenue-generating activity (assets or liabilities) as output and the cost of production (labour, assets, and liabilities) as an input.

Berger and Humphrey (1997) suggest that the IA is more suitable for evaluating the overall efficiency of banks.[48] In an extensive review of 151 studies, Fethi and Pasiouras (2010) found that IA is most prevalent in the bank efficiency literature. The studies prefer the approach mainly because a) it better represents the bank's role in providing financial services, b) the approach is more inclusive in terms of production costs, and c) the approach measures output utilising data that is readily available (see Altunbas, Evans, & Molyneux, 2001; Berger & Humphrey, 1997). In a recent review of banking efficiency literature, Ahmad et al. (2020); and Bhatia et al. (2018) confirm that IA is the most widely used approach in non-parametric studies. Following the broad trend in the banking literature, the research utilises the IA approach to calculate sample banks' cost and profit efficiencies using the SFA technique.

Following Hoang et al. (2020), the present analysis considers three inputs: full-time employees (l); total funding (f); and physical capital (k), and utilises their corresponding input prices, w_l, w_f, w_k in the estimations.[49] The relevant output (y) for the banking industry is their total earning assets. Table 3.4 below outlines the descriptive statistics for the input, output, total cost (C), and profit (P) variables – used to estimate the cost and profit efficiencies of sample banks.

[48] Berger and Humphrey (1997) argue that as investment decisions are beyond branches' control and they are mainly engaged in processing customer documents and bank funding, the PA is more fitting in efficiency analysis at the branch level. However, as the IA considers the overall cost of banking, it is superior for evaluating the importance of frontier efficiency to the financial institutions' profitability, since minimisation of total costs (and not just production costs) is needed to maximise profits (p. 197).

[49] Following Hoang et al. (2020), price of labour (w_l) is measured by total personnel expenses over total assets; price of funding (w_f) is measured by total interest expense over total bank funding; and price of physical capital (w_k) is measured by total depreciation and other capital expenses over total non-earning assets.

Table 3.4: Descriptive Statistics of Variables used in Efficiency Estimations

Variables	Mean	Maximum	Minimum	Std. Dev.	Obs.
w_l	-4.957	-3.226	-6.335	0.530	172
w_f	-3.328	-2.708	-3.972	0.339	172
w_k	-4.118	-1.816	-6.198	0.858	172
y	11.342	13.701	6.271	1.964	172
C	8.409	10.782	3.441	1.908	172
P	6.956	9.544	-0.357	2.002	172

Note: The abbreviations wl, wf, and wk are the natural logarithmic form of the price of three input variables: labour, funding, and physical capital, respectively. Abbreviation y denotes the natural logarithmic form of sample banks' total earning assets. C and P refer to the natural log of total cost and reported profit of sample banks.

3.4.1.2 Translog frontier function

A bank is *technically inefficient* if it can attain a higher level of output for the given inputs (output-oriented measure) or if it can achieve the observed output level by consuming fewer inputs (input-oriented measure) (Kumbhakar et al., 2015). Following Hoang et al. (2020), the present study utilises the input-oriented measure to evaluate the efficiencies of sample banks. However, because of the small number of banks in the sample, the estimation excludes the component t, to increase the degree of freedom and the power of the regression (Vu & Turnell, 2011).[50]

The reduced translog stochastic cost frontier utilised is given as:

$$\mathrm{lnC_i} = \beta_0 + \sum_j \beta_j \,\mathrm{lnw_{j,i}} + \beta_y \,\mathrm{lny_i} + \frac{1}{2}\sum_j\sum_k \beta_{jk}\mathrm{lnw_{j,i}} + \frac{1}{2}\beta_{yy}\mathrm{lny_i lny_i} + \sum_j \beta_{jy}\mathrm{lnw_{j,i}lny_i} + v_i + \eta_i \qquad (3.1)$$

The term v in the estimation model above denotes the noise term.[51] As the cost function is homogeneous of degree 1 in the input prices, symmetric restrictions require $\beta_{jk} = \beta_{kj}$. The

[50] Vu and Turnell (2011), in their analysis of eight Australian banks' efficiency, noted that given the small sample size, high-power components must be excluded to increase the degree of freedom and the power of regression. The authors consequently did not include the interaction of time-variable on inputs and outputs (p. 531).

[51] It is noteworthy that, unlike the production function, the v term does not have a natural interpretation and is added to the cost function to make it stochastic.

price homogeneity condition can be easily imposed in the model by using $w_{j,i}$ for an arbitrary choice of j and normalise C_i and other input prices by it (Kumbhakar et al., 2015). Following Hoang et al. (2020), the study estimates the above translog function in eq. 3.1 using the half-normal stochastic frontier approach, as proposed by Kumbhakar et al. (2015). The price of physical capital (w_k) is used for normalising total cost and prices. Thus, after incorporating price homogeneity restrictions, the cost efficiencies for sample banks are estimated as the following:

$$\ln\left(\frac{C}{w_k}\right)_i = \beta_0 + \beta_y \ln y_i + \beta_l \ln\left(\frac{w_l}{w_k}\right)_i + \beta_k \ln\left(\frac{w_f}{w_k}\right)_i + \frac{1}{2}\beta_{yy}\ln y_i \ln y_i + \frac{1}{2}\beta_{ll}\ln\left(\frac{w_l}{w_k}\right)_i \ln\left(\frac{w_l}{w_k}\right)_i$$

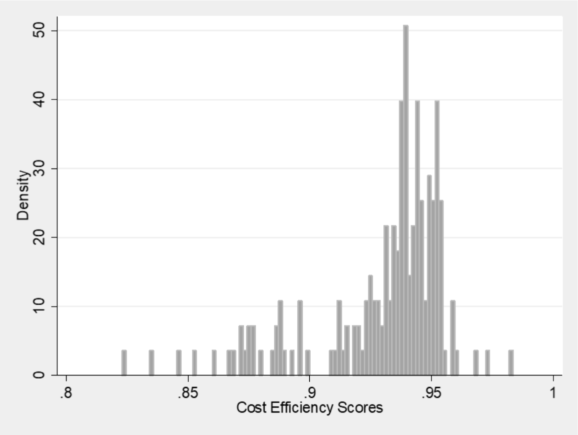
$$+\frac{1}{2}\beta_{kk}\ln\left(\frac{w_f}{w_k}\right)_i \ln\left(\frac{w_f}{w_k}\right)_i + \beta_{lk}\ln\left(\frac{w_l}{w_k}\right)_i \ln\left(\frac{w_f}{w_k}\right)_i + \beta_{ly}\ln y_i \ln\left(\frac{w_l}{w_k}\right)_i + \beta_{ky}\ln y_i \ln\left(\frac{w_f}{w_k}\right)_i + v_i^C$$

$$+ \eta_i^C \tag{3.2}$$

In a survey of eight Australian banks covering 1997 to 2009, Vu and Turnell (2011) reported an average cost efficiency of 0.875. The present study results indicate that, on average, during the period of analysis (2000–2019), sample Australian banks operate with a higher cost efficiency of 0.93. The results confirm the findings of Allen and Rai (1996), who, in their global study, assigned Australia to the group of countries with the most efficient cost structure.

Figure 3.1 below presents the distribution of cost efficiencies derived using eq. (3.2)

Figure 3.1: Cost Efficiency of Australian Banks

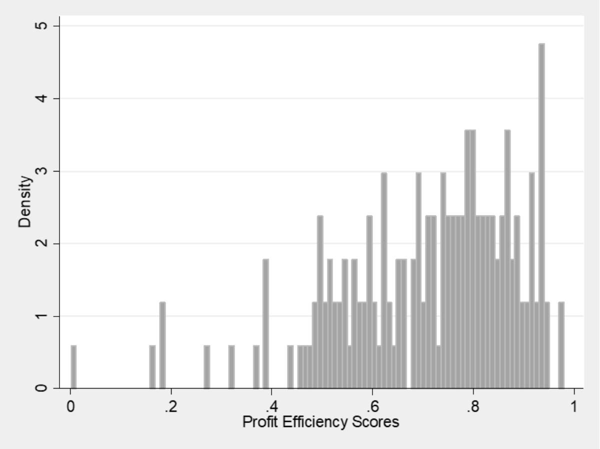


Note: Graph generated by statistical software STATA.

For the profit function, I replace C and the composed error of the model: $v_i^C + \eta_i^C$ in eq. 3.4 above with P and $v_i^P - \eta_i^P$ (see Kumbhakar et al., 2015; Vu & Turnell, 2011).

Analysing the efficiency of Australian banks, Vu and Turnell (2011) reported the average profit efficiency of Australian banks for the period 1997–2009 as 0.878. However, the current analysis results indicate that the average profit efficiency of Australian banks from 2000 to 2019 is much lower, at 0.710. Figure 3.2 below presents the distribution of profit efficiencies for sample banks.

Figure 3.2: Profit Efficiency of Australian Banks



Note: Graph generated by statistical software STATA.

3.4.2 Principal components analysis (PCA)

The present study aims to assess the impact of three ESC investments: branching (Z_B), advertising (Z_A), and technology (Z_T) on the cost and profit efficiencies of the Australian banks. However, a correlation analysis indicates that the three ESC investments are highly correlated.[52]

For a precise estimation of the effect of ESC investments on the cost and profit efficiencies of the sample banks, the study utilises PCA, a dimension-reduction method useful for modelling highly correlated data. It reduces the number of dimensions by removing redundant features of a dataset, while ensuring minimal loss of information (Bruce Ho & Dash Wu, 2009; Kherif & Latypova, 2020). PCA captures the data's total variation and obtains the best solution for the responses at the desired target variable (Şimşek, Doruk, Ceran, & Uygunoğlu, 2021).

In the first step, an overview of eigenvalues and eigenvectors is derived by applying the principal component decomposition to the covariance and correlation matrix associated with the three ESC investment variables (Z_B, Z_A, and Z_T). A higher number of components result in lower eigenvalues, but the eigenvalue must be greater than 1 (one) to be considered a component (Bruce Ho & Dash Wu, 2009). In the PCA performed on the three ESC investments, only one principal component (component 1) is found to associate with eigenvalues greater than one (1). While the total eigenvalue is 3.158, component 1 accounts for 96.36 per cent of the total variance. This means the first principal component explains 96.36 per cent of variations in the ESC. Thus, we choose the weights of the first principal component, given in Table 3.5, to compute the index of ESC.

[52] The correlation analysis indicates that Z_B, Z_A, and Z_T are highly correlated. Precisely, the correlation between Z_B and Z_A is 0.9273; the correlation between Z_B and Z_T is 0.9825; and the correlation between Z_A and Z_T is 0.9261.

To interpret the revealed PCA information, one must study the loadings of the eigenvectors (Bruce Ho & Dash Wu, 2009). Using the loadings from component 1 (in Table 3.5), the study derives the variable ESC to investigate the role of banks' ESC investments on cost and profit efficiencies.

Table 3.5: PCA: Matrix of Component Loadings

Variable	Component 1
Z_B	0.5813
Z_A	0.5697
Z_T	0.5810

Note: Z_B, Z_A and Z_T denote banks' ESC investments in branching, advertising, and IT, respectively.

3.4.3 Unit root test

It is critical to determine the order of integration for all the variables of interest to identify the most appropriate cointegration technique for empirical analysis. The econometric literature proposes several approaches to test unit roots. However, in panel studies, the test proposed by Im, Pesaran, and Shin (2003) (IPS) is most widely applied to establish the stationarity of variables. The approach is based on the augmented Dickey-Fuller (ADF) principle and allows for heterogeneity within panels (Baltagi, 2013, p. 276). The IPS test thus examines the null hypothesis that all panels have a unit root, and rejecting the null hypothesis confirms the stationarity of a non-zero fraction of panels (Erülgen et al., 2020). However, it is important to note that some recent studies suggest that the presence of cross-sectional dependence poses a threat to the validity of standard panel unit root tests. Hence, the research also employs an alternative test, the cross-sectional augmented Im-Pesaran-Shin (CIPS) test (Pesaran, 2007). The CIPS test allows for the heterogeneous unit process augmenting the ADF regression for each unit with cross averages (Erülgen et al., 2020).

Table 3.6 presents the results from the two unit root tests. Notably, the IPS test shows that PES, CES, LDR, CM, and lnGDP are stationary at level (I(0)), while ESC, CS, HHI, and INF are stationary at first-difference (I(1)). On the other hand, the CIPS test confirms that CES, PES, ESC, CM, lnHHI, GDPG, and INF are stationary at level (I(0)), while LDR and CS are stationary at first-difference (I(1)).

3.4.4 Panel autoregressive distributed lag (P-ARDL) model

The unit root tests (in Table 3.6) indicate that not all the variables of interest are integrated in the same order. Thus, conventional panel cointegration techniques cannot be applied to investigate the impact of ESC investments on sample banks' cost and profit efficiencies. Given the framework, the P-ARDL model – as proposed by Pesaran and Smith (1995) and Pesaran, Shin, and Smith (1999) – is most appropriate. The technique has a few advantages. First, the approach does not require the explanatory variables to be integrated of the same order, i.e. it is capable of handling variables that are stationary and non-stationary (integrated of up to order 1 or even fractionally integrated). Second, the approach is more robust for small sample situations, such as the present study. Additionally, the approach offers both long- and short-run parameters in a single estimation (Gangopadhyay & Jain, 2020). Finally, the method requires T to be larger than N (Shaari, Abdul Karim, & Zainol Abidin, 2020), making it the most appropriate technique for the present analysis.

The postulated P-ARDL model to measure the impact of ESC investments on the cost (CES) and profit (PES) efficiencies (Pesaran et al., 1999) is:

$$\Delta y_{it} = \omega_i + \alpha_i\left(y_{i,t-1} - \theta_i' x_{i,t-1}\right) + \sum_{j=1}^{p-1} \emptyset_{ij} \Delta y_{i,t-j} + \sum_{j=0}^{q-1} \delta_{ij} \Delta x_{i,t-j} + \varepsilon_{it} \qquad (3.3)$$

where in Model 1 (Model 2), y_{it} is the CES (PES) of bank i at time t, derived from the SFA (detailed in section 3.4.1); $x_{i,t}(k \times 1)$ is the vector of explanatory variables: ESC investments (ESC), capital strength (CS), loan-to-deposit ratio (LDR), cost management (CM), market concentration and competition (HHI), GDP growth (GDPG), and inflation (INF). The long-run equilibrium relationship between x_{it} and y_{it} is denoted by θ_i, while $\emptyset_{ij}$ and δ_{ij} capture short-run dynamics between variables of interest. Notably, α_i is the error correction term, which denotes the speed of adjustment of sample banks' CES and PES to the long-term equilibrium. In the model specified in eq. 3.3, the terms in the bracket outline the cointegration relationship between x_{it} and y_{it} (Erülgen et al., 2020).

There are three distinct estimators to analyse the panel data using the ARDL approach: the mean group (MG), the dynamic fixed effect (DFE), and the pooled mean group (PMG) estimator. Pesaran and Smith (1995) presented the MG approach. The estimation technique estimates the model for each sample bank separately and then averages all coefficients using a simple arithmetic average. Thus, the estimator allows the intercepts, error variance, and slope coefficients to differ across banks in the short and long term (Alam & Murad, 2020). According to Pesaran et al. (1999), the required conditions for validity and consistency in this method require an adequately large (20–30) number of units. Considering the dataset comprises only nine banks, the MG estimator is not an appropriate approach for the current analysis.

Table 3.6: Panel Unit Root Tests Results

Variables	CIPS				IPS			
	Level		1st difference		Level		1st difference	
	Constant	**Constant and trend**	**Constant**	**Constant and trend**	**Intercept**	**Intercept and trend**	**Intercept**	**Intercept and trend**
PES	-2.85***	-3.29**	-2.15	-2.21	-2.41***	-2.25**	-10.03***	-7.65***
CES	-3.84***	-3.40**	-3.29**	-5.09***	-6.12***	-5.24***	-6.88***	-11.02***
ESC	-3.12***	-3.34**	-3.77***	-2.52	-1.76**	0.67	-9.71***	-7.73***
LDR	-1.68	-2.47	-4.77***	-3.77***	-2.36***	-4.16***	-10.02***	-7.77***
CM	-3.09***	-3.69***	-2.30**	3.12*	-2.99***	-5.21***	-10.80***	-9.87***
CS	-1.96	-3.62***	-3.48***	-3.46**	-1.13	-1.68**	6.82***	-5.09***
HHI	-3.93***	-2.92*	-5.29***	-4.92***	0.25	-0.76	-3.05***	-0.98
GDPG	-4.20***	-4.24***	-6.72***	-8.83***	-8.62***	-6.04***	-10.41***	-8.47***
INF	-3.69***	-3.51***	-4.73***	-3.97***	-0.92	-9.92***	-12.78***	-10.26***

Note: *** indicates significance at the 1% level; ** indicates significance at the 5% level; and * indicates significance at the 10% level. Lag lengths were determined by the Schwarz information criterion (SIC). PES and CES are the profit and cost efficiency scores derived using the SFA approach. ESC denotes the ESC investments of sample banks, derived using the PCA approach. CR, CM, and CS are the bank-specific factors, namely credit risk, cost management, and capital structure. HHI refers to the industry-specific factor: Herfindahl–Hirschman index (HHI). Finally, GDPG and INF are the two macroeconomic variables representing GDP growth and inflation rate.

An alternative approach is the DFE estimator. The DFE approach would pool the data, restricting long- and short-run coefficients to equal across all banks. The technique limits the vector cointegration coefficient to be the same among all banks and limits the speed of adjustments (Alam & Murad, 2020; Shaari et al., 2020). According to Baltagi, Griffin, and Xiong (2000), the DFE models are subject to a simultaneous equation bias and suffer from endogeneity between the lagged dependent variable and the error term; hence, least preferred in panel data studies.

The PMG estimator combines the features of MG and DFE estimators (Ben-Salha, Dachraoui, & Sebri, 2018). On the one hand, it allows short-run coefficients – including the intercepts, the speed of adjustment, and the error variance – to be heterogeneous bank by bank. On the other hand, the long-term slope coefficients are restricted to being homogeneous across the sample (Alam & Murad, 2020). Pesaran et al. (1999) show that, under some regulatory conditions, the PMG estimator is consistent and asymptotically normal (Ben-Salha et al., 2018).

Most empirical studies utilise the PMG estimation technique since it offers an intermediate path between the pooling (DFE) and the average (MG) methods of estimations (Erülgen et al., 2020; Odugbesan & Rjoub, 2019). Therefore, after careful consideration, the PMG estimator is deemed to be the most appropriate technique for the present study.

One of the main advantages of P-ARDL estimation is that it is more efficient and consistent in capturing the existence of a long-run relationship among the variables of interest. To establish cointegration, the error correction term (ECT) coefficient must be negative, statistically significant, and less than 2 (Erülgen et al., 2020; Shaari et al., 2020). The results for Model-1 in Table 3.7 report the ECT coefficient (-0.404), which is negative and statistically significant at a 1 per cent level of significance. Table (3.7) also reports the ECT coefficient for Model-2 (-0.755), which is negative and statistically significant at a 1 per cent level of significance. The results for the two models confirm a stable long-run cointegration among the variables in the two estimations.

Table 3.7 below summarises the P-ARDL results for Model-1 (CES) and Model-2 (PES).

Table 3.7: Panel-ARDL Results

PMG estimator	**Model-1: (CES)**	**Model-2: (PES)**
Error correction term		
ECT	-0.404***	-0.755***
Long-run estimates		
Independent variables	**Coefficient**	**Coefficient**
ESC	-0.030	-0.511***
CM	-0.365***	1.245***
CS	0.784**	3.786***
LDR	-0.020	0.653***
HHI	-0.002	0.487***
GDPG	0.020	-0.001
INF	0.023**	-0.246***
Short-run estimates		
Independent variables	**Coefficient**	**Coefficient**
ΔESC	-0.029	0.097
ΔCM	-0.046	0.734
ΔCS	-0.343	-4.172
ΔLDR	-0.040	0.586
ΔHHI	0.114	-0.184
ΔGDPG	-0.007	-0.048
ΔINF	-0.007	0.101***

Note: *** indicates significance at the 1% level; ** indicates significance at the 5% level; and * indicates significance at the 10% level. Lag lengths were determined by the Schwarz information criterion (SIC). PES and CES are the profit and cost efficiency scores derived using the SFA approach. ESC denotes the ESC investments of sample banks, derived using the PCA approach. LDR, CM, and CS are the bank-specific factors, namely loan-to-deposit ratio, cost management, and capital structure. HHI refer to the natural logarithm of industry-specific factors: the Herfindahl–Hirschman index (HHI). Finally, GDPG and INF are the two macroeconomic variables representing the natural logarithm of GDP growth and inflation.

Endogenous sunk cost investments

The long-run estimates in Table 3.7 show that ESC investments negatively impact CES and PES of sample banks; however, the relationship is of statistical significance only for Model-2 (PES). Notably, a 1 per cent increase in ESC is associated with a 0.511 per cent decline in PES in the long run. According to Koetter, Kolari, and Spierdijk (2012), profit inefficiencies arise when banks do not fully exploit the pricing opportunity set. For instance, banks may sub-optimally allocate resources in acquiring quality and choose to compete vigorously in pricing interest rates to keep rivals out. The results suggest that banks are over-investing in ESC, raising the consumption of inputs, but not outputs, and consequently adversely affecting their PES. The results detect a negative (positive) impact of ESC on CES (PES) in the short run, but the results are not significant.

Bank-specific factors

As expected, the system detects a negative relationship between cost management (CM) and CES in the long run (at a 1 per cent level of significance). A higher non-interest expense to total assets ratio reflects managerial inefficiencies in controlling administrative costs (Vu & Turnell, 2011). Notably, a percentage increase in CM adversely impacts the CES of sample banks by 0.365 per cent in the long term. However, results suggest that CM positively impacts PES of Australian banks, and a percentage increase in the ratio of non-interest expense to total assets is associated with a 1.245 per cent improvement in PES. The results are statistically significant (at 1 per cent) and can be linked to the discussion in the previous chapter (section 2.5, Chapter 2). In Australia, mortgage brokers play a crucial role in loan disbursement. Possibly, banks incurring higher non-interest expenses (in the form of commissions to mortgage brokers) can eventually improve their PES through improved growth and quality of their loan books. The short-run results are statistically insignificant.

Contrary to the findings of Vu and Turnell (2011), the results in Table 3.7 suggest that a percentage increase in CS is associated with a 0.784 (3.786) per cent improvement in CES (PES) of sample banks, in the long run. The estimates are statistically significant and support the view of the Productivity Commission (2018), which suggests that better-capitalised banks enjoy higher credit ratings from international agencies, enabling them to reduce their funding costs. The results of Model-2 (PES) are in line with the findings of Hoang et al. (2020), who established a positive influence of bank capitalisation on NIM and RoE of Australian banks. The short-run results suggest a negative impact of CS on CES and PES of Australian banks; however, the estimates are statistically insignificant.

The results in Table 3.7 suggest a positive influence of LDR on the PES of Australian banks. The statistically significant results indicate that a 1 per cent increase in LDR is associated with a 0.653 per cent improvement in PES and support the findings of Vu and Turnell (2011). As expected, an improvement in the ability of banks to transform interest-bearing deposits into interest-earning loans increases the PES of sample banks. However, although statistically insignificant, the results indicate that, in the long run, a 1 per cent increase in LDR is associated with a 0.02 per cent decrease in CES. Possibly, banks with higher LDR spend more resources on monitoring loans, which explains its adverse impact on CES. The short-run results align with the long-run effects but are not statistically significant for either CES or PES.

Industry-specific factor

The results in Table 3.7 suggest that the industry-specific factor, HHI, is of statistical relevance only in the long-run evaluation of PES. Notably, HHI positively impacts the PES of Australian banks. The results support the widespread notion that less-competitive market structures lead to monopolistic profits (see Bourke, 1989; Molyneux & Thornton, 1992). The long-run results for Model-1 suggest that the impact of lnHHI on CES is mild and statistically insignificant. The direction of short-run results is contrary to the long-run results for both models (Model-1 and Model-2) but is not statistically significant.

Macroeconomic factors

The results in Table 3.7 suggest that GDP growth (GDPG) is not a relevant factor in the evaluation of CES and PES of Australian banks. Model-1 and Model-2 indicate a mildly negative impact of GDPG on the CES and PES of sample banks in the long and short run; however, none of the results are statistically significant. The results confirm the findings of Hoang et al. (2020), who estimated the impact of GDPG on four proxies of shareholder value. The authors concluded that GDPG does not affect NIM, Tobin's q, or economic value-added estimates of Australian banks.

Finally, the results in Table 3.7 suggest that, in the long run, inflation (INF) is associated with a mildly positive impact on the CES of Australian banks. However, the results for Model-2 suggest that INF adversely impacts the PES of sample banks. The long-run results for Model-1 (Model-2) are statistically significant at a 5 (1) per cent level of significance. Interestingly, the short-run results suggest that (although statistically insignificant) INF hurts CES. At the same time, the estimates indicate that INF has a positive impact on PES in the short run, at a 1 per cent level of statistical significance. The results suggest that Australian banks successfully manage cost increases due to inflationary trends in the long run. However, the PES of Australian banks improves only in the short run. As Australia has adopted a monetary policy that targets inflation (Holland et al., 2020), persistent inflation results in an increased cash rate and reserve requirements, in the long run restricting banks' ability to translate cost savings into improved profitability.

3.4.5 Robustness check: Cross-sectionally augmented ARDL (CS-ARDL)

P-ARDL is among the most popular heterogeneous panel estimators. However, the technique cannot address the potential error arising from cross-sectional dependence (Chudik & Pesaran, 2015). Thus, following Erülgen et al. (2020), as a robustness test, the present study utilises the CS-ARDL technique. The CS-ARDL model augments the ARDL model with the linear combination of the average cross-sectional of both the independent and dependent variables, capturing the cross-sectional correlation in the error term (Chudik & Pesaran, 2015). Additionally, the technique produces dependable results even in cases of weak exogeneity (Okumus, Guzel, & Destek, 2021).

The modified model is presented below (Chudik, Mohaddes, & Pesaran, 2013):

$$\Delta y_{it} = \mu_i + \alpha_i\left(y_{i,t-1} - \theta_i' x_{i,t-1} + \alpha_i^{-1} n_i \bar{y}_t + \alpha_i^{-1} y_i' \bar{x}_t\right) + \sum_{j=1}^{p-1} \emptyset_{ij}\, \Delta y_{i,t-j}$$

$$+ \sum_{j=0}^{q-1} \delta_{ij} \Delta x_{i,t-j} + \sum_{j=0}^{p-1} v_{ik} \Delta \bar{y}_{t-j} + \sum_{j=0}^{q-1} y_{ik} \Delta \bar{x}_{t-j} + \varepsilon_{it} \quad (3.4)$$

where $\bar{y}_t$ and $\bar{x}_t$represent the cross-section average of y_{it} and x_{it}. In eq. 3.4, the short-term and long-term behaviour of the cross-sectional correlation are distinguished. Consistent with Eberhardt and Presbitero's (2015) suggestion, only the level parts of the cross-sectional averages are included in the long-term equilibrium relationship in parentheses. The main coefficients of interest are: α_i, the rate of adjustment back to equilibrium; and θ_i', the long-run coefficient associated with y_{it} and x_{it}. The short-run coefficients are denoted by $\emptyset_{ij}$ and δ_{ij} (Erülgen et al., 2020).

Table 3.8 reports the results of alternative models, which utilise the CS-ARDL technique to detect the influence of ESC on CES and PES. As stated before, cointegration among the variables of interest is established if the coefficient of the ECT is negative, statistically significant, and less than 2 (Erülgen et al., 2020; Shaari et al., 2020). Notably, the ECT for both alternative models – Model-1^{a} and Model-2^{a} – confirms long-run cointegration. The ECT for Model-1^{a} (assessing CES) and Model-2^{a} (assessing PES) in Table 3.8 is -1.179 and -1.870 respectively. The ECT coefficients for both estimates are statistically significant at a 1 per cent level of significance.

Notably, the results for ESC in Table 3.8 support the findings of the primary model reported in Table 3.8. The coefficients of the estimates indicate that a 1 per cent increase in ESC is associated with a 0.03 (0.039) per cent decline in cost efficiencies of Australian banks in the long (short) run. The results are not statistically significant, confirming that ESC does not have any meaningful impact on the CES of Australian banks. However, the alternative estimation for PES (Model-2^{a}) results suggest that a 1 per cent increase in ESC is associated with a 0.244 (0.461) per cent decline in PES in the long (short) run. The results for ESC in Model-2^{a} is statistically significant for both the long- and short-run estimates at a 1 per cent level of significance.

The results also confirm that CM and CS are two bank-specific factors of statistical significance impacting CES and PES of Australian banks. In line with the results of the primary model (Model-1 in Table 3.7), the CS-ARDL estimates suggest that an increase in CM adversely impacts CES. In contrast, an increase in CS positively affects the CES of Australian banks in the long run. The alternative model (Model-1^{a}) suggests that a 1 per cent increase in CM (CS) is associated with a 0.165 (1.028) per cent decline (improvement) in CES of Australian banks. Similarly, the alternative model (Model-2^{a}) confirms the findings of the primary model (Model-2) and establishes that both CM and CS positively impact PES in the long run. Notably, a 1 per cent increase in CM and CS is associated with a 0.732 per cent and 3.867 per cent improvement in PES, respectively.

Table 3.8 presents the results from the CS-ARDL estimation:

Table 3.8: Panel CS-ARDL Results

PMG estimator	Model-1[a]: CES	Model-2[a]: PES
Error correction term		
ECT	-1.179***	-1.870***
Long-run estimates		
Independent variables	**Coefficient**	**Coefficient**
ESC	-0.030	-0.244***
CM	-0.165*	0.732***
CS	1.028**	3.867***
LDR	0.067	-0.355
HHI	0.047**	0.500
GDPG	-0.003	-0.004
INF	-0.009*	-0.032
Short-run estimates		
Independent variables	**Coefficient**	**Coefficient**
ΔESC	-0.039	-0.461**
ΔCM	-0.199*	1.371***
ΔCS	1.290**	6.729***
ΔLDR	0.085	-0.246
ΔHHI	0.056**	0.584
ΔGDP	-0.004	0.004
ΔINF	-0.011*	-0.050

Note: *** indicates significance at the 1% level; ** indicates significance at the 5% level; and * indicates significance at the 10% level. Lag lengths were determined by the Schwarz information criterion (SIC). PES and CES are the profit and cost efficiency scores derived using the SFA approach. ESC denotes the ESC investments of sample banks, derived using the PCA approach. LDR, CM, and CS are the bank-specific factors, namely loan-to-deposit ratio, cost management, and capital structure. HHI refers to the natural logarithm of industry-specific factors: the Herfindahl–Hirschman index (HHI). Finally, GDPG and INF are the two macroeconomic variables representing the natural logarithm of GDP growth and inflation.

Contrary to the estimates of primary models (in Table 3.7), the CS-ARDL estimates (in Table 3.8) establish that CM and CS are of statistical relevance in evaluating CES and PES even in the short run. The results of (Model-1[a]) suggest that a 1 per cent increase in CM (CS) results in a 0.199 (1.29) per cent decline (improvement) in CES in the short run. The results of (Model-2[a]) suggest that a 1 per cent increase in CM and CS results in a 1.371 and 6.729 per cent improvement in PES in the short run.

For industry-specific and macroeconomic variables, the CS-ARDL estimations for Model-1^{a} suggest that HHI and INF are the only factors of statistical significance that impact the CES of Australian banks in the long run. Contradicting the results of the primary model, the alternative model (Model-1^{a}) suggests that an increase in HHI (INF) improves (adversely impacts) CES of Australian banks in the long run. Further, the results of Model-1^{a} suggest that INF is the only relevant macroeconomic (or industry-specific) variable of statistical importance in the short run. The system detects a mildly negative impact of inflation on the CES of sample banks in the short run.

The CS-ARDL estimation of industry-specific and macroeconomic variables in Model-2^{a}, although insignificant, confirms the findings of the primary model, Model-2. While INF and GDPG adversely impact PES, HHI positively impacts the PES of Australian banks in the long run.

The study results suggest that the Australian banks sub-optimally invest in ESC. As ESC adversely impacts the sample banks' PES, clearly, the SCP paradigm and the ES theory are not a valid explanation for the extensive outlays Australian banks commit to quality (ESC investment). Two possible explanations exist for the adverse selection of ESC investments in the Australian banking market. First, the managerial decision to acquire quality through ESC investments could be driven by expense-preference behaviour (Hermalin, 1992).[53] Second, military analogy, i.e. the arms race, may help appropriately understand the research findings. Managers may choose to invest in ESC to acquire quality based on perceived strategic benefit, in the knowledge that any competitive advantage drawn from product differentiation will only be temporary (Brady & Targett, 1995). Thus, managers persistently invest without rationally

[53] According to Hermalin (1992), in concentrated markets, managers may engage in non-profit maximisation behaviour to a greater degree and expand inputs beyond levels justifiable by profit maximisation.

assessing the utility of additional quality acquired. Consequently, additional ESC investments do not improve their cost or profit efficiency.

The estimates in Model-1 and Model-1^{a} detect a weak relationship between ESC and CES of sample banks. Hence, I conclude that ESC investments in the Australian banking market are driven by competitive escalation, or the arms-race phenomenon.

3.5 Conclusion

ESC investments are critical firm-specific strategies that influence banks' market share. Chapter 2 established its importance in shaping the concentrated structure of the Australian banking market. As ESC investments consume substantial bank resources, it is critical to evaluate whether managers rationally choose such outlays or if managerial biases plague such strategies.

This study presents a new insight into the competitive behaviour of banks in a concentrated market. Analysing the impact of ESC investments on Australian banks' cost and profit efficiencies using two different panel estimation techniques, the study concludes that managers sub-optimally invest in ESC. The results from the P-ARDL (Table 3.8) and CS-ARDL (Table 3.9) estimations suggest that ESC investments are of no statistical significance in the evaluation of the cost efficiency of Australian banks. However, an increase in ESC investments has a significant negative impact on the profit efficiencies of Australian banks. Results in Model-2 (Model-2^{a}) suggest that a percentage increase in ESC adversely impacts PES by 0.511 (0.244) per cent in the long run.

What explains the suboptimal selection of ESC investments that dampen Australian banks' profitability?

The banking studies in the early 1990s mostly examined interest rate differentials between lending and deposits to assess the effect of market concentration on competition (Berger, Demirgüç-Kunt, Levine, & Haubrich, 2004). These studies focused on establishing either the traditional SCP paradigm or the competing view of ES, mostly assuming that banks will draw monopoly rents, and thus higher profits, in a concentrated market. However, it was not uncommon to obtain a weak relationship between concentration and profitability when firms' market shares (measured by the HHI, or n-firm concentration ratio) were included in the regression (Färe, Grosskopf, Maudos, & Tortosa-ausina, 2015). In one of the early studies in banking, Berger and Hannan (1998) evaluated the QL hypothesis to analyse the relationship between market concentration and bank profitability. The QL hypothesis postulates that higher market power may dampen managerial efforts to maximise operating efficiency (see Hicks, 1935). As a result, firms in concentrated markets may exhibit higher costs and lower profitability.

However, results indicate that a little-known phenomenon – the arms race – is the most appropriate explanation for the adverse selection of ESC investments in the Australian banking sector. Results suggest that banks compete to acquire quality to gain or maintain their market share and neglect its influence on their profitability. Consequently, banks do not draw any monetary benefit from such investments. Nonetheless, the competitive escalation of ESC investments explains the minimal change in market concentration, even after several regulatory interventions since the Campbell (1981) report.

The study concludes that regulatory concerns around concentration in the banking sector (see ACCC, 2018; Murray et al., 2014; Productivity Commission, 2018) are not unjustified. The persistence of ESC-induced inefficiency in the banking system may adversely impact the stability of the financial system in the long term. Better disclosure requirements can be instrumental in curbing managerial bias (Guo, Chan, & Huang, 2018). Thus, it is recommended that regulators urge bankers to clearly report their investments in branching, advertising, and technology – the three prominent forms of ESC investment.

While the study offers a unique insight into managerial biases driving ESC investments, there are some unavoidable limitations. First, the observed inefficiency may result from a specific ESC investment. Thus, a critical limitation of the present study is its inability to precisely detect the effect of each ESC investment (branching, advertising, or technology) on the profit and cost efficiency of sample banks. Second, ESC investments may affect the efficiency of banks differently, depending upon their respective size (large, medium, or small). The study analyses only nine banks and fails to assess the impact of ESC investments on the efficiencies of banks of varying sizes. Finally, the research follows broad literature on efficiency studies in banking and utilises standard models based on a two-step estimation to analyse the issue. In the first step, I estimate observation-specific efficiency measures based on some firm characteristics x_i (section 3.4.1). In the second step, the index developed is regressed on a vector of exploratory variables z_i (section 3.4.4 and 3.4.5). Wang and Schmidt (2002) explain that a two-step approach is biased. According to the authors, if x_i and z_i are correlated, then the estimations obtained in the first step are mis-specified (Kumbhakar et al., 2015). An appropriate solution to overcome the bias problem is to estimate efficiencies using a single-step procedure, which correctly specifies the distribution of y given x and z. However, estimation of efficiency in a single step requires a larger dataset. These limitations will be addressed in a subsequent chapter, which utilises a larger dataset from the European banking market.

CHAPTER 4: What Drives Endogenous Sunk Cost Investments in the European Banking Industry?

The previous chapter (Chapter 3) explored the impact of endogenous sunk cost (ESC) investments on the efficiency of the Australian banking industry. This chapter investigates the influence of ESC investments on European banks, which operate in a unique setup. Banks in the unified economic region of the E.U. compete for market share not only from domestic firms but also from banks headquartered outside their national boundaries, yet within the euro area. While the markets are competitive, concentration is high, which warrants an analysis of drivers of ESC investments and their influence on the banks' performance.

4.1 Introduction

The previous chapter(s) outlined the role of critical ESC investments in the Australian banking sector. The current study explores the influence of ESC investments on the European banking market. Banks in the E.U.[54] enjoy access to a single integrated financial system and can freely establish operations in a homogeneous, competitive environment across the unified economic region[55] (Drach, 2020; Maudos & Vives, 2019). Nonetheless, it means that the banking firms operate in a highly competitive environment. They compete for market share with domestic banks as well as banks headquartered outside their national boundaries, yet within the euro area.

The idea of a single European banking market is relatively old and culminated after a series of consultations and negotiations that began as early as 1957 (Murphy, 2000). Following the

[54] The European Union (E.U.) is a political and economic consortium of 27 member countries (after the United Kingdom withdrew on 31st January 2020).
[55] The implementation of the *First Banking Directive* in 1977, and subsequent E.U. white paper (1985) and the *Second Banking Directive* of 1988 culminated in the establishment of the Single Market for Financial Services in the E.U. in 1993. Refer to Appendix 2 to understand the three major components of the directive and its implications on the competition in the E.U. banking market.

harmonisation of the E.U. financial sector, the banking market in every E.U. member state became contestable (Fiordelisi, Marques-Ibanez, & Molyneux, 2011). Thus, giving banks across member states access to a large market with a consumer base of upwards of 400 million (Murphy, 2000). Subsequent inclusion of Central and Eastern European countries[56] further expanded the market accessible to banks incorporated in the member states (Mamatzakis, Staikouras, & Koutsomanoli-Filippaki, 2008).

Following industry deregulation, a natural expectation is that increased competition will result in a fragmented market structure. However, contrary to the anticipations of regulators, data from the European Central Bank (ECB, n.d.) indicate that the share of the five largest credit institutions (CI) in terms of total banking assets, on average, has increased from 53.29 per cent in 1997 to 67.25 per cent in 2020. Recognising the ineffectiveness of deregulation in introducing competition in the E.U. banking market, in the White Paper (2005–2010), the European Commission declared, "use competition pro-actively to identify and help track barriers in the single market" (Casu & Girardone, 2009a). Notably, the phenomenon is not new to the European banking market. In an early investigation of the E.U. banking market, Molyneux and Forbes (1995) term it a "peculiar feature" as, in almost all countries, only a "handful of large banks tend to emerge over time". Additionally, analysing all banking markets of all 27 member states, Marius Andrieş and Căpraru (2012) conclude that deregulation is not sufficient to increase competition in the European banking market.

Banks in the E.U. are known to enjoy oligopoly powers (Dalla & Varelas, 2019; Maudos & de Guevara, 2007),[57] and the persistence and increase in concentration in the E.U. markets suggest

[56] The largest expansion of the union in terms of population and territory took place on 1st May 2004. Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, and Slovenia – collectively referred to as A10 countries – joined the E.U. Subsequently, Bulgaria and Romania became E.U. members in 2007.

[57] A few studies suggest that the banking market structure in the E.U. is characterised by monopolistic competition (For example, Andrieş & Căpraru, 2014; Apergis, Fafaliou, & Polemis, 2016; Casu & Girardone, 2009a;

that the banks have been able to counter the regulatory will and successfully maintain and even gain market share, configuring the market structure as per their preference, but how?

Banks are known to engage in ESC competition to configure the market structure as per their preference (see Dick 2006, 2007, 2008). ESC investments are choice variables that aim to achieve vertical product differentiation (quality) and enhance consumers' "willingness to pay" (Jain & Gangopadhyay, 2020; Ollinger & Fernandez-Cornejo, 1998; Sutton, 1991). In a market with high competitive intensity, banking firms invest in ESC to protect and gain market share by introducing vertical differentiation service quality (Vives, 2016). According to Dick (2007, 2008), when the market size expands, banking firms raise their provision of quality by incurring higher fixed sunk costs in quality. Consequently, higher-quality banks corner market share from their peers, who incur relatively smaller investments in similar attributes, resulting in a concentrated market structure.

Since ESC investments consume significant resources of a firm (Senyuta & Žigić, 2016), it is critical to identify the notion that drives such critical outlays in quality. Notably, managers may assume different strategies to gain market power through investments in ESC. For instance, under the structure–conduct–performance (SCP) paradigm, managers may strategically over-allocate resources in ESC to improve their market share. On the one hand, their over-investment in quality raises the barriers to entry and, on the other, pushes existing competitors to match their level of investments or quit the competition (see Posner, 1975; Tullock, 1967). Consequently, banks investing in quality will improve their profit efficiencies through market power obtained at the expense of cost efficiencies (Berger & Hannan, 1998).

Staikouras & Koutsomanoli-Fillipaki, 2006; Yildirim & Philippatos, 2007). These studies primarily rely on the competition model proposed by Panzar and Rosse (1987), also known as *H-statistic.* Numerous researchers highlight that the Panzar and Rosse model systematically overestimates competitive conduct and presents distorted results (Bikker, Shaffer, & Spierdijk, 2012; Sanchez-Cartas, 2020; Shaffer & Spierdijk, 2015) and thus the findings of monopolistic competition in the E.U. banking market is questionable.

The proponents of the efficient structure (ES) hypothesis propose an alternative view. According to the ES theory, the intensity of market competition and market concentration may not necessarily be negatively related[58] (VanHoose, 2017). The advocates of the theory claim that efficient firms dominate the market not through market power but because of their better cost efficiencies, which allows them to set lower (higher) loan (deposit) rates and seize market share from their less-efficient rivals (Schaeck & Cihák, 2014). Suppose banks' investments in ESC improve their cost and profit efficiencies. In that case, one may conclude that managerial decisions to invest in ESC are driven by their zeal to improve the efficiency of their organisation to gain market share.

Nonetheless, investments in ESC may be driven by the arms-race phenomenon, something I found applicable in the Australian banking market. The military analogy suggests that managerial decisions in selecting ESC investment could be based on perceived strategic benefit. However, as they know that any competitive advantage drawn from product differentiation will only be temporary (Brady & Targett, 1995), managers may persistently invest without rationally assessing the utility of additional quality acquired to protect their market share. Consequently, there is a continuous growth in ESC investments, which does not affect the bank's cost or profit efficiencies and may even adversely impact them. Alternatively, the quiet life (QL) hypothesis (see Berger & Hannan, 1998) may influence banks' investments in ESC. The QL argument posits that banks with market power lack an incentive to maximise (minimise) profits (costs). As a result, bankers may unreasonably invest in ESC, resulting in a loss of cost and profit efficiencies.

[58] In contrast to the SCP paradigm, which assumes the intensity of the competition (i.e. how fiercely market participants would compete to acquire customers) would be low in highly concentrated markets, ES theory posits that efficient banks gain dominance in the market irrespective of intensity of competition (Shaffer, 2004).

There is a renewed interest in the structure and performance of European banks, especially after the severe underperformance of the sector during the GFC (Minviel & Ben Bouheni, 2021), which resulted in bailouts costing E.U. member states more than 4.8 trillion euros[59] (see European Commission, 2012). The report from the European Banking Federation (2018) outlines the reduction in the number of CI in the E.U. since 2008 and raises the question, "Should the oligopolistic structure of the banking sector be a concern for regulators?" (Dalla & Varelas, 2019). Banks in the union engage in non-price quality competition through investments in branching (see Heggestad & Mingo, 1976; Scott, 1978; White, 1976), advertising (e.g. Pinho, 2000), and technology (e.g. Koetter & Noth, 2013) to gain market power and maintain the concentrated structure of their respective markets. Thus, analysing the drivers of ESC investments will help uncover whether the ongoing increase in concentration in the European banking markets should be a concern for regulators or not.

While there is extensive literature exploring the impact of developments in the post-GFC era on the performance of E.U. banks, to the best of my knowledge, none of these studies explores the impact of ESC investments on E.U. banks' performance. The present research addresses this void and makes a few critical contributions to the banking literature.

First, following the GFC and subsequent Eurozone debt crisis, there is an increased emphasis on investigating the efficiency with which E.U. banks allocate resources (Matousek, Rughoo, Sarantis, & George Assaf, 2015; Minviel & Ben Bouheni, 2021). As ESC investments consume significant firm resources (Senyuta & Žigić, 2016), the study explores the impact of ESC investments on the cost and profit efficiencies of top E.U. banks, uncovering the strategic utility of such investments and their probable effect on the stability of the overall sector. In doing so, the study also unravels the drivers of such critical investments in quality.

[59] Based on the European Commission's State Aid Scoreboard: https://ec.europa.eu/competition-policy/state-aid/scoreboard_en

Second, efficiency literature primarily utilises standard models based on a two-step estimation technique. In the first step, observation-specific efficiency measures are estimated based on some firm characteristics, say x_i. In the second step, the index developed is regressed on a vector of exploratory variables z_i. Wang and Schmidt (2002) explain that a two-step approach is biased. According to the authors, if x_i and z_i are correlated, the estimations obtained in the first step are mis-specified (Kumbhakar et al., 2015). An appropriate solution to overcome the bias problem is to estimate efficiencies using a single-step procedure, which correctly specifies the distribution of output y given x and z. The present study presents robust results analysing the issue using both the conventional two-stage approach and the single-step stochastic frontier technique, supplementing the literature on bank efficiencies.

Next, section 4.2 reviews the critical literature on the efficiency of E.U. banks. Section 4.3 defines the variables of interest and explains the data, while section 4.4 outlines the methodology and discusses the results. Finally, section 4.5 offers concluding comments.

4.2 Literature Review

The banking literature extensively discusses the relationship between market structure (market concentration) and European banks' business performance (e.g. efficiency). This is because the basic principle of business activities assumes that banks' conduct will depend on the market structure, influencing their performance (Gavurova, Kocisova, & Kotaskova, 2017). The banking literature explores various attributes of European banks, establishing SCP, ES, or the QL paradigm. However, to the best of my knowledge, no research explains the drivers of ESC investments in the E.U. banking market. The following subsections summarise the critical literature in the context of E.U. banks under differing paradigms.

4.2.1 Structure–conduct–performance (SCP)

The relationship between market concentration and bank performance has traditionally been analysed within the scope of the SCP paradigm. The fundamental assertion of the SCP hypothesis is that, in more concentrated markets, banks set prices that are less favourable to consumers (higher loan rates and lower deposit rates) due to competitive imperfections (Berger, 1995a). In an early analysis, Molyneux and Thornton (1992) investigated asset-based returns of banks in 18 European countries. The authors found support for the expense-preference expenditure theories and established the traditional relationship between concentration and bank profitability (SCP) in the European markets. On similar lines, Molyneux and Forbes (1995) emphasised the application of the SCP paradigm, claiming that banking market concentration lowers the cost of collusion and results in higher profits for the European banks.

Similarly, analysing the Central and Eastern European banking markets, Yildirim and Philippatos (2007) detected a negative relationship between market concentration and efficiency. Additionally, the authors noted that foreign banks were more cost efficient but less profit efficient than their domestic competitors. In an analysis of 27 E.U. banking markets, using a panel Granger causality approach, Ferreira (2013) found negative causation running from concentration to efficiency and efficiency to concentration. In line with the SCP hypothesis, the author claims that banks operate inefficiently in concentrated markets since they face less competition.

The literature on credit availability to small firms extensively examines the relationship between concentration in E.U. banking markets and obstacles firms face in obtaining finance. Investigating the impact of bank competition on firm credit, Grandi and Bozou (2018) found that less competition adversely impacts credit availability, especially of smaller firms, in the euro area. The authors analysed a detailed firm–bank matched dataset and concluded that firms associated with banks with high market power are more credit constrained. Additionally, the authors found that smaller firms receive less short-term credit than larger firms for a given level of market power. The study supports the findings of Ryan, O'Toole, and McCann (2014), who analysed 20 European markets and concluded that increased market power results in increased financing constraints for small and medium enterprises (SMEs). Similar results were documented by Fungáčová, Shamshur, and Weill (2017), who suggest that an increase in the competition encourages banks to incur higher expenditure on soft information, which translates into a higher cost of credit in 20 European markets, especially for smaller enterprises.

However, in analysing banking markets in 19 European countries, Wang, Han, and Huang (2020) found mixed evidence. The authors found that banks' market power at disaggregate levels adversely impacts the lending of small firms. Nonetheless, according to the authors, market power facilitates more long-term lending to small firms, especially for informationally opaque firms, as they engage in relationship banking.

Analysing individual banking markets in Europe, studies have validated the SCP paradigm. For example, analysing the Italian banking market, Agostino and Trivieri (2010) submitted that firms receiving debt in less-competitive markets perform more poorly than firms obtaining loans in a more competitive market, indicating higher intermediation costs in concentrated markets. In the context of Austrian banking markets, Rumler and Waschiczek (2016) noted that disintermediation[60] and higher concentration positively influence bank profitability. Similarly, Nicolas (2021) finds that banks' market power increases the interest rate charged to small firms in the French banking market.

[60] The authors refer to disintermediation as a lower percentage of loans over total assets.

4.2.2 Efficient structure (ES)

A significant antagonist theory challenging the claims of the SCP paradigm is the ES hypothesis. This claims that differences in profit levels are attributable to differences in operational efficiency (Vennet, 2002). In an early assessment of the banking markets in 11 European countries, Goldberg and Rai (1996) failed to find any significant relationship between concentration and profitability and documented support for the ES hypothesis. In a subsequent study of the E.U. banking market, analysing the Second Banking Directive of 1989 (implemented between 1991 and 1994 by different member states of the E.U.), which resulted in the formation of financial conglomerates,[61] Vennet (2002) also found support for the ES hypothesis. The author noted that universal banks were more cost and profit efficient than their non-universal rivals, and operational efficiency was the critical determinant of bank profitability. On similar lines, analysing the E.U. banking market, Casu and Girardone (2006) investigated the period following the introduction of the *single banking licence*.[62] They found that increased competition compelled banks to become more efficient.

Similarly, analysing the determinants of profitability in eight major E.U. banking markets, Goddard, Liu, Molyneux, and Wilson (2013) found that, following the introduction of the euro, competition intensity increased in the region, eliminating excess profitability. Consistent with the ES hypothesis, the authors concluded that cost efficiency is a more important determinant of profitability than either concentration or market share. On similar lines, analysing 10 major banking markets in Europe, Schaeck and Cihák (2014) concluded that competition significantly

[61] Financial conglomerates are financial institutions that offer an entire range of services. Apart from offering traditional banking services, they also engage in selling insurance products, underwriting of securities, and carrying out securities transactions on behalf of clients (Vennet, 2002).

[62] The Second Banking Directive introduced the concept of a *single passport* in the E.U. banking market. It meant that a bank licensed to do business in any E.U. nation could freely operate in any other E.U. nation on whatever basis it considered most advantageous. Specifically, the host country could not impose any restrictions on the bank (please refer to Chapter 1 for details).

improves the banking sector's stability through the efficiency channel. The authors analysed pre-GFC data and suggested that competition incentivises banks to strengthen their cost efficiencies as competitive markets reallocate profits from unsuccessful banks to successful banks. In other words, "efficient banks pass the market test and survive, while weak banks shrink, sell out, and exit the market" (p. 235). Nonetheless, in a post-GFC analysis of the E.U. banking market, Dalla and Varelas (2019) confirm that increased market concentration triggered cost efficiencies due to economies of scope.

In a broader analysis of the European banking market, Claeys and Vander Vennet (2008) documented a negative relationship between efficiency and interest rate margins in the developed markets of Western Europe and accession countries (new members of the E.U.), but not in the non-accession countries. The authors claim that in the Western banking markets, banks pass benefits from better cost management to their customers in the form of better interest rate conditions. In contrast, large banks accrue scale economies in the accession countries, which they pass to their customers to gain market share. Similarly, in a comprehensive analysis of 27 E.U. banking markets, Andrieş and Căpraru (2014) establish that competition triggers cost and profit efficiencies. The authors find that gains in profit efficiencies were larger than cost efficiencies. They claim that increasing competition compels banks to diversify product portfolios and services and enter new markets with higher but riskier returns, improving their profit efficiencies.

Notably, some researchers document only a partial application of the ES hypothesis in the European banking market. For instance, analysing the Spanish banking market, Maudos (1998) found support for the *modified efficient structure hypothesis*, suggesting that even though efficiency is the most critical determinant of profitability, it is also impacted by banks' market share. Similarly, investigating major E.U. banking markets of France, Germany, Italy, Spain and the United Kingdom, Casu and Girardone (2009b) found limited evidence of the ES hypothesis. The authors found positive causation between market power and efficiency and rejected the QL hypothesis. However, they documented a weak causality running from efficiency to competition, and thus could not fully support the application of the ES hypothesis.

4.2.3 Quiet life (QL)

The QL hypothesis predicts a positive relationship between market power and bank inefficiency (Maudos & de Guevara, 2007). Originally tested in the U.S. banking market by Berger and Hannan (1998), the QL effect is associated with a higher cost per unit output in a concentrated market due to slack management. The authors suggest that in concentrated markets, the difference between the actual price and competitive price allows the management to consume a part of the additional profits in the form of a quiet life, in which they do not put full effort to minimise costs.

Delis and Tsionas (2009) analysed an unbalanced dataset from banking markets in the 11 members of the European Monetary Union (EMU)[63] and found significant evidence of the QL hypothesis. Applying a novel *local maximum likelihood* approach, the authors found a negative relationship between bank efficiency and market power.[64] Similarly, Gavurova et al. (2017) applied the panel Granger causality approach and detected a one-way causality running from performance to concentration in a comprehensive analysis of the E.U. banking market. Rejecting the SCP paradigm, the authors established that the negative relationship between concentration and performance confirms the QL hypothesis.

Researchers have documented the QL effect in several individual banking markets in Europe. For example, Coccorese and Pellecchia (2010) established that banks with market power were

[63] Note that there is a difference between EMU and E.U. Only 19 of the 27 E.U. member states form EMU. Countries in the EMU involve in coordinated economic and fiscal policy, adhere to a common monetary policy, and have a common currency – the euro.

[64] The authors also found partial support to the ES hypothesis as the findings suggest that the most efficient banks possess market power.

less efficient and confirmed the operation of the QL hypothesis in the Italian banking market. Nonetheless, assessing the interplay between efficiency and market power among German savings banks, Hackethal, Koetter, and Vins (2012) applied non-parametric graphical analysis and found limited evidence supporting the QL hypothesis. The authors offer an alternative explanation for loss in efficiency, suggesting that operational inefficiency may arise due to overconsumption of local inputs, as domestic savings banks use their freedom to promote the economy of their local region. Similarly, in testing the QL hypothesis in the Spanish banking market, Färe et al. (2015) highlight that prior studies assume a linear relationship between market power and efficiency. Applying flexible techniques, and after controlling ownership structure and business models, the authors establish that "quiet life" might be applicable only for a few financial institutions in the dataset. In an analysis of the Croatian banking market, Huljak (2015) detected a negative relationship between bank market power and efficiency and supported the QL hypothesis; however, the association between market power and bank efficiency was economically weak. Further, Řepková and Stavárek (2013) documented the causal relationship between competition and bank efficiency, supporting the QL effect in the Czech banking sector.

In a broader analysis, Maudos and de Guevara (2007), investigating 15 European markets, noted a positive relationship between market power and cost efficiencies of banks and rejected the QL hypothesis. Additionally, the authors suggested that welfare gains associated with reduced market power superseded the loss in the cost efficiency of banks and supported removing barriers to competition. Similarly, Casu and Girardone (2009b) documented positive causation between market power and efficiency, outright rejecting the QL hypothesis in the five major E.U. banking markets. Finally, in an analysis of seven Central and Eastern European banking markets, Andries (2011) also dismissed the QL hypothesis.

Notably, several competing studies document alternative explanations for bank performance or conduct in relation to the observed market structure. For instance, Ratti, Lee, and Seol (2008) and Fungáčová et al. (2017) established the application of the information hypothesis[65] (see Petersen & Rajan, 1995) in European economies in the context of firm lending and market concentration. Moreover, Csaba and Márton (2003) and Pawlowska (2016) established the relative market power (RMP)[66] argument (see Smirlock, 1985), analysing different European banking markets, establishing market power as a relevant determinant of bank profitability.

While the banking literature extensively evaluates the role of market structure in the performance and conduct of E.U. banks from varying perspectives, no study analyses the drivers of ESC investments in the sector. Since ESC investments consume significant resources of a firm, it is critical to evaluate the managerial motivation behind such critical outlays in quality. The present study fulfils this void in the existing literature and presents new insights into the competitive landscape of the E.U. banking market.

4.3 Data and Definition of Variables

Data on ESC variables is often missing from major databases and are thus required to be compiled manually. As annual reports of unlisted entities are hard to obtain and often not translated into English, only listed entities were considered in the present investigation. While the E.U. banking market is enormous, and thousands of CIs cater to consumers' deposit and financing needs, it is essential to note that small CIs are unlikely to engage in ESC competition

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[65] The information hypothesis argues that market power allows banks to forgo interest rate premiums from relatively opaque firms in lieu of establishing a relationship that enables them to extract informational rents in subsequent periods. Conversely, in competitive banking markets, as banks must break-even in each period, they hold risk-adjusted loan portfolios, charging higher interest rates to borrowers exhibiting greater uncertainty. Additionally, as banks cannot capitalise on the information advantage in a competitive environment, they are disincentivised to build relationships with borrowers (Ryan et al., 2014).

[66] The RMP hypothesis posits that only banks with large market share and well-differentiated products can exert market power in setting prices and extract economic profits (Claeys & Vander Vennet, 2008).

due to their limited resources (see Dick, 2007, p. 68). Instead, such firms target and operate in a small market or cater to the needs of a specialised segment (for instance, agriculture), often through competitive pricing and industry-specific expertise. Thus, for an effective evaluation of ESC in the E.U. banking market, the study filters the E.U. banking data. It investigates only banking firms classified as *universal commercial banks* with average equity, deposit, and lending of at least US$ 1 billion in the FitchConnect® database.

By specifying the size (US$ 1 billion), smaller banking firms, which are unlikely to engage in ESC competition, were dropped from the analysis. The study period has been carefully chosen to analyse the post-GFC period. The filtering process culminated in a final dataset of 34 sample banks from 13 E.U. member states[67] *(please refer to Appendix 4 for a complete list of sample banks)* for the period 2009–2018 (37 quarters).

To understand managerial conduct in selecting the level of ESC investments, cost (CES) and profit (PES) efficiencies of sample E.U. banks are calculated using the SFA approach. The precise derivation of CES and PES is detailed in section 3.4.1 (Chapter 3). Following the banking literature on ESC competition, the research investigates the effect of three ESC variables on the efficiency of sample banks: branching (Z_B) (see Cerasi et al., 1998, 2002; Cohen & Mazzeo, 2010; Dick, 2006), technology (Z_T) (see Barros, Berglöf, Fulghieri, & Vives, 2005; Jain & Gangopadhyay, 2020; Joseph & Stone, 2003; Vives, 2001), and advertising (Z_A) (see Dick, 2007; Martín-Oliver & Salas-Fumás, 2008). To estimate the joint impact of highly correlated ESC investments and overcome modelling challenges (please refer to Table 4.3 for correlation analysis), the study derives the variable ESC, using PCA, which is

[67] The research is data driven and I have not selected specific countries for the analysis. As banks under US$ 1 billion in market capitalisation, deposits and loans were dropped, smaller economies in the E.U. with a weak domestic financial system were not analysed. For instance, Swedbank (one of the sample banks incorporated in Sweden) is the largest bank in Estonia, an E.U. member country which has not been analysed in the study as none of its domestic banks were large enough to compete giant banking corporations from across the union.

a commonly used dimension-reduction technique. Section 3.4.2 (of Chapter 3) explains the utility and application of the procedure.

For a precise evaluation of the influence of ESC on CES and PES of sample banks, the study utilises bank-specific, industry-specific, and macroeconomic variables.[68]

Table 4.1 below defines each variable of interest and its source.

Table 4.1: Description of the Variables of Interest Utilised in the Empirical Analysis

Variables	Definitions	Data source
CES	Cost efficiency score of each sample bank. Detailed derivation in section 3.4.1 of Chapter 3	-
PES	Profit efficiency score of each sample bank. Detailed derivation in section 3.4.1 of Chapter 3	-
ESC	The main variable of interest represents the ESC investments of sample European banks. The variable has been derived by applying PCA on branching, advertising, and IT data. The detailed derivation of the variable is explained in section 3.4.2.	-
Z_A	Natural logarithm of advertising and marketing expense of sample European banks	FitchConnect, DataStream and annual reports
Z_B	Natural logarithm of the size of the branch network of sample European banks	FitchConnect, DataStream and annual reports
Z_T	Natural logarithm of investments in proprietary technology of sample European banks[69]	DataStream[70]

[68] Please refer to section 3.3 of Chapter 3 for a brief review of bank-specific, market-specific, and macroeconomic variables utilised in the present study.

[69] The European Parliament and the E.U. Council adopted Regulation 1606/2002/E.C. on 19th July 2002, mandating all listed companies (including banks) to prepare consolidated financial statements following International Financial Reporting Standards (IFRS) – starting 1st January 2005 (André, Dionysiou, & Tsalavoutas, 2018; ECB, 2005). The regulation triggered a significant change in the accounting of certain software assets, which were previously expensed or capitalised at the discretion of each firm. Under IFRS, internally developed software (proprietary technology) are capitalised and reported as intangible assets if i) it is probable that it will fetch future economic benefits to the enterprise, and ii) the item has a reliably measurable cost (André et al., 2018).

[70] The study utilises data field 'Intangibles, Net' from DataStream, which in the context of the banking industry includes i) capitalised software development costs, ii) capitalised R&D costs (if any), iii) costs associated with the acquisition of customer databases, and iv) acquired mortgage servicing rights. Notably, goodwill falls out of the definition of intangible assets given that it is a non-identifiable asset, without physical substance.

CS	The ratio of equity to total assets represents the capital strength of a bank	FitchConnect
LDR	The ratio of loans to deposits denotes banks' ability to transform deposits into loans	FitchConnect
CM	The ratio of non-interest expense to total assets represents cost management at banks	FitchConnect
HHI	A structural measure of market competition: Herfindahl–Hirschman index	European Central Bank (ECB) Database
GDPG	GDP growth	World Bank
INF	Rate of inflation	World Bank

Table 4.2 presents the descriptive statistics of the data utilised in the present research.

Table 4.2: Data Descriptive Statistics

Variables	Mean	Maximum	Minimum	Std. Dev.
CES	0.762	0.928	0.284	0.101
PES	0.606	1.013	-0.043	0.187
ESC	-0.001	4.422	-3.941	1.625
Z_A	3.316	6.640	-0.295	1.428
Z_B	6.776	9.671	3.095	1.257
Z_T	5.136	8.971	-0.134	1.979
CS	0.078	0.205	-0.056	0.031
LDR	1.039	3.571	0.386	0.413
CM	0.026	0.108	-0.021	0.014
HHI	0.070	0.260	0.011	0.035
GDPG	0.933	7.504	-10.491	2.943
INF	1.412	6.393	-1.808	1.523

Note: The abbreviations CES and PES stand for the cost and profit efficiencies of each sample bank. ESC denotes the sample banks' ESC investments. Z_A, Z_B, and Z_T represents advertising expense, size of the branch network, and investments in proprietary technology – the three ESC variables analysed in the study. CS, LDR, and CM are bank-specific factors representing capital structure, loan-to-deposit ratio, and cost management. HHI is the industry-specific feature capturing the effect of concentration through the Herfindahl–Hirschman index. GDPG and INF are the two macroeconomic factors controlling the impact of GDP growth and inflation on bank performance.

Table 4.3 below outlines the correlation between the variables of interest.

Table 4.3: Correlation Analysis

	CES	PES	ESC	Z_A	Z_B	Z_T	CS	LDR	CM	HHI	GDP	INF
CES	1.000											
PES	-0.447	1.000										
ESC	-0.131	0.219	1.000									
Z_A	-0.085	0.247	0.935	1.000								
Z_B	-0.144	0.195	0.901	0.759	1.000							
Z_T	-0.105	0.136	0.904	0.814	0.743	1.000						
CS	-0.113	0.165	-0.354	-0.302	-0.359	-0.335	1.000					
LDR	0.305	-0.304	-0.038	-0.158	0.042	0.009	-0.096	1.000				
CM	-0.463	-0.110	-0.062	-0.116	0.062	-0.139	0.294	-0.059	1.000			
HHI	-0.051	0.228	-0.146	-0.060	-0.206	-0.160	0.132	-0.069	-0.138	1.000		
GDPG	-0.110	0.274	-0.143	-0.046	-0.241	-0.115	0.349	-0.136	-0.076	0.084	1.000	
INF	0.098	-0.184	-0.084	-0.070	-0.040	-0.129	0.112	0.100	0.206	-0.100	-0.104	1.000

Note: The abbreviations CES and PES stand for the cost and profit efficiencies of each sample bank. ESC denotes the sample banks' ESC investments. Z_A, Z_B, and Z_T represents advertising expense, size of the branch network, and investments in proprietary technology – the three ESC variables analysed in the study. CS, LDR, and CM are bank-specific factors representing capital structure, loan-to-deposit ratio and cost management. HHI is the industry-specific feature capturing the effect of concentration through the Herfindahl–Hirschman index. GDPG and INF are the two macroeconomic factors controlling the impact of GDP growth and inflation on bank performance. Variables with high correlation are intentionally highlighted.

Section 3.3 of the thesis elaborates on the relevance and importance of variables used in evaluating bank performance. Notably, industry-specific and country-specific variables utilised in the current analysis are critical as they also capture the influence of varying significance of the financial sector across various banking markets investigated in the research.

While HHI reflects the competition intensity in each market analysed (Berger, 1995a), GDPG helps model the varying degree of credit demand in different economies (see Athanasoglou et al., 2008; Trujillo-Ponce, 2013). Further, as inflation causes the value of demand deposits and reserves to shrink (Perry, 1992), INF essentially outlines the demand for deposit services in different E.U. economies.

4.4 Methodology and Results

Similar to Chapter 3, the present study first engages a conventional two-step empirical approach to analyse the impact of ESC investments on the cost and profit efficiencies of European banks. In step one, sample banks' cost and profit efficiencies are derived using the SFA. A common problem in modelling economic relationships using panel datasets is the possibility that the cross-section units are interdependent at a given time period (Pesaran, 2021). Thus, in step two, I undertake cross-section dependence tests to determine the appropriate evaluation technique. The results (please refer to Table 4.6) detect cross-sectional dependence in residuals. Hence, the most appropriate approach to estimate the relationship between ESC investments and bank performance in the second step is the CS-ARDL technique proposed by Chudik and Pesaran (2015). The approach addresses the problem of the interdependence between cross-section units in panel datasets (Erülgen et al., 2020) and produces dependable results even in case of weak exogeneity (Okumus et al., 2021).

4.4.1 Stochastic frontier approach (estimation of cost and profit efficiencies)

The present study utilises the intermediate approach (IA) to select relevant input and output variables to estimate cost and profit efficiencies *(please refer to section 3.4.1.1 for a discussion about different methods and an explanation of the suitability of the IA approach)*. Following Hoang et al. (2020), the present analysis considers three inputs: full-time employees (l), total funding (f), and physical capital (k), and utilises their corresponding input prices, w_l, w_f, w_k in the estimations.[71] The relevant output (y) for the banking industry is their total earning assets. Table 4.4 below outlines the descriptive statistics for the three input, output, total cost (C) and profit (P) variables – used to estimate the cost and profit efficiencies of sample banks.

Since the sample banks have reported losses (negative profits) in some observed periods, applying the standard profit function is not feasible to measure profit efficiency. Following Chen and Lu (2021), the study thus defines the profit variable P as $\ln(PBT + \theta + 1)$, where PBT is profit before tax and θ is the absolute value of the minimum value of PBT over all sample banks.

Table 4.4: Descriptive Statistics of Variables used in Efficiency Estimations

Variables	Mean	Maximum	Minimum	Std. Dev.
w_l	10.82902	11.98782	9.280849	0.57253
w_f	-4.0122	-1.01376	-7.60284	0.74846
w_k	-3.82017	-1.16419	-7.53302	1.00522
y	11.03783	14.50558	7.050339	1.554
C	7.946707	11.14207	4.204413	1.51889
P	9.712566	10.38717	0	0.46324

Note: The abbreviations wl, wf, and wk are the natural logarithmic form of the price of three input variables: labour, funding, and physical capital, respectively. Abbreviation y denotes the natural logarithmic form of sample banks' total earning assets. C and P refer to the total cost and profit of sample banks.

[71] Following Hoang et al. (2020), price of labour (w_l) is measured by total wage cost over the number of employees; price of funding (w_f) is measured by total interest expense over total bank funding; and price of physical capital (w_k) is measured by total depreciation and other capital expenses over total non-earning assets.

As detailed in section 3.4.1.2, the present research utilises an input-oriented translog frontier function to estimate sample E.U. banks' cost and profit efficiencies. As a result, the reduced translog stochastic cost frontier is given as:

$$\ln C_i = \beta_0 + \sum_j \beta_j \ln w_{j,i} + \beta_y \ln y_i + \frac{1}{2}\sum_j \sum_k \beta_{jk} \ln w_{j,i} + \frac{1}{2}\beta_{yy} \ln y_i \ln y_i + \sum_j \beta_{jy} \ln w_{j,i} \ln y_i + v_i + \eta_i \quad (4.1)$$

The price homogeneity condition is imposed in the model by using $w_{j,i}$ for an arbitrary choice of j and normalise C_i and other input prices by it (Kumbhakar et al., 2015). The price of funding (w_f) is used for normalising total cost and prices. Thus, after incorporating price homogeneity restrictions, the cost efficiencies for sample banks are estimated as:

$$\ln\left(\frac{C}{wf}\right)_i = \beta_0 + \beta_y \ln y_i + \beta_l \ln\left(\frac{wl}{wf}\right)_i + \beta_k \ln\left(\frac{wk}{wf}\right)_i + \frac{1}{2}\beta_{yy} \ln y_i \ln y_i + \frac{1}{2}\beta_{ll} \ln\left(\frac{wl}{wf}\right)_i \ln\left(\frac{wl}{wf}\right)_i + \frac{1}{2}\beta_{kk} \ln\left(\frac{wk}{wf}\right)_i \ln\left(\frac{wk}{wf}\right)_i + \beta_{lk} \ln\left(\frac{wl}{wf}\right)_i \ln\left(\frac{wk}{wf}\right)_i + \beta_{ly} \ln y_i \ln\left(\frac{wl}{wf}\right)_i + \beta_{ky} \ln y_i \ln\left(\frac{wk}{wf}\right)_i + v_i^C + \eta_i^C \quad (4.2)$$

The analysis results indicate that, on average, during the period of analysis (2009Q1–2018Q1), sample E.U. banks operated with a cost efficiency of 0.76.

For the profit function, I replace C and the composed error of the model: $v_i^C + \eta_i^C$ in eq. 4.2 above with P and $v_i^P - \eta_i^P$ (see Kumbhakar et al., 2015; Vu & Turnell, 2011). The reduced translog stochastic profit function is given as:

$$\ln P_i = \beta_0 + \sum_j \beta_j \ln w_{j,i} + \beta_y \ln y_i + \frac{1}{2}\sum_j \sum_k \beta_{jk} \ln w_{j,i} + \frac{1}{2}\beta_{yy} \ln y_i \ln y_i + \sum_j \beta_{jy} \ln w_{j,i} \ln y_i + v_i - \eta_i \quad (4.3)$$

Finally, the price homogeneity condition is imposed by using the price of funding (w_f) to normalise total profit (P) and other input prices. The profit efficiencies of sample E.U. banks are estimated as:

$$\ln\left(\frac{P}{wf}\right)_i = \beta_0 + \beta_y \ln y_i + \beta_l \ln\left(\frac{wl}{wf}\right)_i + \beta_k \ln\left(\frac{wk}{wf}\right)_i + \frac{1}{2}\beta_{yy}\ln y_i \ln y_i + \frac{1}{2}\beta_{ll}\ln\left(\frac{wl}{wf}\right)_i \ln\left(\frac{wl}{wf}\right)_i + \frac{1}{2}\beta_{kk}\ln\left(\frac{wk}{wf}\right)_i \ln\left(\frac{wk}{wf}\right)_i + \beta_{lk}\ln\left(\frac{wl}{wf}\right)_i \ln\left(\frac{wk}{wf}\right)_i + \beta_{ly}\ln y_i \ln\left(\frac{wl}{wf}\right)_i + \beta_{ky}\ln y_i \ln\left(\frac{wk}{wf}\right)_i + v_i^C - \eta_i^C \quad (4.4)$$

The results suggest that the sample banks operated on average with a profit efficiency of 0.61. In an early evaluation of cost and profit efficiencies of banks in 10 E.U. member states, Maudos, Pastor, Pérez, and Quesada (2002) noted similar trends and documented lower levels of profit efficiency as compared to cost efficiency levels.

4.4.2 Panel unit root test

CS-ARDL is an efficient technique to estimate variables that are stationary at I(0), I(1), or a mixture of the two, but not I(2) (Ahmed, 2020). Thus, it is critical to establish that all the variables assessed in the model are stationary at either level or the first difference.

Following recent studies that utilise the CS-ARDL approach in empirical analysis (see Ahmed, 2020; Erülgen et al., 2020; Noureen, Iqbal, & Chishti, 2022; Okumus et al., 2021), the current paper engages the two most common panel unit root techniques. The first is the test proposed by Im et al. (2003) (IPS), and the second is the cross-sectional augmented Im-Pesaran-Shin (CIPS) test proposed by Pesaran (2007). The CIPS test has a few advantages and is thus commonly applied in CS-ARDL studies. Primarily, it accommodates panel heterogeneity and allows for possible cross-sectional correlations (Ahmed, 2020). Both tests have the null hypothesis that all panel series are non-stationary.

Table 4.5 below outlines the panel unit root test results. Notably, the CIPS test indicates that PES, CS, HHI, and INF are stationary at level, while CES, ESC, LDR, CM, and GDPG are stationary at first difference. The IPS test suggests that CS and INF are stationary at level, while CES, PES, ESC, LDR, CM, HHI, and GDPG are stationary at first difference. Overall, the test results confirm that the variables are stationary at I(0) or I(1), but not I(2).

Table 4.5: Panel Unit Root Tests Results

Variables	CIPS		IPS	
	Level	1st difference	Level	1st difference
CES	-2.081*	-3.176***	4.01173	-7.136***
PES	-2.528***	-3.897***	3.1234	-16.351***
ESC	-0.663	-2.241**	1.50309	-8.754***
CS	-2.216**	-2.977***	-1.754**	-9.061***
LDR	-1.814	-3.736***	-0.93274	-16.139***
CM	-2.026	-3.630***	-1.388*	-9.180***
HHI	-2.640***	-4.200***	6.60756	-11.603***
GDPG	-1.986	-4.631***	2.32407	12.216***
INF	-3.234***	-4.713***	-3.679***	-8.747***

Note: *** indicates significance at the 1% level; ** indicates significance at the 5% level; and * indicates significance at the 10% level. Lag lengths were determined by the Schwarz information criterion (SIC). PES and CES are the profit and cost efficiency scores derived using the SFA approach. ESC denotes the ESC investments of sample banks, derived using the PCA approach. CR, CM, and CS are the bank-specific factors, namely credit risk, cost management, and capital structure. HHI refers to the industry-specific factor: Herfindahl–Hirschman index (HHI). Finally, GDPG and INF are the two macroeconomic variables representing GDP growth and inflation rate.

4.4.3 Cross-sectionally augmented ARDL (CS-ARDL)

According to Westerlund (2007), Panel-ARDL estimation techniques are relevant in studies in which the time-series dimension of the panel is relatively larger than the cross-sectional dimension (T > N), and such is the case in the current analysis. Conventionally, P-ARDL has been the most commonly applied technique to estimate panel datasets with different orders of integration in the variables. The P-ARDL approach collectively accounts for the slope heterogeneity (Erülgen et al., 2020). According to Phillips and Sul (2003), if the cross-section correlations in the errors are ignored, the results could be inaccurate. Thus, the study examines the correlation in residuals of the basic models to select an appropriate estimation technique.

Table 4.6 outlines the cross-section dependence test results.

Table 4.6: Cross-Section Dependence Test

Test	Model-1: CES	Model-2: PES
Breusch-Pagan LM	2645.039***	2745.704***
Pesaran scaled LM	68.232***	71.428***
Pesaran CD	-2.964***	-1.042

Note: *** indicates significance at the 1% level; ** indicates significance at the 5% level; and * indicates significance at the 10% level.

The results in Table 4.6 reject the null hypothesis of no correlation in residuals; thus, P-ARDL is not suitable for the current analysis. Therefore, the present study employs the CS-ARDL approach. Initially proposed by Pesaran and Smith (1995), and further enhanced by Chudik and Pesaran (2015), the CS-ARDL technique involves augmenting the set of variables on the right-hand side with the cross-sectional averages of the dependent variable, regressors, and a series of their lagged values. These additional terms address the "cross-sectional correlation in the error term" (Erülgen et al., 2020). As the CS-ARDL technique takes into consideration time dynamics, cross-sectional heterogeneity, and cross-sectional dependence (Ahmed, 2020; Noureen et al., 2022), and produces dependable results even in the case of weak exogeneity (Okumus et al., 2021), it is the most suitable approach for the current analysis.

Eq. 4.3 below outlines the postulated CS-ARDL estimation utilised in the current analysis (please refer to sections 3.4.4 and 3.4.5 for additional details about the CS-ARDL approach).

$$\Delta y_{it} = \mu_i + \alpha_i\left(y_{i,t-1} - \theta_i' x_{i,t-1} + \alpha_i^{-1} n_i \bar{y}_t + \alpha_i^{-1} y_i' \bar{x}_t\right) + \sum_{j=1}^{p-1} \emptyset_{ij}\, \Delta y_{i,t-j} +$$
$$\sum_{j=0}^{q-1} \delta_{ij} \Delta x_{i,t-j} + \sum_{j=0}^{p-1} v_{ik} \Delta \bar{y}_{t-j} + \sum_{j=0}^{q-1} y_{ik} \Delta \bar{x}_{t-j} + \qquad (4.5)$$

where in Model-1, y_{it} is the cost efficiency scores (CES) derived from eq. (4.2) and x_{it} is a vector of explanatory variables; ESC investments (ESC), cost management (CM), capital structure (CS), loan-to-deposit ratio (LDR), the measure of market competition, Herfindahl–Hirschman index (HHI), GDP growth (GDPG) and the rate of inflation (INF). The notations $\bar{y}_t$ and $\bar{x}_t$ in eq. 4.5 represent the cross-section average of y_{it} and x_{it}. The short- and long-term behaviour of the cross-sectional correlation are distinguished. Consistent with the suggestion of Eberhardt and Presbitero (2015), only the level parts of the cross-sectional averages are included in the long-term equilibrium relationship in parentheses. The main coefficients of interest are: α_i, the rate of adjustment back to equilibrium; and θ_i', the long-run coefficient associated with y_{it} and x_{it}. The short-run coefficients are denoted by $\emptyset_{ij}$ and δ_{ij} (Erülgen et al., 2020). While, in Model-2, only the CES is replaced by profit efficiency scores (PES) as the dependent variable.

Table 4.7 below outlines the results from the CS-ARDL estimations, analysing the impact of ESC and other bank-specific, industry-specific, and macroeconomic factors on the CES (Model-1) and PES (Model-2) of the sample E.U. banks. To establish cointegration, the error correction term (ECT) coefficient must be negative, statistically significant, and less than 2 (Erülgen et al., 2020; Shaari et al., 2020). The results in Table 4.7 show that the ECT is negative for both Model-1 (-0.182) and Model-2 (-0.216) and statistically significant at a 1 per cent level of significance. These results confirm stable long-run cointegration among the variables.

Endogenous sunk cost investments (ESC)

The results in Table 4.7 suggest that, in the long run, ESC investments adversely impact CES, but have a positive influence on the PES of sample E.U. banks. The results are statistically significant at 1 per cent and indicate that a percentage increase in ESC hurts CES by 0.076 per cent; however, it improves PES by 0.215 per cent. The current results contradict the findings of Chapter 3, where the model(s) detected a negative influence of ESC on the CES[72] and PES of Australian banks. The short-run results in Table 4.7 reflect trends contrary to long-run effects.

[72] The results for CES in Chapter 3, analysing the Australian banks were statistically insignificant.

Table 4.7: Panel CS-ARDL Results

PMG estimator	**Model-1: CES**	**Model-2: PES**
Error correction term		
ECT	-0.182***	-0.216***
Long-run estimates		
Independent variables	**Coefficient**	**Coefficient**
ESC	-0.076***	0.215***
CM	-7.212***	-1.454
CS	-1.402***	3.387*
LDR	0.089**	-0.017
HHI	3.330***	-4.923
GDPG	-0.002	-0.018**
INF	0.009***	-0.032***
Short-run estimates		
Independent variables	**Coefficient**	**Coefficient**
ΔESC	0.019	-0.151
ΔCM	-4.417**	-4.846
ΔCS	0.262	2.718
ΔLDR	0.005	-0.090
ΔHHI	0.924	0.606
ΔGDPG	-0.002*	0.001
ΔINF	0.001	-0.002

Note: *** indicates significance at the 1% level; ** indicates significance at the 5% level; and * indicates significance at the 10% level. The lag lengths were determined by the Schwarz information criterion (SIC). PES and CES are the profit and cost efficiency scores derived using the SFA approach. ESC denotes the ESC investments of sample banks, derived using the PCA approach. CR, CM, and CS are the bank-specific factors, namely credit risk, cost management, and capital structure. HHI refers to the industry-specific factor: Herfindahl–Hirschman index. Finally, $GDPG$ and INF are the two macroeconomic variables representing GDP growth and inflation rate.

However, the estimates are not of statistical significance. The research hypothesised that if the ES argument is valid in the context of the E.U. banking market, banks would strategically select investments in ESC to improve their cost efficiencies. Nonetheless, the results in Table 4.7 indicate that investments in ESC negatively impact CES; thus, the ES hypothesis is rejected in the E.U. banking market.

Alternatively, it was hypothesised that managers might overinvest in ESC to maintain and gain market power and subsequently consume part of the economic rents, which would have negatively affected both the cost and profit efficiencies of the E.U. banks. However, the results reject the QL effect in the E.U. banking market as ESC positively impacts PES in the long run.

The findings in Table 4.7 support the SCP paradigm, indicating that managerial conduct in selecting ESC outlays is governed by their desire to gain market power. In doing so, they hurt their cost efficiencies (CES) but can improve their profit efficiencies (PES). These results are close to the findings of Molyneux and Thornton (1992). In an early analysis of the European banking market, the authors established the SCP paradigm, detecting a positive and significant relationship between market concentration and profitability alongside *expense-preference behaviour* (see Hannan, 1979).

Bank-specific factors

As expected, Model-1 detects a strong negative and statistically significant impact of CM on CES of banks, both in the long (at 1 per cent of significance) and short run (at 5 per cent of significance). CM is the ratio of non-interest expense to total assets and captures managerial inefficiencies in controlling administrative expenses (Vu & Turnell, 2011). Results suggest that a percentage increase in CM is associated with a 7.212 (4.417) per cent decline in the CES of sample banks in the long (short) run. Notably, the influence of CM on PES, though negative, is statistically insignificant both in the long and short run.

The estimations for capital structure (CS) support the findings of Altunbas, Carbo, Gardener, and Molyneux (2007). Results suggest that a percentage increase in CS is associated with 1.402 per cent (3.387 per cent) decline (improvement) in CES (PES) of sample banks in the long run. The results are statistically significant at a 1 per cent (10 per cent) level of significance for Model-1 (Model-2). The study's findings are consistent with the argument that maintaining a high level of capital impedes banks' ability to compete because equity is more costly than debt (Schaeck & Cihák, 2012). However, as better capitalisation alleviates agency problems between shareholders and managers (Chortareas, Girardone, & Ventouri, 2012), well-capitalised banks operate at better profit efficiency.

Results in Table 4.7 suggest a positive (negative) impact of loan-to-deposit ratio (LDR) on CES (PES) of sample banks. LDR represents the ability of banks to transform deposits into loans. The findings are reasonable because a higher ratio of loans to deposits means that a bank utilises inputs more productively (Vu & Turnell, 2011). However, as LDR also serves as a core indicator of liquidity mismatch, banks with high LDR may face a funding gap, resulting in high dependence on market funding, which can be more volatile than retail funding (Van den End, 2016). Thus, a higher LDR can positively impact CES of banks while diminishing their PES. Estimates suggest that a percentage increase in LDR is associated with a 0.089 per cent improvement in CES (statistically significant at 5 per cent level of significance) but has a mild negative impact of 0.017 per cent on PES (statistically insignificant) of E.U. banks. Short-run results suggest similar trends but are statistically insignificant.

Industry-specific factors

The study uses the HHI to account for industry-specific conditions. The results in Table 4.7 contradict the findings of prior studies on the European banking market (Andrieş & Căpraru, 2014; Ferreira, 2013; Fiordelisi et al., 2011; Schaeck & Cihák, 2014), indicating that banks in the concentrated markets operate with greater efficiency. Prior studies mostly utilise pre-GFC or dated datasets, which may be the reason for the significant deviation in the current analysis findings. Estimates suggest that a 1 per cent increase in HHI is associated with a 3.330 per cent increase in CES (statistically significant at 1 per cent). Notably, the system detects a negative impact of HHI on PES; however, the results are statistically insignificant. The efficient structure hypothesis explains the findings in Table 4.7. In competitive markets, firms dominate not through market power but by improving their cost efficiencies, which allows them to set lower (higher) loan (deposit) rates and seize market share from their less-efficient rivals (Demsetz, 1973; VanHoose, 2017). Thus, banks in the E.U. markets with higher HHI operate at a higher cost efficiency, which reflects in the estimates of Model-1. However, these cost savings do not translate into higher profitability, possibly because banks price their products competitively to maintain market dominance.

Macroeconomic factors

The results suggest that GDPG has a mildly negative impact on the cost efficiencies of sample banks only in the short run, and a 1 per cent increase in GDPG is associated with a 0.002 per cent decline in CES (statistically significant at 10 per cent level of significance). For Model-2, the estimates contradict the findings of Petria, Capraru, and Ihnatov (2015) and suggest that GDPG negatively impacts the PES of E.U. banks in the long run. The results in Table 4.7 indicate that a 1 per cent increase in GDPG is associated with a 0.018 per cent decline in PES of sample banks. The long-run effects for Model-2 are statistically significant at a 5 per cent level of significance. The results partly support the findings of Chortareas et al. (2012). They claim that banks operating in the E.U. were less efficient in controlling costs in expanding markets, which resulted in lower efficiency.

Finally, the estimates in Table 4.7 suggest that inflation (INF) positively (negatively) influences the CES (PES) of E.U. banks in the long run. Notably, the short-run coefficients are negligible and statistically insignificant. The results indicate that a percentage increase in INF is associated with a 0.009 per cent improvement in CES; however, it adversely impacts PES by 0.032 per cent. The results for Model-2 support the findings of Koutsomanoli-Filippaki, Mamatzakis, and Staikouras (2009), who documented a negative relationship between high inflationary trends and the profit efficiency of E.U. banks. According to Uhde and Heimeshoff (2009), inflation influences interest rates, impacting banks' asset quality and thus profitability.

Results indicate that an increase in inflation adversely affects the quality of bank assets in the E.U., which results in lower PES in the long run. Further, using a confidential dataset of ECB macroeconomic quarterly projections, Granziera, Jalasjoki, and Paloviita (2021) found that ECB tends to underpredict (overpredict) inflation when inflation is above (below) its target. The inefficiency in the ECB inflation forecast may adversely affect banks' ability to factor risk appropriately in pricing their loans, hurting their PES in the long run.

4.4.3 Stochastic frontier estimation: Translog half-normal model with heteroscedasticity

The estimations in Table 4.7 are derived using the conventional two-step procedure. In the first step, observation-specific cost and profit efficiencies are estimated (as detailed in 4.4.1). Later, in the second step, the CS-ARDL technique is employed to assess the effect of a vector of deterministic variables on bank efficiencies (calculated in the first step). The two-step procedure has long been recognised as biased. The exclusion of correlated variables, which are hypothesised to impact firms' efficiency, results in model mis-specification (Battese & Coelli, 1995) and prejudiced results (Wang & Schmidt, 2002). A suitable solution to overcome the undesirable statistical properties of the two-step procedure is the single-step procedure,[73] which estimates the parameters of the relationship between efficiency and key explanatory variables collectively (Kumbhakar et al., 2015).

For a precise estimation of the effect of ESC investments on the cost and profit efficiencies of sample E.U. banks, the study employs the single-step approach proposed by Kumbhakar et al. (2015). Besides modelling the impact of ESC on CES and PES in a single estimation, the

[73] Initially, the one-step procedure for investigating inefficiency was introduced in the context of truncated-normal models by Kumbhakar, Ghosh, and McGuckin (1991) and Reifschneider and Stevenson (1991). Later, Huang and Liu (1994) and Battese and Coelli (1995) introduced models with a similar algebraic form for the pre-truncated mean function of u_i. However, its application to the half-normal model is relatively straightforward and easy to apply (Kumbhakar et al., 2015).

technique will also allow independent evaluation of the impact of highly correlated ESC factors: advertising (Z_A), branching (Z_B), and information technology (Z_T) on the CES and PES of sample banks in a single estimation.

A cost frontier model with a normal distribution v_i and a half-normal distribution of η_i is represented as (bank subscript i omitted):

$$\ln C^a = \ln C^*(w, y) + \eta + v \tag{4.6}$$

$$= \ln C^*(w, y) + \in \tag{4.7}$$

where $\in \equiv v + \eta$ is the composed error of the model.

$$\eta \sim N^+(0, \sigma_u^2) \tag{4.8}$$

$$v \sim N(0, \sigma_v^2), \tag{4.9}$$

A single-step approach estimates the influence of correlated deterministic variables by parameterising the distribution function of η (in eq. 4.8), which is assumed to follow a half-normal distribution as a function of Z_i – a vector of ESC factors: Z_A, Z_B, and Z_T and ESC[74] in the present study.[75]

The corresponding log-likelihood function for observation i is:

$$L = -\ln\left(\frac{1}{2}\right) - \frac{1}{2}\ln(\sigma_u^2 + \sigma_v^2) + \ln\phi\left(\frac{-\in}{\sqrt{\sigma_u^2+\sigma_v^2}}\right) + \ln\phi\left(\frac{\mu_*}{\sigma_*}\right) \tag{4.10}$$

where, $$\mu_* = \frac{\sigma_u^2 \in}{\sigma_u^2+\sigma_v^2}, \tag{4.11}$$

[74] The variable derived using the PCA approach.
[75] $\eta_i = \delta Z_i + \xi_i$, where Z_i is a vector of ESC factors: Z_A, Z_B, and Z_T and ESC, δ is a vector of unknown parameters to be estimated, and ξ_i represents a random variable.

$$\sigma_*^2 = \frac{\sigma_u^2\sigma_v^2}{\sigma_u^2+\sigma_v^2} \tag{4.12}$$

It is important to note that by simply replacing $-\in$ with $\in$ in (4.6) above, the log-likelihood function can be easily obtained for the profit frontier model (Model-2[a]). This is true for models with alternative distribution assumptions and also for the model statistics such as $E(u|\in)$, $E(e^{-u}|\in)$, the associated confidence intervals, and the marginal effects (Kumbhakar et al., 2015). The effect of Z_i on efficiency of sample banks will be captured by σ_u^2 in (4.10) above.

If the banks are fully efficient (i.e., $\eta_i = 0$), the model reduces to an OLS. The LR test (which follows a mixed Chi-square distribution) tests the null hypothesis of no technical inefficiency. Comparing the log-likelihood of the ordinary least squares (OLS) model to that of the half-normal model, the null hypothesis of no technical inefficiency is rejected at a 1 per cent significance level.

Table 4.8 below outlines the stochastic frontier cost (Model-1[a]) and profit (Model-2[a]) estimations for sample E.U. banks, using the single-step approach of Kumbhakar et al. (2015), which assesses the impact of Z_A, Z_B, Z_T, and ESC by modelling them as exogenous determinants of inefficiency.

Table 4.8: SFA: Half-Normal Model with Heteroscedasticity

Exogenous determinant of inefficiency	**Model-1[a]: CES**	**Model-2[a]: PES**
	Coefficient	**Coefficient**
ESC	1.0695***	-0.2930***
Z_A	-0.0110***	-0.0080***
Z_B	0.0003***	0.0005***
Z_T	-0.0005***	0.0005***

Note: *** indicates significance at the 1% level; ** indicates significance at the 5% level; and * indicates significance at the 10% level. PES and CES are the profit and cost efficiency scores. ESC denotes the ESC investments of sample banks, derived using the PCA approach. Z_A is advertising ESC investments, Z_B refers to the branching network in each period, and Z_T denotes investments in proprietary technology by sample banks.

The results in Table 4.8 suggest that the coefficient of ESC, Z_A (advertising), Z_B (branching), and Z_T (IT) are statistically significant at 1 per cent for Model-1^a and Model-2^a. However, it is essential to note that the coefficient does not reflect the marginal effect of Z_i on the mean and the variance of inefficiency. The observations' specific estimates of the efficiency index exp $(-u_i)$ and the marginal effect of Z_i in the models estimated above are derived following Battese and Coelli (1988) as:

$$E[\exp(-u_i) \mid \in_i] = \exp\left(-\mu_{*i} + \frac{1}{2}\sigma_*^2\right)\frac{\Phi\left(\frac{\mu_{*i}}{\sigma_*} - \sigma_*\right)}{\Phi\left(\frac{\mu_{*i}}{\sigma_*}\right)}, \tag{4.13}$$

where, μ_{*i} and σ_* are defined in (4.11) and (4.12) above. The maximum likelihood estimates of the parameters are substituted into the equation to obtain point estimates of exp $(-u_i)$.

Table 4.9 below outlines the marginal effect of Z_i on CES and PES of sample E.U. banks and on the variance of technical efficiency.

Table 4.9: Marginal Effect of $\boldsymbol{Z_i}$

Exogenous determinant of inefficiency	**Model-1^a: CES**		**Model-2^a: PES**	
	Inefficiency	**Variance**	**Inefficiency**	**Variance**
ESC	0.13284	0.04908	-0.08262	-0.10325
Z_A	-0.00136	-0.00050	-0.00225	-0.00282
Z_B	0.00003	0.00001	0.00014	0.00017
Z_T	-0.00006	-0.00002	0.00015	0.00019

Note: PES and CES are the profit and cost efficiency scores. ESC denotes the ESC investments of sample banks, derived using the PCA approach. Z_A is advertising ESC investments, Z_B refers to the branching network in each period, and Z_T denotes investments in proprietary technology by sample banks.

Interestingly, the results in Table 4.9 confirm the findings from the CS-ARDL estimations (Table 4.7). The positive (negative) marginal effect of ESC on CES (PES) implies that increasing investments in ESC by E.U. banks results in lower (higher) cost (profit) efficiencies. Results from Model-1^a and Model-2^a also offer insights into the impact of investments in different forms of ESC (advertising, branching, and technology) on sample banks' cost and profit efficiencies. Notably, advertising (Z_A) investments are associated with improved CES and PES, while the expansion of the branching network (Z_B) adversely impacts both cost and profit efficiencies of sample banks. Finally, the effect of developing proprietary technology (Z_T) positively influences CES, but adversely impacts PES of sample banks.

4.5 Conclusion

Following the enactment of the Second Banking Directive in 1993, banking markets in the member states of the E.U. witnessed a series of reforms aimed at deregulating the banking industry. As the banking sector in the region progressed towards full integration, the regulators in the member states minimised control over domestic markets, relying on market forces to determine its structure (Cerasi et al., 1998, 2002). However, the GFC uncovered several systemic weaknesses amongst E.U. banks (Arghyrou & Kontonikas, 2012; Lane, 2012). Following the crisis, governments across the union were forced to bail out banking institutions and provide guarantees and capital to avert a systemic collapse (Hahn, Momtaz, & Wieandt, 2022). The expected volume of the *rescue package* pumped into the E.U. banking system during the crisis years is over 4 trillion euros (European Commission, 2012; Matousek et al., 2015). Given the extent of the damage, "never again" was the collective determination of the governments,[76] and regulations concerning supervision, capital requirements, and leverages were re-introduced to restore stability and avoid any similar bailouts in the future (Hahn et al., 2022).

Following the re-regulation of the sector, the ongoing concentration has increased in the E.U. banking markets at an alarming rate (Dalla & Varelas, 2019). As banks engage in ESC

[76] G-20 meeting in Pittsburgh (2009) and the White House "Remarks by the President at G20 Closing Press Conference" (25th September 2009).

competition to gain market share and navigate the structure towards a concentrated one, the present study explores the motives of such investments through an analysis of the effect of ESC investments on sample banks' cost and profit efficiencies.

The present study first utilises a conventional two-step approach to investigate the impact of ESC investments on sample banks' cost and profit efficiencies. Using the CS-ARDL technique proposed by Chudik and Pesaran (2015), the study concludes that, in the long run, ESC investments negatively impact the cost efficiencies of E.U. banks; however, they improve the profit efficiencies of the sample banks. Results in Table 4.7 suggest that a 1 per cent increase in ESC reduces (improves) CES (PES) by 0.076 (0.215) per cent.

In an early analysis of the European banking market, Molyneux and Thornton (1992) concluded the operation of the SCP paradigm established expense-preference theory alongside a positive influence of market concentration on bank profitability measures. The current research results are similar, indicating that the SCP paradigm best explains managerial conduct in selecting ESC investments. Results suggest that managers use ESC investments strategically to gain an advantage over rivals and corner market share. While the strategy results in lower cost efficiencies, they gain market power, which allows them to improve their profit efficiencies.

To confirm my results obtained from the two-step CS-ARDL estimation process, I utilised a single-step efficiency measure to investigate the influence of ESC investments on the cost and profit efficiencies of E.U. banks. The approach offers robust results and overcomes the limitations of the two-step process, which, although widely used in efficiency literature, is deemed biased (see Kumbhakar et al., 2015; Wang & Schmidt, 2002). Additionally, the single-step estimation technique allows me to assess the impact of three different forms of ESC investment on the cost and profit efficiencies individually.

Interestingly, the single-step estimation in Table 4.9 confirms the results obtained by applying the CS-ARDL technique in section 4.4.3. The results suggest that ESC investments increase (decrease) cost (profit) inefficiency. Additionally, the results indicate that advertising (Z_A) investments of sample banks are associated with improved cost and profit efficiencies, while branching (Z_B) hurts both costs as well as profit efficiencies of European banks. Finally, investments in technology (Z_T) produce mixed results, negatively affecting cost efficiencies but positively impacting profit efficiencies of sample banks.

There are growing concerns about concentration in the E.U. banking market and its possible impact on the sector's stability (European Banking Federation, 2018), which is still recovering from the jolts of the GFC and the recent Covid-19 crisis. However, the study finds that the ongoing concentration is not accidental but a strategic outcome of managerial conduct. Managers are tactically investing in quality to improve their market share, enabling them to improve their profitability.

While the study presents a unique insight into managerial motivation in selecting ESC investments, the present study has one notable limitation. Prior studies have noted differences in the regulatory and competitive environment between developed and developing E.U. member states. The present study does not analyse the influence of ESC investments in different market segments within the E.U. Additionally, the results for investment in technology (Z_T) produce a confusing outcome. It impacts the profit efficiencies positively but hurts the bank's cost efficiencies. There are possibilities of a non-linear relationship between investments in technology and bank performance, which demands further investigation.

CHAPTER 5: Understanding the Paradox of Technology for Banks' Profitability: The Threshold Effect Investigation

Chapter 4 highlighted the impact of different ESC investments on E.U. banks' cost and profit efficiencies. Notably, while advertising (branching) reflects a clear positive (negative) effect on bank performance, results for technology are somewhat confusing. Although technology has made radical changes in the banking and financial sectors, puzzling paradoxes mar its impact on bank performance. Chapter 5 uses the panel threshold effect to evaluate the precise impact of technology on bank performance through its intermediation with advertising and branching, presenting a new insight into evaluating technology sunk cost investments.

5.1. Introduction

In their 1998 book, *Information Rules: A Strategic Guide to the Network Economy* – widely recognised as an indispensable guide to the new economy – Shapiro and Varian (1998) wonder whether the digital revolution is a game-changer in economic science, so that economic science should reconsider its "concepts, its paradigm, and its methods" to be able to explain the changes in the economic world. With rapid changes in technology, information economics seems to have impacted the economic paradigm. The importance of fixed costs along with zero marginal costs, due to various types of network effects (both in production and consumption) by non-rival consumption goods, will call forth detailed enquiries on how investment in networks impacts individual profitability (see Besley, Blundell, Gammie, & Poterba, 2010; Shapiro & Varian, 1998). What is critical is making economic decisions about investment with fixed, often sunk, costs involving network externalities. An important element in such decisions is the influence of investment in technology on individual bank profitability. The present research is critical to understanding how endogenous sunk costs (ESC), like investment in technology, can influence banks' profitability.[77]

E.U. member countries have displayed a great penchant for strongly regulating the commercial activities of their banks than their counterparts in other industrial societies (Gruben & McComb, 1997), possibly to support the harmonisation of the E.U. banking markets (Maudos & Vives, 2019; Murphy, 2000). Despite the regulation, the banking industry in many European countries has experienced low levels of efficiency and, relative, poor economic performance. In order to address this inefficiency, most European countries have been eager to introduce IT for use by entities engaged in trade, investment, and financial services; this has increased their banks' capacity to offer more benefits to their clientele, thereby promoting gains in productivity and profitability. Research on the role of financial development in economic development can often be traced back to Schumpeter (1912), who unequivocally stresses the role of a country's banking system in triggering, propelling, and perpetuating economic development. Though the relationship between IT and business performance has attracted the attention of researchers in various countries over the years, the results from these studies have been markedly conflicting, prompting Brynjolfsson (1993) and Brynjolfsson and Hitt (1996) to label and highlight this relationship as a modern paradox.[78] For the first time, this chapter attempts to explain the paradox using the threshold effect approach. The present study will explore the link between IT and the profitability of 34 major commercial banks in Europe over 10 years to explain the paradox.

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[77] Investment in IT connotes a wide range of computerised technologies that enables communication and the electronic capturing, processing, and transmission of information (see OECD, 2004). The benefits of application of IT include cost reduction, greater access to geographically dispersed customers, and increased opportunities for effective cross-selling, amongst others.

[78] Thus, the benefits from IT to the banks are still a matter of deep concern in the academic parlour. As we saw in section 5.2, some studies find a positive relationship between IT and banks' performance (Becchetti, Bedoya, & Paganetto, 2003; Hernando & Nieto, 2007; Indjikian & Siegel, 2005) while others note the polar opposite (OECD, 2004).

The study's main contribution is twofold: first, it establishes a non-monotonic relationship between IT sunk cost investments and profitability. By testing for threshold effects in the relationship between IT and a bank's profitability, the study discovers an unknown impact from thresholds for the first time, to the best of my understanding, which can explain the conflicting results in the context of IT sunk cost investments and its impacts on bank profitability. The findings of the study address an important question about the efficacy of managerial decision-making in the banking industry of several European countries. Competitive pressure is an important ingredient of managerial decision-making in any sector, which has received robust empirical support in the literature. Several important studies establish that a firm's competitive environment drives its investments, financing, cash distributions, corporate governance, analysts' earnings forecasts, and hedging decisions (e.g. Akdogu & MacKay, 2012; Balakrishnan & Cohen, 2011; Datta, Iskandar-Datta, & Sharma, 2011; Fama, 1980; Kothari, Loutskina, & Nikolaev, 2006; Shleifer, 2004). Yet, how ESC strategies – for example, investment in information and technology – undertaken by the management, impact profitability is still unclear. Perpetuating differences in productivity across both firms and countries have always mesmerised researchers. A longstanding question is whether differences in managerial inputs across firms can explain discrepancies in profitability (see Foster, Haltiwanger, & Syverson, 2008; Hsieh & Klenow, 2009).[79] The present study seeks to understand the critical link between managerial decisions on ESC investments in IT and the dynamics of profitability at the microeconomic level in top-tier European banks. In this chapter, the procedure suggested by Hansen (2000) is applied to establish the existence of threshold effects in the relationship between IT investments and banks' performance.

[79] The idea that *managerial technology* shapes the productivity of inputs was initially mooted by Walker (1887), later emphasised by Leibenstein (1966), and was central to the Lucas (1978) model of firm size. Although management has long been emphasised by the media, business schools, and policymakers, economists have typically been sceptical about its importance (see Hsieh & Klenow, 2009).

Section 5.2 offers a brief review of the extant literature research context. Section 5.3 explains relevant variables and the dataset. Then, section 5.4 provides the methodology and discusses the study's empirical findings. Finally, section 5.5 concludes.

5.2 Literature Review

Organisations across sectors are widely perceived to improve performance through investments in IT. However, there is an ongoing debate on the efficacy of massive corporate investments in IT, predominantly after the famous remark by Noble Laureate economist Robert Solow (1987):

> … what everyone feels to have been a technological revolution, a drastic change in our productive lives, has been accompanied everywhere, including Japan, by a slowing down of productivity growth, not by a step up. You can see the computer age everywhere but in the productivity statistics. (p. 36)

Solow (1987) claims that since the beginning of the computer age, productivity growth has been slowing across different economies, and the perceived gains from investments in IT remain missing. Since the above illustrious quote from Solow (1987), the productivity paradox of IT is widely known as the *Solow paradox*. Even after more than three decades since the narrative around the paradox emerged, it remains relevant and extensively studied as productivity growth continues to dwindle across geographies while corporate investment in IT continues to bloat.[80] Numerous studies have investigated the Solow paradox in various banking

[80] According to Bureau of Labour Statistics, annual productivity growth fell from an average 2.73 per cent in 2000 through 2010 to an average of 1.06 per cent between 2010 and 2018 (Pabilonia, Jadoo, & Khandrika, 2019). Trends in other industrialised economies is similar. For instance, the OECD member states recorded a decline in annual labour productivity growth from an average 1.46 per cent from 2001 through 2010, to an average 0.98 per cent per year between 2010 and 2017 (OECD, 2019).

markets; however, with mixed results, the banking literature is divided over the existence of the Solow paradox in the industry.

For instance, analysing the impact of IT investments on the productivity of Canadian banks from 1974 to 1987, Parsons, Gotlieb, and Denny (1993), consistent with the economic theory, found little evidence of productivity growth associated with evolving computer technology. The authors explain that the returns were negative throughout the 1970s when the banks initiated IT investments because the initial computerisation projects had no cost justification. Instead, they were undertaken solely for strategic reasons to profit from perceived future benefits. Parsons et al. (1993) concluded that benefits from banks' IT sunk cost investments (if any) accrued to their customers and did not directly lead to any gains for the bank. In analysing 135 U.S. retail banks, Prasad and Harker (1997) found similar results. The authors concluded that additional investments in IT might have no real benefits and are more of a "strategic necessity to stay even with the competition".

Berger and Mester (2003) presented contradictory results suggesting that during 1991 to 1997, the cost productivity of the U.S. banks deteriorated, while the profit productivity improved substantially. They argue that the widely used profit approaches do not consider "revenue-based productivity gains", i.e., higher revenues paid for the improved quality – due to which they fail to capture changes in output quality or the profit maximisation goal of banks. However, Berger (2003) explains that, as the benefits derived from IT investments may get competed away, they may not reflect in banks' profitability. In an analysis of the 12 largest U.S. banks, Shu and Strassmann (2005) found IT investments to be the only input variable that provided more dollar value than the input cost on the margin. Still, the authors did not find any conclusive evidence on the relationship between IT investment and banks' profitability. In a comprehensive analysis of the U.S. market, Ho and Mallick (2010) found results similar to Berger (2003), suggesting that due to significant network effect in the U.S. banking industry, the cost-saving benefits banks accrue through IT investment are competed away. Further, analysing the relationship between market share and IT expenditure, the authors concluded the existence of a profitability paradox.

In a seminal paper, Beccalli (2007) investigated 737 European banks over 1995–2000 and found little relationship between total IT investment and improved bank profitability and efficiency. The author confirmed the existence of a profitability paradox, attributing the phenomenon to the possible use of IT investments by banks for strategic reasons, resulting in a heterogeneous impact on banks, leading to overall reduced profits for the banking industry (p. 2229). However, in an analysis of more than 600 Italian banks between 1989 and 2000, Casolaro and Gobbi (2007) reported contradicting results, suggesting that banks' total factor productivity (TFP) growth is associated with IT investments of 1.8 per cent when estimated from the profit function. Similar findings have been documented for the U.K. banking market (see Holden & El-Bannany, 2004). Martín-Oliver and Salas-Fumás (2008) investigated the influence of IT capital (and advertising) on the output of Spanish banks. The authors attributed one-third of sample banks' output to their accumulated IT capital; however, they could not find any relationship between the IT capital of sample banks and profitability. Analysing 27 European banking markets, Hasan, Schmiedel, and Song (2012) noted that retail payment transaction technologies positively influenced bank performance, especially for savings and cooperative banks. In an analysis of 457 German banks, Koetter and Noth (2013) documented a positive relationship between IT-augmented TFP, bank output, and market power, supporting the information-generation hypothesis (see Hauswald & Marquez, 2003). Finally, in a relatively recent analysis of 28 E.U. banking markets, Del Gaudio, Porzio, Sampagnaro, and Verdoliva (2021) investigated the effect of IT diffusion, adoption, and infrastructure on profitability and exerted a positive role of technology in improving bank performance.

In a qualitative study of banks in the Asia-Pacific region,[81] Swierczek, Shrestha, and Bechter (2005) assessed the perceptions of bank managers regarding IT investments. The authors found that IT investments improved bank productivity but not profitability. Banks with declining profits perceived higher IT benefits and invested in IT to enhance the deposit and loan account services, but it did not improve the "value of the accounts". The authors suggested that banks that attempt to gain market share by offering more customer convenience without regard to their bottom line hurt their overall profitability through additional IT investments. However, analysing the Korean banking market between 1990 and 1998, Kim and Davidson (2004) documented some counterintuitive findings. The authors claim that IT expenditure improves labour productivity and substitutes payroll expenses with operating and administrative costs, consequently increasing banks' market share, revenue, and profits. In the context of the Indian banking market, Gupta et al. (2018) reported the existence of the profitability paradox. The authors suggested that competition in the banking market may trigger an arms race, resulting in over-investment in IT, and consequently hurting bank profits. In a recent analysis, Shanmugam and Nigam (2020) employed a novel clustering-based approach from machine learning to individually study the impact of technology on the performance of 50 commercial banks in India. The authors found results consistent with Gupta et al. (2018) and suggest that most banks can acquire similar IT capabilities as technology becomes cheaper over time. Hence, there is no significant, sustainable competitive advantage of IT investments.

A notable shortcoming of the studies reviewed above is that scholars expected and explored a linear relationship between IT investment and bank performance. As heterogeneity is a common problem of panel datasets, i.e. banks may differ, and structural relationships may vary

[81] The study utilised survey responses from 103 banks: 59 (57%) responses were collected from Japan alone; 26 (25%) from banks in ASEAN countries, namely, Indonesia, Malaysia, Philippines and Thailand. The remaining 18 (17.5%) were from Australia, Bangladesh, Hong Kong, India, New Zealand, South Korea, Sri Lanka, and Taiwan.

across observations (Wang, 2015), the present study employs Hansen's (1999) panel threshold model to precisely evaluate the impact of IT investment on bank performance. The following section outlines the variables of interest, followed by the empirical strategy employed in the study.

5.3 Data and Definition of Variables

The dataset utilised in the study has been created for the 34 top-tier (commercial) banks of Europe from 2009 to 2018. Some of the information has been obtained from centralised repositories, such as the World Bank and the European Central Bank (ECB) sources, and the rest has been collected from annual reports, DataStream® and FitchConnect®. The primary purpose of the dataset is to investigate the IT paradox in the E.U. banking market through a panel threshold approach. In the subsections below, I outline the relevant variables utilised in the empirical test detailed in section 5.4. For the convenience of readers, following Hansen (1999, 2000), I have classified these variables as the dependent variable, threshold variable, threshold-dependent variables, and threshold-independent variables. Additionally, the chapter investigates the threshold effect on other measures of bank performance, classified below as additional dependent variables.

5.3.1 Dependent variable

Profit before tax (lnPBT): In analysing the non-monotonic relationship between IT investments and bank profitability, the study uses profit before tax of sample banks across the analysis period as the primary dependent variable. The data for the variable is sourced from DataStream®.

Since the sample banks have reported losses (negative profits) in some observed periods, applying the standard profit function is not feasible to measure profit efficiency. Following Chen and Lu (2021), the study thus defines the profit variable lnPBT as $\ln(\mathrm{PBT} + \theta + 1)$, where PBT is profit before tax and θ is the absolute value of minimum value of PBT over all sample banks.

5.3.2 Threshold variable

IT expense ($\mathbf{lnZ_T}$): According to Carr (2003, 2004), a distinction is necessary between *proprietary technologies* and *infrastructural technologies.* One can consider investments in infrastructural technologies as exogenous in modern banking. Arguably, infrastructural technologies do not offer any meaningful competitive advantage. Such technologies are considered essential to participate in the market, and competing firms can quickly and cheaply acquire such technologies due to their rapid *commoditisation*. For example, internet banking is a standard facility offered by firms across the sector today and does not require massive outlays by banks. On the other hand, proprietary technologies resemble a patent, which delivers an exclusive competitive edge to the firm that owns it. Investments in exclusive IT represent an endogenous choice of a firm that aims at developing a competitive advantage through cost savings or improved quality in service delivery.

The European Parliament and the E.U. Council adopted Regulation 1606/2002/E.C. on 19th July 2002, mandating all listed companies (including banks) to prepare consolidated financial statements following International Financial Reporting Standards (IFRS), starting 1st January 2005 (André et al., 2018; ECB, 2005). The regulation triggered a significant change in the accounting of certain software assets, which were previously expensed or capitalised at the discretion of each firm. Under IFRS, internally developed software (proprietary technology) is capitalised and reported as intangible assets if i) it is probable that it will fetch future economic benefits to the enterprise, and ii) the item has a reliably measurable cost (André et al., 2018).

Following Carr (2003, 2004), the present study utilises data on intangibles from DataStream to proxy a bank's investments into proprietary technology. In the context of the banking sector, the field *Intangibles, Net* in the database[82] includes i) capitalised software development costs, ii) capitalised R&D costs (if any), iii) costs associated with the acquisition of a customer database, and iv) acquired mortgage servicing rights.

5.3.3 Threshold-dependent variables

The success of technology relies heavily on its acceptance. Originating from the psychological theory of reasoned action and theory of planned behaviour, the technology acceptance model (TAM) has emerged as the fundamental model in understanding predictors of user behaviour towards potential acceptance or rejection of the technology (Granic & Marangunic, 2019). Introduced by Fred Davis (1989), the TAM suggests that the system's actual usage is a response that can be explained or predicted by a stimulus unrelated to the introduced technology itself. The model further indicates that three factors explain the motivation of users to adopt new technology: i) perceived ease of use; ii) perceived usefulness; and iii) attitude towards using it (Marangunic & Granic, 2014). The present research utilises advertising and branching as the two external stimuli that shape user perception and attitudes around investments in proprietary technology (Z_T) and impact banks' profitability.

Branching ($\mathbf{lnZ_B}$): The number of branches of a bank in a country gives the branching endogenous sunk cost. The relevant data on branching was first compiled from FitchConnect®

[82] The field also includes costs associated with broadcasting rights, FCC licences, resource (such as water) access rights, which are relevant for telecommunication, broadcasting, and utility firms. Importantly, the field does not include goodwill.

and DataStream®. Later, missing values were manually collected from published annual reports of sample banks.

Advertising ($\ln Z_A$): Similar to branching, the present study utilises advertising sunk cost data from databases FitchConnect® and DataStream®. Any missing observations were later manually collected from the annual reports of sample E.U. banks.

5.3.4 Threshold-independent variables

The present study utilises a set of threshold-independent variables to isolate and precisely analyse the influence of branching and advertising in different threshold regimes of IT investments. The microeconomic framework used in the study engages the following threshold-independent variables:

Cost management ($\ln CM$): The ratio of non-interest expense to total assets represents cost management at banks. The variable is commonly used in the estimation of bank profitability (Hoang et al., 2020). The data for CM is sourced from FitchConnect®.

Bank size ($\ln TA$): Banks in the dataset differ in size. Several studies analysing bank profitability in Europe establish bank size as an influencer of bank profitability (e.g. Ayadi, Bongini, Casu, & Cucinelli, 2021; Menicucci & Paolucci, 2016). The empirical model utilises the total assets of each sample bank as a proxy of size.

Labour cost ($\ln w_l$): The study also utilises the price of labour as a threshold-independent variable. The relevant variable is calculated as a ratio of total wage cost divided by the number of full-time employees (FTE). The data for the variable is sourced from FitchConnect® and DataStream®. In addition, missing observations are manually collected from the company's annual reports. The variable controls the effect of (in)efficiencies augmented in profitability by human resource management at the bank (see Fukuyama, Hashimoto, Matousek, & Tzeremes, 2021).

Funding cost ($\mathbf{lnw_f}$): The study next utilises the price of funding, calculated as a ratio of total interest expense divided by the total funding of each sample bank. The relevant data for the variable is sourced from FitchConnect®. Banks may differ in terms of funding sources and liquidity, which impacts their cost of funding and thus profitability (see Le, Hoang, Wilson, & Managi, 2020). The variable thus controls for liquidity (in)efficiency on the profitability of sample banks.

Cost of physical capital ($\mathbf{lnw_k}$): Physical capital is a critical input variable in producing banking services and is defined as expenditures on plants and equipment, as measured by depreciation plus other capital expenses on a firm's income statement (Olson & Zoubi, 2011). The study utilises the price of physical capital, calculated as a ratio of depreciation and capital expenditure divided by non-earning assets of each sample bank as a relevant threshold variable. The relevant data for the variable is sourced from FitchConnect® and DataStream®.

Market concentration ($\mathbf{lnHHI}$): The level of competition in the market is a critical industry-specific determinant of bank performance, which has been widely investigated in the banking literature. The Herfindahl–Hirschman index (HHI) is the most widely used structural measure of competition (Hoang et al., 2020). HHI is calculated by squaring the market share of each firm competing in the market and then summing the resulting numbers:

$$\mathrm{HHI} = s_1^2 + s_2^2 + s_3^2 \dots\dots + s_n^2$$

where $s_1, s_2, s_3 \dots s_n$ is the market share of each sample bank. As HHI gives higher weight to the market share of larger banks, a higher (lower) HHI denotes higher (lower) market concentration, reflecting weaker (stronger) competition. The SCP hypothesis asserts that in concentrated markets (markets with higher HHI), banks will exercise market power in pricing products and improve their profits. Conversely, the ES theory expects an increase in HHI to be an outcome of improved efficiency (Berger, 1995a). Thus, the variable controls the effect of competition in each sample bank's domestic market. Relevant data for the variable is readily available and sourced from the European Central Bank database.

5.3.5 Additional dependent variable

The study explores the threshold effect of IT sunk cost investments on three alternative determinants of bank profitability.

Total cost (lnTC): Bankers expect IT to rationalise cost over time and often perceive such investments as a *necessity* to pursue efficient cost management (Beccalli, 2007), especially since competition in the E.U. banking market intensified following deregulation (De Bandt & Davis, 2000). Thus, an alternative model examines whether the relationship between IT ESC and sample banks' total cost is linear or non-linear. The relevant data for the measure is sourced from FitchConnect®.

Total deposit (lnTD): Technology is known to improve banks' market share in the deposit segment at the expense of their competitors. For instance, in an early analysis of technology adoption among 956 banks, Daniel, Longbrake, and Murphy (1973) found that early adopters of technology experience economies of scale in demand deposits. Similar results were reported by Santos and Peffers (1995) in the context of banks' investments in ATM technology. The study utilises data available from FitchConnect® to assess the impact of IT sunk cost on total deposits of sample banks.

Net loan (lnNL): Banks in Europe engage lending technologies to expand in new markets and overcome the competitive advantage local bankers hold in accessing soft information about borrowers (Ferri, Murro, Peruzzi, & Rotondi, 2019). Berger and Udell (2002, 2006) suggest that transaction-based lending is not a homogenous technology, but a set of distinct techniques used by financial intermediaries. As banks can use IT to gain an advantage in the lending segment and improve profitability through expanding market share, the present research examines the relationship between IT sunk cost investments and net loans of sample banks. The relevant data for the net bank loan is obtained from FitchConnect®.

Table 5.2 presents the descriptive statistics of the data utilised in the present research.

Table 5.2: Data Descriptive Statistics

Variables	**Description**	**Mean**	**Maximum**	**Minimum**	**Std. Dev.**
lnPBT	Dependent variable	9.638	10.289	0.000	0.552
$\ln Z_T$	Threshold variable	4.965	8.847	0.693	1.935
$\ln Z_B$	Threshold-dependent variable	6.753	9.599	3.135	1.256
$\ln Z_A$	Threshold-dependent variable	3.296	6.607	-0.176	1.434
lnCM	Threshold-independent variable	3.198	4.632	1.863	0.442
lnTA	Threshold-independent variable	11.091	14.588	7.330	1.556
$\ln w_l$	Threshold-independent variable	3.927	5.035	2.766	0.559
$\ln w_f$	Threshold-independent variable	2.830	5.816	0.286	0.774
$\ln w_k$	Threshold-independent variable	3.087	5.446	-0.403	0.928
lnHHI	Threshold-independent variable	4.150	5.452	3.025	0.459
lnTC	Dependent variable (additional Model-1)	7.855	11.126	5.009	1.455
lnTD	Dependent variable (additional Model-2)	10.649	6.919	13.783	1.397
lnNL	Dependent variable (additional Model-3)	10.648	6.479	13.654	1.456

Note: The abbreviations lnPBT stand for the profit before tax of each sample bank. $\ln Z_T$, $\ln Z_B$, and $\ln Z_A$ represents investments in proprietary technology, size of the branch network, and advertising expense. lnCM and lnTA are bank-specific factors representing cost management and bank size, $\ln w_l$, $\ln w_f$, and $\ln w_k$ are the price of various inputs used in producing banking services, and lnHHI is the industry-specific feature capturing the effect of concentration through the Herfindahl–Hirschman index. Finally, lnTC, lnTD, and lnNL refer to the total cost, total deposits, and net loans of sample banks, which are additionally examined.

5.4 Methodology and Results

The effects of IT investments are seen in the improvements in productivity and economic growth at the macro-level (Brynjolfsson & Hitt, 1996; OECD, 2004; Oliner & Sichel, 2000; Stiroh, 2002). Nonetheless, its impact on bank performance is obscure (Beccalli, 2007; Ho & Mallick, 2010). In support of the common findings, Chapter 4 suggests that IT investments improve the cost efficiencies but foster profit inefficiencies in E.U. banks, indicating ambiguity in the effect of IT investments on bank performance. Hansen (1996) noted that regression functions may not be identical across all observations in a sample and may fall into discrete categories, and so proposed the fixed-effect panel threshold model. The approach divides individual observations into classes based on the value of an observed variable (Hansen, 1999) and describes the jumping character or structural break in the relationship between variables (Wang, 2015). The present study utilises the panel threshold approach of Hansen (1999) for a precise analysis of the relationship between the IT investments and the performance of E.U. banks.

5.4.1 Single-threshold model

One can describe the relationships between IT investments and bank profitability more formally using the following single-threshold model (Shabir, Jiang, Bakhsh, & Zhao, 2021):

$$\mathrm{lnPBT_{it}} = \mu_{it} + \beta_1 X_{it} I\left(\mathrm{lnZ_{T_{it}}} < \gamma\right) + \beta_2 X_{it} I\left(\mathrm{lnZ_{T_{it}}} \geq \gamma\right) + e_{it} \qquad (5.1)$$

In eq. (5.1), $\mathrm{lnPBT_{it}}$ is the measure of profitability and X_{it} is a vector of explanatory variables. While $\mathrm{lnZ_{T_{it}}}$ is the threshold variable – IT sunk cost investments – and γ is the threshold parameter that divides the equation into two regimes (groups) with coefficient β_1 and β_2, depending on whether the threshold variable ($\ln Z_{T_{it}}$) is less than or greater than the threshold value of γ. Finally, $I(.)$ is the indicator function that assumes the value one, if the stated argument in the function is true, and 0 otherwise, while e_{it} denotes the disturbance.

Rearranging eq. (5.1):

$$\ln PBT_{it} = \begin{cases} \mu_i\ \alpha_1 X_{it} + \beta_1 \ln Z_{T_{it}} + e_{it}, \left(\ln Z_{T_{it}} < \gamma\right) \\ \mu_i\ \alpha_1 X_{it} + \beta_2 \ln Z_{T_{it}} + e_{it}, \left(\ln Z_{T_{it}} \geq \gamma\right) \end{cases} \tag{5.2}$$

Several macroeconomic, bank-specific, and other market-specific factors may influence bank profitability (please refer to section 3.3 for a detailed review). Since it is not possible to capture the effect of all these elements, it is supposed to be accounted for in unobserved fixed effects (Shabir et al., 2021). In eq. (5.2) μ_i is a permanent term that captures cross-sectional unobserved heterogeneity because of the differences between sample banks and all other factors of variance in $\ln PBT_{it}$ not controlled by X_{it}.

If γ is known, the model is similar to an ordinary linear model. However, if γ is unknown, there is a problem of nuisance parameter, making the distribution of γ estimators non-standard. Hansen (1999) shows that $\hat{\gamma}$ is a consistent estimator of γ and suggests that one can test $\gamma = \gamma_0$ forming the confidence interval using the *no-rejection region* method, applying the likelihood-ratio (LR) statistic as below (Wang, 2015).

$$LR_1(\gamma) = \frac{[LR_1(\gamma) - LR_1(\hat{\gamma})]}{\hat{\sigma}^2} \xrightarrow{Pr} \xi \tag{5.3}$$

$$Pr(x < \xi) = (1 - e^{\frac{-x}{2}})^2$$

The significance level α determines the lower (upper) limit corresponding to the maximum (minimum) value in the LR series, which is less than the α quantile, and can be computed from the following inverse function:[83]

$$c(\alpha) = -2\log\left(1 - \sqrt{1-\alpha}\right) \tag{5.4}$$

Alike testing the threshold effect, one can examine whether the coefficients are the same in each regime (Shen, 2005). The null hypothesis and the alternative hypothesis (linear versus single-threshold model) are:

$$H_0: \beta_1 = \beta_2$$

$$H_1: \beta_1 \neq \beta_2$$

The F statistic is construed from (Shabir et al., 2021):

$$F_1 = \frac{(S_0 - S_1)}{\hat{\sigma}^2} \tag{5.5}$$

In eq. (5.5) S_0 is the residual sum of square (RSS) of the linear model. Under the null hypothesis, the threshold (γ) is not identified, and F_1 has non-standard asymptotic distribution. Using bootstrap[84] on the critical values of the F statistic, one can test the significance of the threshold effect.

[83] For example, for α = 0.1, 0.05, and 0.01 the quantiles are 6.53, 7.35, and 10.59, respectively. If $LR_1(\gamma_0)$ exceeds $c(\alpha)$, then we reject the null hypothesis.

[84] Hansen (1996) suggests 5 steps to design bootstrap: Step 1: Fit the model under H_1 and obtain the residual $\hat{e}_{it}^*$. Step 2: Develop a cluster resampling $\hat{e}_{it}^*$ with replacement to obtain the new residual v_{it}^*. Step 3: Generate a new series under H_1 data generating process, $y_{it}^* = X_{it}^*\beta + v_{it}^*$. Step 4: Fit the model under H_0 and H_1, and compute F_1 using eq. (5.5). Step 5: Repeat steps 1 – 4 B times, and the probability of F is $Pr = I(F > F_1)$, namely, the proportion of $F > F_1$ in bootstrap number B.

5.4.2 Multiple-thresholds model

It is important to note that the multiple threshold-effect tests are sequential, i.e. we test the double-threshold model if we reject the null hypothesis in a single-threshold model (Wang, 2015). Following Kuo, Li, and Yu (2013), the study utilises an extension of Hansen's (1999) model, which allows the modelling of multiple thresholds (multiple regimes) in the dataset. The estimated model is:

$$\ln PBT_{it} = \mu + X_{it}(\ln Z_{T_{it}} < \gamma_1)\beta_1 + X_{it}(\gamma_1 \leq \ln Z_{T_{it}} < \gamma_2)\beta_2 + X_{it}(\ln Z_{T_{it}} \geq \gamma_2)\beta_3 + u_i + e_{it} \qquad (5.6)$$

In eq. (5.6), γ_1 and γ_2 are the thresholds that divide the equation into three regimes with coefficients β_1, β_2, and β_3. A critical issue in operating threshold models is estimating threshold parameter (γ) (Kuo et al., 2013). Following Bai (1997); Bai and Perron (1998), the study utilises the sequential estimator to estimate threshold parameters. The procedures are presented as follows (Wang, 2015):

1. Fit the single-threshold model and obtain the threshold estimator γ_1 and the RSS $S_1(\widehat{\gamma_1})$.
2. Given $\widehat{\gamma_1}$, estimate the second threshold and its confidence interval using:

$$\hat{\gamma}_2^r = \underset{\gamma_2}{\arg\min}[S_2^r(\gamma_2)]$$

$$S_2^r = S[\min(\widehat{\gamma_1}, \gamma_2) \max(\widehat{\gamma_1}, \gamma_2)]$$

$$LR_2^r(\gamma_2) = \frac{[S_2^r(\gamma_2) - S_2^r(\hat{\gamma}_2^r)]}{\hat{\sigma}_{22}^2}$$

3. As $\hat{\gamma}_2^r$ is efficient, but $\hat{\gamma}_1^r$ is not. The first threshold is reestimated as:

$$\hat{\gamma}_1^r = \arg\min_{\gamma_1}[S_1^r(\gamma_1)]$$

$$S_1^r = S[\min(\gamma_1, \widehat{\gamma_2}) \max(\gamma_1, \widehat{\gamma_2})]$$

$$LR_1^r(\gamma_1) = \frac{[S_1^r(\gamma_1) - S_1^r(\hat{\gamma}_1^r)]}{\hat{\sigma}_{21}^2}$$

The F statistic is construed from:

$$F_2 = \frac{[(S_1(\widehat{\gamma_1}) - S_2^r(\hat{\gamma}_2^r)]}{\hat{\sigma}_{22}^2} \quad (5.7)$$

The bootstrapping technique for the multiple threshold estimation is similar to that in the single-threshold model[83] (Wang, 2015, p. 124).

5.4.3 Determining the number of thresholds

In eq. (5.5), the study introduced F_1 as a test of no threshold against one threshold. If F_1 rejects the null of no threshold in the context of the model outlined in eq. (5.6), following Hansen (1999), the research will proceed with a follow-up test to discriminate between one and two thresholds using the approximate LR test of one versus two thresholds based on eq. (5.7). The test statistics for F_1 and F_2 along with their bootstrap[85] values are presented in Table 5.2 below.

Table 5.2: F-Test Results Establishing the Number of Thresholds

Test for a single threshold	
F_1	80.946
P-value	0.01
(10%, 5%, 1% critical values)	(44.995, 55.330, 78.436)
Test for double threshold	
F_2	11.396
P-value	0.79

[85] 100 bootstrap replications were used for each of the bootstrap tests.

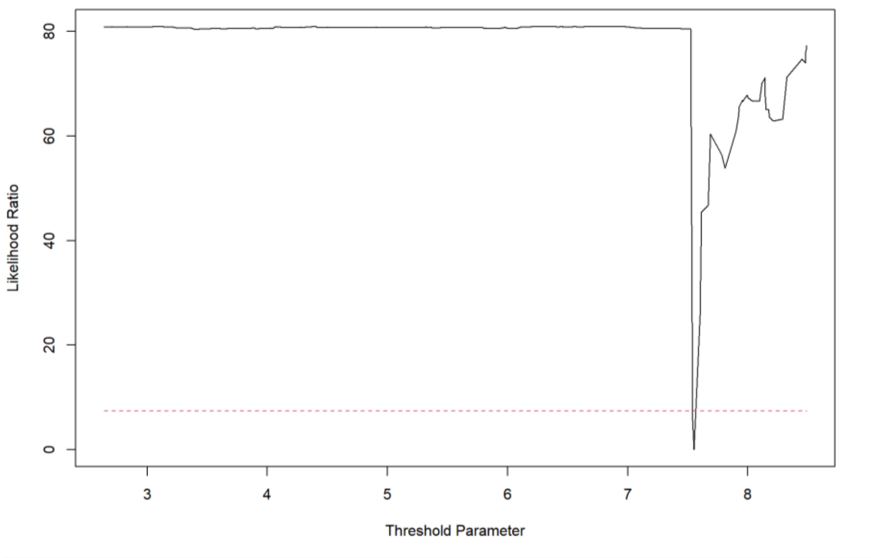
(10%, 5%, 1% critical values)	(61.560, 90.524, 159.446)

The test for the single threshold F_1 in Table 5.2 is highly significant with a bootstrap p-value of 0.01. However, the test of double threshold F_2 is not close to being statistically significant with a bootstrap p-value of 0.79. Thus, it is concluded that there is a single threshold in the regression relationship. Table 5.3 below reports the single threshold and its asymptotic 95 per cent confidence intervals

Table 5.3: Threshold Estimates

Estimate	95% confidence interval	Sum of squared errors
$\hat{\gamma}_1^r$ 7.551	[7.539, 7.551]	66.435

Figure 5.1: Confidence Interval Construction in Single-Threshold Model



Source: Constructed by statistical software: RStudio®.

The model identifies the single threshold in the dataset at $\hat{\gamma}_1^r$=7.551. As seen in Figure 5.1, there is a major dip in the likelihood ratio around the estimate of 7.551.

Table 5.4 below reports the percentage of firms that fall into the two regimes each year.

Table 5.4: Percentage of Firms in Each Regime by Year

Firm class	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
$\ln Z_T < 7.551$	85.29%	85.29%	85.29%	85.29%	91.18%	88.24%	85.29%	88.24%	88.24%	85.29%
$\ln Z_T > 7.551$	14.71%	14.71%	14.71%	14.71%	8.82%	11.76%	14.71%	11.76%	11.76%	14.71%

Notably, most sample banks (85.29 per cent to 91.18 per cent) choose to invest below the threshold value of 7.551, while only a handful of sample banks (8.82 per cent to 14.71 per cent) outspend their competitors during the analysis period.

5.4.4 Bank profitability in different IT sunk cost regimes

Following the confirmation of a single threshold in the regression relationship in 5.4.3, the study explores the impact of IT in the two regimes, as explained in eq. (5.6). Table 5.5 below reports the regression slope estimates, conventional ordinary least squares (OLS) standard errors, White-corrected standard errors and t-statistics. In line with the broad literature (Athanasoglou et al., 2008; Detragiache, Tressel, Turk-Ariss, & Thomsen, 2018; Uhde & Heimeshoff, 2009), the results indicate that non-interest expense (lnCM) and interest expense (($\ln w_f$) are statistically significant influencers of lnPBT. Both elements adversely impact bank profitability. Precisely, a percentage increase in the ratio of non-interest expense to total assets (lnCM) is associated with a 0.459 per cent decline in profit before tax (lnPBT) of banks. Similarly, a percentage increase in the price of funding ($\ln w_f$) is associated with a 0.076 per cent decline in lnPBT. Additionally, contrary to the findings of Bourke (1989); Molyneux and Thornton (1992); Staikouras and Wood (2004), results suggest that market concentration, proxied by lnHHI, has a negative relationship with bank profitability. In line with the findings of Căpraru and Ihnatov (2014); Eide, Erraia, and Grimsby (2021); Petria et al. (2015); Uhde and Heimeshoff (2009), results suggest that a percentage increase in market concentration adversely impacts bank profitability by 0.409 per cent, but the relationship is weak and statistically significant only at a 10 per cent level.

Table 5.5: Regression Estimates: Single-Threshold Model

Regressor	Coefficient estimate	OLS Std. Err.	White Std. Err.	t-stat
Threshold-independent variables				
lnCM	-0.459	0.133	0.180	-2.549
lnw_l	0.284	0.237	0.264	1.076
lnw_f	-0.076	0.066	0.044	-1.750
lnw_k	0.006	0.066	0.026	0.246
lnHHI	-0.409	0.260	0.255	-1.605
lnTA	-0.053	0.175	0.053	-0.984
Threshold-dependent variables				
$\text{lnZ}_\text{B}\ \text{I}(\text{lnZ}_\text{T} \leq 7.551)$	-0.197	0.177	0.175	-1.124
$\text{lnZ}_\text{A}\ \text{I}(\text{lnZ}_\text{T} \leq 7.551)$	0.017	0.101	0.042	0.405
$\text{lnZ}_\text{B}\ \text{I}(\text{lnZ}_\text{T} \leq 7.551)$	-0.624	0.279	0.522	-1.195
$\text{lnZ}_\text{A}\ \text{I}(\text{lnZ}_\text{T} \leq 7.551)$	0.991	0.377	0.777	1.275

Note: The abbreviations lnZ_T, lnZ_B, and lnZ_A represent investments in proprietary technology, size of the branch network, and advertising expense. lnCM and lnTA are bank-specific factors representing cost management and bank size, and lnw_l, lnw_f, and lnw_k are the price of various inputs used in producing banking services. Finally, lnHHI is the industry-specific feature capturing the effect of concentration through the Herfindahl–Hirschman index.

The coefficients of primary interest are those on threshold-dependent variables. The point estimates suggest that branching (lnZ_B) negatively, and advertising (lnZ_A), positively, impact lnPBT in both regimes, supporting the results from Chapter 4. Notably, banks incurring lower IT expenditure (in the low regime) have lower coefficients for both lnZ_B and lnZ_A, suggesting that lnZ_T amplifies the impact of the two on bank profitability. Notably, the coefficient for branching (lnZ_B) is approximately five times larger for banks in the high regime than those in the low regime. The results suggest that banks engaging in greater IT sunk cost investments must tactically scale back their branch network to reduce the adverse impact of branching on performance. Similarly, the coefficients suggest that IT sunk cost investments significantly magnify the positive impact of advertising on bank profitability. Indicatively, banks in the high regime witness a 0.991 per cent increase in their profitability following a percentage increase in their advertising, while banks in the low regime experience only a 0.017 per cent increase in their profitability for a percentage increase in advertising expense.

Nonetheless, there are some concerns with the estimations. First, the White standard error on the coefficients concerning the threshold-dependent variables in the high regime is relatively high, suggesting that there is still considerable uncertainty in the estimate (Hansen, 1999). Second, there is a significant difference in the conventional OLS standard errors and the White-corrected ones, suggesting heteroskedasticity, which violates one of the main assumptions of the analysis.

5.4.5 Additional estimations

The study evaluates a few additional models for a comprehensive analysis of the IT threshold effect on bank performance comprehensively. Specifically, the study explores the relationship between IT ESC and sample banks' total cost (lnTC), total deposit (lnTD), and net lending (lnNL).

Table 5.6: F-Test Results Establishing the Number of Thresholds in Additional Models

Test for a single threshold	**Dependent variable: lnTC**	**Dependent variable: lnTD**	**Dependent variable: lnNL**
F_1	25.359	20.418	27.753
P-value	0.44	0.45	0.36
(10%, 5%, 1% critical values)	41.76, 53.44, 65.11	33.22, 39.85, 47.78	44.16, 46.36, 73.49

Note: The abbreviations lnTC, lnTD, and lnNL represent the natural log values of the total cost, total deposits, and net loans of sample E.U. banks.

The test for the single threshold F_1 in Table 5.6 is statistically insignificant with a bootstrap p-value > 0.10 in all three alternative models explored in the study. The results suggest that the relationship between sample banks' IT sunk cost investments and accounting measures other than profitability is monotonic.

5.4.6 Robustness check

In a detailed examination of various profitability measures of banks, Golin and Delhaise (2013) point out that return on average assets is a key determinant of bank performance. Several studies assess the performance of European banks by modelling profitability using return on average assets (ROAA) (e.g. Detragiache et al., 2018; Molyneux & Forbes, 1995; Petria et al., 2015). Thus, the study assesses an alternative model as a robustness test to confirm and evaluate the non-linear relationship between IT ESC investments and bank profitability, using ROAA as the target variable. ROAA is an accounting ratio calculated by dividing operating profit by average total assets. The measure of profitability shows the profits earned per euro of assets and indicates how effectively banks' assets are managed to generate revenues. By using average assets, our alternative model captures changes in banks' assets during the financial year (Pasiouras & Kosmidou, 2007). The relevant data of ROAA is sourced from FitchConnect®.

The estimated alternative model is:

$$\mathrm{ROAA}_{it} = \mu + X_{it}(\mathrm{ITNIE}_{it} < \gamma_1)\beta_1 + X_{it}(\gamma_1 \leq \mathrm{ITNIE}_{it} < \gamma_2)\beta_2 + X_{it}(\mathrm{ITNIE}_{it} \geq \gamma_2)\beta_3 + u_i + e_{it} \quad (5.8)$$

Since ROAA is a ratio, for a straightforward interpretation of the results, in eq. (5.8), the alternative model replaces $\ln Z_T$ with ITNIE as the threshold variable. The variable ITNIE is derived by dividing the value of the IT sunk cost investments of each sample bank by its total non-interest expense. Similarly, the two threshold-dependent variables employed in the model are also in ratio form. First, BRNIE, which represents the total number of branches divided by the total non-interest expense of the sample bank; and, second, ADNIE, which denotes the ratio of the share of advertising expense in total non-interest expense of sample banks.

Finally, in eq. (5.8), X_{it} is a vector of threshold-independent variables. In the alternative model, I replaced bank-specific threshold-independent variables (in the primary model) – lnTA and lnCM – with two alternative accounting ratios: loan-to-deposit ratio (LDR) – an accounting ratio measuring loans to deposits – and capital structure (CS) – the ratio of equity to total assets. Studies commonly use LDR in the estimation of bank performance.[86] The variable captures bank liquidity, with higher values denoting lower bank liquidity (Pasiouras & Kosmidou, 2007). Similarly, banking literature employs CS as a relevant bank-specific factor to evaluate bank performance. A high capital-assets ratio is assumed to indicate lower leverage and, thus, lower risk (Pasiouras & Kosmidou, 2007). Other threshold-independent variables are retained from the primary model and include HHI – the measure of market concentration – and, finally, the price of key input variables in delivering banking services – the price of labour (w_l), price of funding (w_f), and price of physical capital (w_k).

As detailed above, eq. (5.5–5.7), first, the model establishes the number of thresholds in the dataset using the LR test. Table 5.7 below presents test statistics for F_1, F_2, and F_3 along with their bootstrap[87] values.

Table 5.7 below outlines the descriptive statistics of the data utilised in the present research.

[86] Several studies utilise loan to total assets as an alternative to loan to total deposits to model bank liquidity in estimations.
[87] 100 bootstrap replications were used for each of the bootstrap tests.

Table 5.7: Data Descriptive Statistics

Variables	Description	Mean	Maximum	Minimum	Std. Dev.
ROAA	Dependent variable	0.568	3.370	-13.310	1.315
ITNIE	Threshold variable	0.115	1.059	-0.435	0.133
BRNIE	Threshold-dependent variable	0.688	2.805	-0.241	0.544
ADNIE	Threshold-dependent variable	0.021	0.094	-0.030	0.017
LDR	Threshold-independent variable	1.064	3.262	0.439	0.435
CS	Threshold-independent variable	0.078	0.173	-0.042	0.031
w_l	Threshold-independent variable	0.059	0.154	0.016	0.030
w_f	Threshold-independent variable	0.023	0.336	0.001	0.028
w_k	Threshold-independent variable	0.031	0.232	0.001	0.027
HHI	Threshold-independent variable	0.071	0.233	0.021	0.036

Note: The abbreviations LDR and CS stand for bank-specific factors, namely loan-to-deposit ratio and equity to total assets. ITNIE is the threshold variable, calculated as the ratio of IT ESC investments to non-interest expenses. BRNIE and ADNIE are the two threshold-dependent variables, representing the ratio of branches to the total non-interest expense and advertising expense as a proportion of total non-interest expense. Finally, w_l, w_f, and w_k denote the price of various inputs used in producing banking services, and HHI is the industry-specific feature capturing the effect of concentration through the Herfindahl–Hirschman index.

Table 5.8: F-Test Results Establishing the Number of Thresholds

Test for a single threshold	
F_1	31.366
P-value	0.07
(10%, 5%, 1% critical values)	(25.631, 33.742, 60.894)
Test for double threshold	
F_2	46.546
P-value	0.02
(10%, 5%, 1% critical values)	(27.382, 39.398, 46.199)
Test for triple threshold	
F_3	112.108
P-value	0.00
(10%, 5%, 1% critical values)	(29.882, 34.614, 83.329)

The F-Test results in Table 5.8 above suggest that there exist three thresholds in the regression relationship.

Table 5.9 below reports the triple threshold and its asymptotic 95 per cent confidence intervals.

Table 5.9: Triple Threshold Estimates

	Estimate	95% confidence interval	Sum of squared errors
$\hat{\gamma}_1^r$	0.149	[0.146, 0.149]	175.818
$\hat{\gamma}_2^r$	0.165	[0.161, 0.168]	151.144
$\hat{\gamma}_3^r$	0.178	[0.173, 0.266]	199.322

The model identifies thresholds in the dataset at $\hat{\gamma}_1^r = 0.149$, $\hat{\gamma}_2^r = 0.165$, and $\hat{\gamma}_3^r = 0.178$. Following confirmation of the triple threshold in the regression relationship, the study explores the impact of ITNIE in different regimes as explained in eq. (5.6). Table 5.9 below reports the regression slope estimates, conventional OLS standard errors, White-correlated standard errors, and t-statistics.

As stated before, the coefficients of primary interest are those on threshold-dependent variables. Contrary to the expectations, the results suggest that BRNIE positively affects ROAA in all regimes. However, banks with ITNIE in the range of 0.165 to 0.178 experience the largest gains in ROA from branching. Further, advertising positively influences ROAA in all regimes, except when the ITNIE of sample banks is between 0.165 and 0.178. The positive influence of advertising on ROAA maximises when banks' ITNIE is between 0.149 and 0.165.

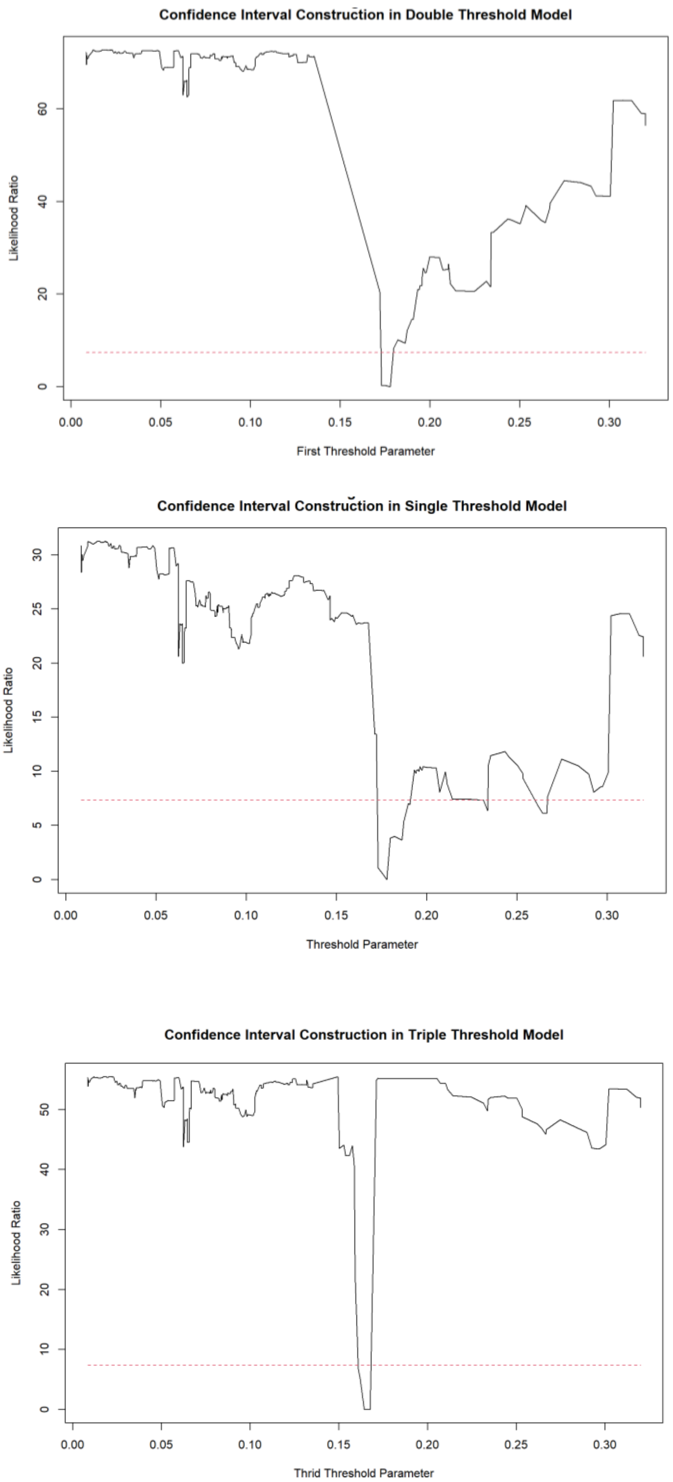
While the concerns of certainty of the estimations persist in the alternative model tested in the study, it helps establish that the relationship between IT ESC investments and bank profitability is non-monotonic.

Table 5.10: Regression Estimates: Triple-Threshold Model

Regressors	Coefficient estimate	OLS Std. Err.	White Std. Err.	t-stat
Threshold-independent variables				
LDR	0.7587	0.4412	0.4185	1.8128
w_l	-7.1748	4.517	9.7301	-0.7374
w_f	29.7422	3.3633	10.6578	2.7907
w_k	-6.8097	5.7087	4.4124	-1.5433
HHI	-1.6129	3.1541	3.4386	-0.4691
CS	3.4211	2.6089	2.1677	1.5782
Threshold-dependent variables				
BRNIE $I(\text{ITNIE} \leq 0.149)$	0.23	0.3291	0.5707	0.403
ADNIE $I(\text{ITNIE} \leq 0.149)$	29.7077	7.6318	7.2934	4.0732
BRNIE $I(0.149 < \text{ITNIE} \leq 0.165)$	0.1151	0.7543	0.5886	0.1955
ADNIE $I(0.149 < \text{ITNIE} \leq 0.165)$	38.4816	20.9575	15.2325	2.5263
BRNIE $I(0.165 < \text{ITNIE} \leq 0.178)$	8.9316	2.2766	2.0441	4.3694
ADNIE $I(0.165 < \text{ITNIE} \leq 0.178)$	-191.025	35.9933	31.8479	-5.998
BRNIE $I(\text{ITNIE} > 0.178)$	0.7299	0.3381	0.6557	1.1132
ADNIE $I(\text{ITNIE} > 0.178)$	37.9149	9.2612	11.3331	3.3455

Note: The abbreviations LDR and CS stand for bank-specific factors, namely loan-to-deposit ratio and equity to total assets. ITNIE is the threshold variable, calculated as the ratio of IT ESC investments to non-interest expenses. BRNIE and ADNIE are the two threshold-dependent variables, representing the ratio of branches to the total non-interest expense and advertising expense as a proportion of total non-interest expense. Finally, w_l, w_f, and w_k denote the price of various inputs used in producing banking services, and HHI is the industry-specific feature capturing the effect of concentration through the Herfindahl–Hirschman index.

Figure 5.2: Confidence Interval Construction (Alternative Model)



Source: Constructed by statistical software: RStudio®.

5.5 Conclusion

In comparison to other industries, banks allocate substantially higher resources to IT. For instance, Mai, Speyer, and Hoffmann (2012) suggest that European banks' IT costs consume 7.3 per cent of their revenues, as opposed to merely 3.7 per cent across all other major industries. However, the existing literature is split, and while some studies establish the existence of the IT productivity paradox (Beccalli, 2007), others differ (e.g. Del Gaudio et al., 2021). The present research uses the panel threshold test to explore the Solow paradox in the E.U. banking sector. In contrast to previous studies, the research establishes a non-monotonic relationship between IT sunk cost investments and profitability. Results from the primary model suggest that sample banks can be split into two regimes. First, banks in the low regime, i.e. sample banks incurring IT sunk costs lower than the threshold value ($\mathrm{lnZ_T} < 7.551$), and second, banks in the high regime, i.e. sample banks incurring IT sunk costs higher than the threshold value ($\mathrm{lnZ_T} > 7.551$).

Notably, IT sunk cost investments substantially amplify the adverse (positive) effect of branching (advertising) on profitability. A percentage increase in branching (advertising) reduces (increases) bank profitability by 0.624 (0.991) per cent among banks in the high regime. However, banks in the low regime experience a much milder impact, and a percentage increase in branching (advertising) results in a 0.197 (0.017) per cent increase (decrease) in bank profitability. To further understand the influence of IT investments, the study examines the threshold effect on other measures of bank performance. However, as reported in Table 5.6, the results indicate that the relationship between IT ESC and alternative measures of the total cost (lnTC), total deposits (lnTD), and net loans (lnNL) of banks is monotonic.

Examining various profitability measures of banks, Golin and Delhaise (2013) suggest that return on average assets is a key determinant of bank performance. Thus, the study presents an alternative model as a robustness check to assess the impact of IT sunk cost investments on bank profitability. The alternative model confirms the findings of the primary model, establishing the threshold effect in the evaluation of bank performance. The study finds overwhelming evidence of a triple threshold effect separating banks based on their IT investments to the non-interest ratio (ITNIE). The model detects three thresholds, indicating that sample banks can be classified into four regimes. First, banks in the lowermost regime, with investments in IT to non-interest expense ratio lower than the first threshold ($\text{ITNIE} \leq 0.149$). Second, banks in the lower-middle regime, with investments in IT sunk cost to non-interest expense ratio higher than the first threshold but less than equal to the second threshold detected by the model ($0.149 < \text{ITNIE} \leq 0.165$). Third, banks in the upper-middle regime, with investments in IT sunk cost to non-interest expense ratio higher than the second threshold but less than equal to the third threshold detected by the model ($0.165 < \text{ITNIE} \leq 0.178$). Finally, banks in the topmost regime, with investments in IT sunk cost to non-interest expense ratio higher than the third threshold ($\text{ITNIE} > 0.178$).

Notably, results in Table 5.9 indicate a significant difference in the impact of ESC investments in ADNIE and BRNIE on sample banks' ROAA in different regimes. Indicatively, banks in the upper-middle regime can leverage their branching network to the maximum. In contrast, banks in the lower-middle regime can derive better utility from advertising expenses (in proportion to their total non-interest expense), improving their ROAA.

Employing innovative technology is critical for firms to stay ahead of the competition; nonetheless, the unexpected failure of IT investments in boosting bank efficiency, as widely documented by researchers, has renewed concerns observed by Solow in the late 1980s (Prakash, Singh, & Sharma, 2021). The extant literature is split and often presents competing results accepting or rejecting the notion of the productivity paradox. The present study makes an exciting revelation. To date, to the best of my knowledge, no study explores the threshold effect by segregating banks based on their IT investments. Although the study results cannot decode the black box completely, it makes two significant contributions. First, the results establish that the relationship between bank profitability and IT investment is non-linear. Thus, studies accepting or rejecting the profitability paradox must account for this attribute to analyse the role of IT in bank performance. Second, the study finds that the relationship between IT investment and bank profitability is very complex. Therefore, further investigation using an extension of the prescribed model that allows for heteroscedasticity and random effects is highly desirable.

CHAPTER 6: Conclusion

The last chapter of the thesis summarises the study's key findings and highlights their implications for academia and industry. The chapter also outlines the limitations of the research and states possible future research areas.

6.1 Background

Researchers have debated the influence of market structure on the stability and efficiency of the banking sector since the wave of deregulation in the last quarter of the 20th century significantly altered the competitive landscape of the global banking industry. Two main arguments dominate the debate. First, founded by Keeley (1990), the *competition-fragility* view predicts that more competition erodes market power, profit margins, and franchise value, encouraging risk-taking behaviour among banks, and making the overall banking system fragile (see Allen & Gale, 2000; Arnoud & Thakor, 2000; Méon & Weill, 2005; Park & Peristiani, 2007). Contrarily, the alternative *competition-stability* proposition, led by Boyd and De Nicoló (2005), suggests that less competition lures banks to misuse market power to charge a higher interest rate to borrowers, exacerbating the moral hazard and adverse selection problem and consequently diminishing banking market stability (Beck et al., 2006; Cetorelli, Hirtle, Morgan, Peristiani, & Santos, 2007; Mishkin, 1999).

In analysing 23 industrial economies, Berger et al. (2009) noted that the two opposing views might not necessarily yield predicted results. In their investigation, the authors found support for both the competition-fragility and competition-stability arguments.[88] Notably, both theories

[88] Notably, Berger et al. (2009) establish that a higher degree of market power lowers the overall risk exposure of the banks (supporting the competition-fragility view). However, market power also contributed to loan risk in concentrated markets (supporting the competition-stability view).

produce inconclusive empirical evidence about the impact of increasing competition on bank performance (Karadima & Louri, 2020; Uhde & Heimeshoff, 2009). As a result, there is a longstanding dilemma about the most appropriate philosophy (Menezes & Quiggin, 2012). The current study posits that concentration is not an adequate measure of competition in the banking market. Mainly, the literature ignores a significant factor influencing concentration in the banking industry: endogenous sunk cost (ESC) investments, which is likely responsible for this dilemma. ESC investment is a firm-specific strategic investment in quality that allows banks to introduce vertical product differentiation[89] in rendering homogeneous services. Such investments trigger market concentration (Dick, 2007); however, their impact on competition is somewhat complex.

On the one hand, investments increase competition in domestic markets, as rival banks are constantly under pressure to match the quality of leading banks to protect their market share. On the other hand, the competitive escalation of ESC investments creates a natural barrier, restricting participation from new firms and resulting in lower competition. The fact that banks compete to gain market share and improve profitability through ESC investments underpins this study's importance. Relying on Sutton's (1991) ESC theory, the study decodes the impact of endogenous firm-specific strategies on bank performance. It thus presents a nuanced approach to evaluating ESC-driven competition's effect on the banking sector and offers new insight into the competition-fragility and competition-stability argument.

Explaining why some industries observe natural oligopolies regardless of rapid growth in market size, Sutton (1991) devised the ESC theory. Based on Shaked and Sutton's (1987) claim that:

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[89] Vertical form of product differentiation focuses on differentiation in a product (or service) based on quality. In any market, a quality hierarchy exists that ranks products (and services) of one kind from a position of low quality to the highest quality product.

> …entry in certain industries is limited to a small number of firms, not because fixed costs are so high relative to the size of the market, but rather because the possibility exists, primarily through incurring additional fixed costs, of shifting the technological frontier constantly forward towards more sophisticated products (p. 141).

Sutton (1991), in his outstanding work, explains that firms attempt to "enhance consumers' willingness to pay" through "a proportionate increase in fixed cost" in quality (p. 47). He argues that fixed investments in the vertical form of product differentiation by a few large firms in an industry pushes rivals to either match the quality of their larger peers or quit the market (Ellickson, 2007). Consequently, as the market size expands, a few firms incur higher ESC, which discourages new participation on the one hand and triggers consolidation on the other, resulting in a concentrated market structure (Dick, 2007).

Rising concentration in the banking markets of Australia and the E.U., regardless of regulatory efforts to introduce competition (see Drach, 2020; Murray et al., 2014), is a matter of concern for regulators and other stakeholders (see ACCC, 2018; European Banking Federation, 2018). The present research integrates Sutton's concepts of ESC competition into well-founded theoretical and econometric models to unmask the mysterious phenomenon. The study adapts Sutton's (1991) advertising model to highlight what explains the competitive escalation of ESC investments in the banking markets and how it impacts the performance of banks in Australia and the E.U.

The present research departs from the previous studies analysing competition and concentration in the banking industry through Sutton's notion (e.g. Cohen & Mazzeo, 2010; Dick, 2007; Jain & Gangopadhyay, 2020). The study utilises the most appropriate statistical techniques to examine a range of banking, industrial organisation, and behavioural theories, adding new dimensions to the scarce literature exploring the operation of Sutton's notion in the banking industry and offering a unique insight into its relationship with consumer and managerial behaviour in the context of banking.

The thesis comprises four main investigative chapters (Chapter 2 to Chapter 5). First, analysing the Australian banking industry, Chapter 2 establishes the role of ESC investments in shaping concentration in the lending and deposit segments separately. Chapter 3 examines the drivers of ESC investments in the Australian banking market from a behavioural perspective. Precisely, the study investigates the influence of ESC investments on Australian banks' cost and profit efficiencies to model managerial motives to commit massive outlays on enhancing bank quality.

Notably, several studies investigate the effect of market structure on the profitability and performance of E.U. banks (e.g. Ferreira, 2013; Fungáčová et al., 2017; Mirzaei, Moore, & Liu, 2013). However, ESC investments – a critical factor that shapes market structure – are not included in the analysis, obscuring managerial rationale in committing resources to quality. Chapter 4 employs data from the E.U., overcoming data limitations associated with the Australian banking market and presenting a comprehensive insight into the influence of managerial choice in selecting ESC investments on the performance of E.U. banks. Finally, Chapter 5 debunks the debate around Solow's (1987) productivity paradox, establishing the heterogeneous effect of the level of IT sunk cost investments on the performance of the banking sector.

The next section, 6.2, succinctly summarises the study's key findings, answering the research questions identified in Chapter 1. Subsequently, section 6.3 outlines the contribution of the study. Section 6.4 highlights the limitations of the current research. Finally, the chapter offers a few recommendations for future research in section 6.5 before concluding remarks in section 6.6.

6.2 Main Findings

6.2.1 ESC impacts banks' market structure in the lending and deposit segments differently

There is small literature exhibiting the influence of ESC investments on banking market structure (see Cohen & Mazzeo, 2010; Dick, 2007, 2008). However, prior studies solely focused on the U.S. banking market and did not investigate banks' market power individually in the lending and deposit segments. Further, the influence of different forms of ESC investments on banking operations has not been documented, to the best of my understanding. In Chapter 2, the study examines the impact of three forms of ESC investments (advertising, branching, and IT) on the market structure of the Australian banking industry in the lending and deposit segments separately, offering new insights into the discussion.

First, employing panel vector error correction models (P-VECM), the study establishes a positive long-run unidirectional causality running from ESC investments to market share in the deposit segment (MSD). However, the results indicate that no direct causal relationship exists between banks' ESC investments and their market share in the lending segment (MSL). The findings highlight a critical phenomenon of consumer behaviour in the banking industry. Intuitively, while depositors derive value from specific endogenous features – allowing banks to maintain and gain market share in the deposit segment – borrowers are not influenced by the quality banks indicate through ESC outlays.

Prior studies that explore the operation of ESC in the banking industry do not distinguish between different banking operations and primarily focus on the deposit markets alone. For instance, in an important paper analysing Sutton's notion in the U.S. banking market, Dick (2007) classifies dominant banks as "leading banks with the largest market shares that jointly hold over half of the market's deposits" (p. 54). In a subsequent analysis of the rural banking markets in the U.S., Cohen and Mazzeo (2010) acknowledge differences in bank customers' lending and funding behaviour but never analysed the impact of ESC investments in the two business segments. Besides other variables, APRA (2019) publishes periodic data on total deposits held and loans disbursed by ADIs in Australia. The data enabled the present research to precisely model the effect of ESC on the market share of sample banks in two different business segments (deposits and lending) separately. Thus, the chapter is the first study examining the impact of ESC investments on market concentration in two different banking business segments.

The empirical model suggests a strong influence of MSD on MSL, indicating that ESC investments indirectly impact concentration in the lending segment. Intuitively, Australian banks' market power in the deposit segment allows them to bring down their cost of funding, which is the most significant expense for lenders operating in the Australian financial system (Productivity Commission, 2018). Thus, a substantial share in the deposit segment allows dominant banks to compete vigorously in the lending segment, driving concentration in the lending segment.

In addition to the causalities, Chapter 2 also calculates elasticities, documenting the impact of each form of ESC investment on banks' market share in the lending and deposit segments individually in the long run. Using the fully modified OLS (FMOLS) approach, the study finds that branching and advertising are the only statistically significant ESC investments impacting MSD and MSL. Precisely, a percentage increase (decrease) in branching expense improves (dampens) MSD (MSL) by 0.39 (0.31) per cent; and a percentage increase in advertising expense is associated with a 0.08 (0.18) per cent improvement (decline) in MSD (MSL). Notably, results suggest that investments in IT are statistically insignificant.

An alternative model with macroeconomic control variables is also tested in the chapter. The findings of the alternative model confirm the causality results in the primary model. However, the elasticities for the different forms of ESC investments differ. Chapter 2, in general, highlights the difference in the operation of ESC investments in the lending and deposit segments individually. Additionally, the chapter discusses how each form of ESC impacts the banks' market share and supports the findings through various articulations of the underlying issues in the Australian banking sector.

6.2.2 The arms-race phenomenon in the Australian banking market

Researchers have actively explored the efficiency of Australian banks in the context of various regulatory measures (Avkiran, 1999; Paul & Kourouche, 2008; Williams, 2003), economic and financial disruption (Moradi-Motlagh & Babacan, 2015; Vu & Turnell, 2011), mergers and acquisitions (Neal, 2004; Wu, 2008), and shareholder value (Hoang, Hoang, & Yarram, 2020; Kirkwood & Nahm, 2006; Shamsuddin & Xiang, 2012), among other issues. However, no study documents the impact of ESC investments on bank efficiency (Gangopadhyay, Jain, & Bakry, 2022 is an exception that investigates the role of I.T. sunk cost investments in the Australian banking sector). As ESC investments may consume substantial bank resources, it is critical to investigate what drives such massive outlays in quality. Chapter 3 utilises two different panel estimation techniques to document the impact of ESC investments on Australian banks' cost and profit efficiencies and fill the void in the literature.

The study first utilises the stochastic frontier analysis (SFA) approach to derive Australian banks' cost and profit efficiency scores. In line with the findings of prior banking studies, results confirm that Australian banks, on average, operate at high cost (0.93) and profit (0.875) efficiencies. Subsequently, using the panel autoregressive distributed lag (P-ARDL) approach, Chapter 3 investigates ESC investments' short- and long-run impact on Australian banks' efficiencies after controlling for critical bank-specific, industry-specific, and macroeconomic factors. Results (Table 3.7) confirm cointegration between ESC and cost and profit efficiencies of the sample banks; however, the relationship is of statistical significance only for the profit efficiencies. In other words, ESC investments of Australian banks do not impact their cost efficiencies but adversely affect their profit efficiencies. Precisely, a percentage increase in ESC investments is associated with a 0.511 per cent decline in profit efficiencies of Australian banks.

While P-ARDL is among the most popular heterogeneous panel estimators, the technique cannot address the potential error arising from cross-sectional dependence (Chudik & Pesaran, 2015). Thus following Gangopadhyay et al. (2022), the study utilises the cross-sectionally augmented autoregressive distributed lag (CS-ARDL) technique. The CS-ARDL model augments the ARDL model with the linear combination of the average cross-sectional of independent and dependent variables, capturing the cross-sectional correlation in the error term (Chudik & Pesaran, 2015). The alternative CS-ARDL models confirm the findings of the P-ARDL models. Results (Table 3.8) validate cointegration between ESC investments and sample Australian banks' cost and profit efficiencies. Additionally, the results confirm that ESC investments only impact the profit efficiencies of the bank and not their cost efficiencies.

The chapter relies on the military analogy of the arms race to explain the research findings. Stemming from the *security dilemma* or *spiralling model* (see Jervis, 1978), the phenomenon explains the factors driving corporate investment decisions (e.g. Essendorfer, Diaz-Rainey, & Falta, 2015; Weston & Kashyap, 2021). According to Baliga and Sjöström (2004), in the context of managerial behaviour, the metaphor describes a trend where close rivals (dominant banks) decide whether or not to acquire weapons (quality) in an arms-race game based on the decision of their competitors. The phenomenon predicts that ESC investments by one bank will trigger a matching or even higher escalation in sunk cost investments by the rivals, in "self-defence" (to defend their market share). Jervis (1978) describes the behaviour as "irrational" because the best outcome is "for nobody to arm". However, incomplete information about the opponent's preference causes even rational players to engage in an arms build-up (Kydd, 1997), which adversely impacts their performance.

Chapter 3 thus concludes that bankers select ESC to acquire quality based on perceived strategic benefit. However, knowing that any competitive advantage drawn from product differentiation will only be temporary (Brady & Targett, 1995), they persistently invest without rationally assessing the utility of additional quality acquired. Consequently, ESC does not offer any cost advantages to the Australian banks while adversely affecting their profitability.

6.2.3 ESC investments reinforce the SCP paradigm in the E.U. banking sector

The E.U. banking market is unique as banks in member states can operate freely throughout the unified economic region. Consequently, domestic banks compete not only with local rivals but also with banking firms headquartered outside their national territories yet within the euro area. In an early assessment, Vives (2001) anticipated the operation of Sutton's (1991) ESC theory in the European banking market. The author argued that as the European banking markets transformed into the service industry, banks invested in fixed sunk costs, increasing concentration in an expanding market.

During the harmonisation process of the E.U. banking and financial sector, regulators minimised banking regulations to facilitate a *single market*, hoping to see a reduction in market concentration and an improvement in bank performance (see Casu & Girardone, 2009a). However, *national champions* (Vives, 2001) have successfully retained their dominant position (see European Banking Federation, 2018), overturning the regulators' expectations. According to Vives (2001), banks in the E.U. invest in ESC to reduce operating costs or improve service quality. Chapter 4 evaluates the managerial motivation driving ESC investments in the E.U. banking market. For instance, banks may strategically select ESC investments to lower their costs and gain market share, as anticipated by the proponents of the ES hypothesis (see Vennet, 2002). Conversely, banks may use ESC investments as a tool to achieve market power through quality improvement. Consequently, banks will observe a dent in their cost efficiencies but an improvement in their profit efficiencies (see Berger, 1995a).

Following the SFA approach utilised in the previous chapter, the study first calculates the cost and profit efficiencies of the E.U. banks. Results suggest that during the period of analysis (2009Q1 to 2018Q1), sample banks, on average, operated at a cost (profit) efficiency of 0.76 (0.61). The efficiency results of the study align with the broad literature, which has noted lower levels of profit efficiencies in contrast to cost efficiencies in the E.U. banking market (e.g. Maudos et al., 2002). After detecting cross-sectional dependence (using the cross-section dependence tests), the study applies the CS-ARDL approach to evaluate the impact of ESC investments on the cost and profit efficiencies of sample E.U. banks.

The findings of the CS-ARDL (Table 4.7) suggest that, in the long run, a 1 per cent increase in ESC investment is associated with a mild decline (0.076 per cent) in the cost efficiencies of the E.U. banks; however, it improves their profit efficiencies substantially (0.215 per cent). The results suggest that bankers strategically invest in ESC, which lowers their cost efficiencies, but the resulting market power helps improve their profit efficiencies. Thus, the SCP paradigm best explains the managerial behaviour in selecting ESC investments in the E.U. banking market.

6.2.4 Impact of different forms of ESC on the performance of banks is heterogeneous

The initial estimations evaluate the influence of ESC investments on the cost and profit efficiencies using a two-step approach.[90] However, scholars claim that the two-step procedure may produce biased results. For example, the exclusion of correlated variables (hypothesised to impact firms' efficiency) in the first step may result in model mis-specification (Battese & Coelli, 1995) and prejudiced results (Wang & Schmidt, 2002). The study employs a translog half-normal model with heteroscedasticity (the single-step approach) proposed by Kumbhakar et al. (2015) to overcome the undesirable biases of the two-step procedure. The technique estimates the parameters of the relationship between efficiency and key explanatory variables collectively (Kumbhakar et al., 2015). Thus, besides offering a robustness check to the estimates derived from the two-step procedure, it also allows independent evaluation of the impact of highly correlated ESC factors: advertising, branching, and IT on the cost and profit efficiencies of sample banks in a single estimation.

The approach supplements the chapter's findings in two ways. First, the single-step estimation results in Table 4.9 confirm the study's primary findings from the CS-ARDL technique (Table 4.7). The results ratify that increasing investment in the ESC adds cost inefficiencies but mitigates profit inefficiencies of the E.U. banks. Further, the estimation uncovers that various forms of ESC investment impact the E.U. banks' cost and profit efficiencies differently. For example, the results (Table 4.9) show that advertising is a critical ESC investment for the banking sector, reducing cost and profit inefficiencies; however, branching networks trigger cost and profit inefficiencies. Finally, IT has a mixed effect. It lowers the cost inefficiencies of the banks but aids profit inefficiencies.

[90] First, the cost and profit efficiencies are estimated (using the SFA technique). Later, in the second step, the CS-ARDL approach is employed to assess the effect of a vector of deterministic variables on bank efficiencies (calculated in the first step).

The finding of a heterogeneous relationship between different forms of ESC investments and bank performance has some important implications. Notably, bankers need to carefully assess which ESC investment delivers the best value to customers. Chapter 5's results support the findings of Martín-Oliver and Salas-Fumás (2008), indicating that the banks' advertising influences customers' choices in the E.U., and thus improves overall bank performance. However, physical branching adversely impacts the performance of banks. Migliorelli (2018) noted that European banks had witnessed a sharp decline in customer visits to the banks' physical branches. The author suggests that a typical bank customer passed from "a couple of visits a month" to only "a couple of visits a year". Intuitively, the trend may have deteriorated since the onset of the recent health pandemic (Covid-19). The change in customer behaviour thus confirms that physical branching may no longer serve as a distinct quality characteristic for bank customers, as reflected in our results. Finally, IT has a mixed effect on the performance of banks, supporting the findings of Del Gaudio et al. (2021). Assessing the E.U. banking market, the authors suggest that IT adoption, on the one hand, may result in cost savings; for example, in the form of staff downsizing. On the other hand, staff retraining and related organisational challenges stemming from implementing new technologies in the organisation may plague E.U. banks' performance.

6.2.5 IT investments and bank profitability relationship is non-monotonic

Solow (1987) noted a decline in productivity growth alongside an enormous increase in allocation of organisational resources to acquire IT across sectors. Since Solow's discovery, many scholars have highlighted that the massive investments in technology do not benefit firms, questioning managerial prudence in selecting IT ESC. As E.U. banks allocate significantly larger resources than other industries in acquiring IT (Mai et al., 2012), scholars have extensively researched the phenomenon in the E.U. banking industry. However, existing literature evaluating the issue has empirically established opposing views (e.g. Beccalli, 2007; Del Gaudio et al., 2021). Results of Chapter 4 confirm the complex relationship between IT investments and bank performance, showing that IT ESC improves cost but hurts profit efficiencies of sample banks.

A careful analysis of the literature highlights that prior studies exploring the issue assume a linear relationship between banks' IT investments and performance. As IT is an endogenous (choice) variable, ignoring the common problem of heterogeneity in panel datasets may lead to biases in results (see Wang, 2015). Chapter 5 utilises Hansen's (1999) fixed-effect panel threshold models to evaluate the impact of IT investments on bank performance from a new dimension. As the regression function may differ across all observations in a sample and may fall into discrete regimes, Hansen's (1999) approach divides the dataset into classes based on the value of an observed variable (called the threshold variable). The study examines the profitability of the E.U. banks in different regimes based on the model's threshold values of IT investments, overcoming the shortcomings of prior research.

Results from the primary model (Table 5.3) suggest that sample banks can be split into two regimes. First, banks in the low regime, i.e., sample banks with IT investments ($\mathrm{lnZ_T}$) lower than the threshold value of 7.551 ($\mathrm{lnZ_T} < 7.551$), and, second, banks in the high regime, i.e., sample banks incurring IT sunk costs higher than the threshold value ($\mathrm{lnZ_T} > 7.551$). The results (Table 5.5) indicate that IT sunk cost investments amplify the impact of other ESC investments on bank profitability. Notably, a percentage increase in branching (advertising) reduces (increases) bank profitability by 0.624 (0.991) per cent among banks in the high regime. However, banks in the low regime experience a much milder impact and a percentage increase in branching (advertising) results in a 0.197 (0.017) per cent decrease (increase) in bank profitability.

The chapter explores the threshold effect of IT investments on the E.U. banks' performance utilising an alternative measure of profitability: return on average assets (ROAA). The alternative model confirms the findings of the primary model and establishes a triple threshold[91] effect (Table 5.7) in the evaluation of bank performance. Furthermore, results (Table 5.9) indicate a significant difference in the impact of ESC investments in advertising and branching on sample banks' ROAA in different regimes. Banks in the upper-middle regime can leverage their branching network to the maximum. In contrast, banks in the lower-middle regime benefit the most from advertising expenses.

A critical input of the study is that it establishes that the relationship between IT investments and bank performance is non-monotonic, exposing a severe defect in the findings of prior studies, which proves or opposes the productivity paradox in the E.U. banking sector. Thus, the study concludes that for a precise estimation of banks' IT investments on performance, scholars must account for non-linearity to avoid estimation biases.

6.3 Comparison of the Australian and the E.U. Banking Markets

Capturing the impact of ESC investments on the performance of Australian and European banks, the study notes that investments in quality impact the cost and profit efficiencies of the banking sector operating in diverse competitive environments differently.

The study finds that in a highly concentrated market, such as Australia, banks accumulate quality at the expense of profit efficiencies to strengthen and protect their market position. The study results indicate that managers engage in an arms race to counter the influence of their

[91] First, banks in the lowermost regime, with investments in IT to non-interest expense ratio lower than the first threshold (ITNIE≤0.149). Second, banks in the lower-middle regime, with investments in IT sunk cost to non-interest expense ratio higher than the first threshold but less than equal to the second threshold detected by the model (0.149<ITNIE≤0.165). Third, banks in the upper-middle regime, with investments in IT sunk cost to non-interest expense ratio higher than the second threshold but less than equal to the third threshold detected by the model (0.165<ITNIE≤0.178). Finally, banks in the topmost regime, with investments in IT sunk cost to non-interest expense ratio higher than the third threshold (ITNIE>0.178).

rivals' investments in quality. As a result, the industry witnesses a competitive escalation of ESC investments, which transforms into a futile exercise as none of the participants benefit. On the one hand, the status quo is maintained, and there is no material change in the market share of individual banks. On the other hand, overinvestment in quality does not improve the cost efficiencies of the banks; however, their profit efficiencies are adversely impacted.

The analysis of the Australian banking sector indicates that bankers consistently invest in ESC to obtain strategic advantages, knowing that the rivals will match and compete away any short-term benefits obtained through product differentiation (Brady & Targett, 1995). In the words of Jervis (1978), the behaviour of Australian banks can be classified as "irrational" because the best outcome would be a collusive act of no additional investments in ESC. Nonetheless, as noted by Kydd (1997), incomplete information about the opponent's choice compels even rational players (bankers) to engage in an arms build-up.

Notably, in comparison to Australia, competition in the E.U. banking market is higher. Following the deregulation, which resulted in a *single market* for the banking sector across E.U. member states (Casu & Girardone, 2009a), domestic banks strive to protect their market position, not only from rivals within their national borders but also from banking firms from across euro area.

In contrast to Australia, the investigation of the E.U. banking market reflects a different picture. The study finds that ESC investments adversely affect the cost efficiencies of E.U. banks; however, it improves their profitability. Furthermore, the findings indicate that bankers in the E.U. strategically select investments in ESC. Although the strategy results in higher costs, it allows them to exercise market power and improve their profitability.

From a managerial behavioural perspective, the results support the operation of the SCP paradigm in the E.U. banking market. According to the results, the key motivation of bankers to invest in ESC in the E.U. banking market is to gain market power through quality improvement, which dents their cost efficiencies but enhances their profitability (see Berger, 1995a).

Analysing the two banking markets with different degrees of competition intensity adds significant value to my research. The study results indicate that in markets where the competition is greater, bankers are likely to exercise greater prudence in utilising ESC investments to gain and maintain market share. However, the overall impact of ESC investments on consumer welfare and systemic stability remains beyond the current study's purview. However, it may be investigated through additional research in the future.

6.4 Contribution of the Study

The present study contributes to the body of knowledge through an in-depth analysis of the applicability of Sutton's (1991) sunk cost theory in the banking industry. The study employs advanced econometric tools to establish that regulators cannot solely control the (banking) market structure via regulatory policies. Banks in Australia and the E.U. strategically use ESC investments to influence their market share and prevent market structure fragmentation. This section underpins the important contribution of the study and highlights its relevance to academics, policymakers, and other stakeholders.

First, Cohen and Mazzeo (2010) noted that banks' investments in quality might have a differentiating conceptual appeal to lenders and depositors. The present study pioneers in establishing the heterogeneity in the relationship between different forms of ESC and the two market segments banks cater to: lending and deposits. This study's findings suggest that depositors respond to banks' quality; however, borrowers are indifferent to the ESC investments of Australian banks. The results highlight a critical consumer behaviour phenomenon in the banking market. Intuitively, bank customers as depositors are quality-conscious but price-sensitive as borrowers. However, ESC investments indirectly impact concentration in the lending segment. The findings indicate that banks' market share in the deposit segment influences their market share in the lending segment. Higher market share in the deposit segment enables banks to reduce their funding costs – the most significant expense for lenders (Productivity Commisssion, 2018). Thus, lower funding costs enable dominant banks (with high market share in the deposit segment) to drive concentration in the lending segment by pricing loans aggressively.

The study's findings propose that while regulators target banks' lending practices (see Grant & Deer, 2020), regulating the deposit segment is likely to be more effective in addressing the imbalance in market power and possibly enhancing consumer welfare. Additionally, the results provide valuable insight into the competitive landscape of the Australian banking market. The findings recommend that financial firms (and new-age digital banks) seeking opportunities to develop business in the deposit segment must focus on enhancing the quality of their offerings through investments in ESC. In contrast, these firms must compete through pricing for a more significant market share in the lending segment.

Second, as ESC investments consume significant firm resources (Senyuta & Žigić, 2016), it is critical to establish the rationale behind such massive outlays to acquire quality. The present study is the first research that models managerial motivation in selecting critical ESC investments in the Australian banking market. The study detects a statistically insignificant influence of ESC on the cost efficiencies, and a negative impact of ESC investments on the profit efficiencies, of the sample Australian banks. The findings indicate that a little-known phenomenon – the arms race – drives ESC investments in the Australian banking sector. The military metaphor suggests that Australian banks may engage in a competitive escalation of ESC investments, perceiving strategic advantage. However, as any competitive advantage will be short lived (as rivals will imitate to protect their market position),[92] they neglect associated financial benefits (Brady & Targett, 1995), which reflects in their cost and profit efficiencies.

The study's findings confirm that regulatory concerns around concentration in the Australian banking sector (see ACCC, 2018; Murray et al., 2014; Productivity Commission, 2018) are legitimate. The persistence of ESC-induced inefficiency in the banking system may adversely impact the financial system's stability in the long term. As better disclosure requirements can be instrumental in curbing managerial bias (Guo et al., 2018), the study recommends that regulators urge banks to report their investments in branching, advertising, and technology (the three primary forms of ESC investments) vigorously.

Third, in contrast to the Australian banking market, banks in the E.U. operate in a unique competitive environment. Besides contending with banks within their national boundaries, they need to defend their market share from banking firms across the unified economic region of the E.U., who can freely establish operations in their home country (Drach, 2020; Maudos & Vives, 2019). For a comprehensive analysis of the influence of the ESC investments in the banking industry, the present research investigates the E.U. banking market. In contrast to the Australian banking sector, the results show that ESC investments positively (negatively) influence sample E.U. banks' profit (cost) efficiencies, establishing that the SCP paradigm best explains managerial conduct in selecting ESC investments. Intuitively, managers use ESC investments strategically to gain an advantage over rivals and grab larger market shares. While the strategy results in lower cost efficiencies, they gain market power, enabling them to enhance their profit efficiencies.

[92] For example, suppose a bank starts a new branch, in expectation of enhancing its market share. Rivals may soon operate in the vicinity in response to protect their market share, possibly neglecting the financial viability of expanding their branch network.

Amidst growing concerns around increasing concentration in the E.U. banking markets (European Banking Federation, 2018), the research findings offer new insight into the competitive landscape of E.U. banking. Following the GFC,[93] which also shook the E.U. banking sector, banks are possibly trying to strengthen their balance sheets through strategic investments in ESC, which improves their market power and allows them to improve profit margins. Although the exercise has a mildly negative impact on their cost efficiencies, there is a significant improvement in the banks' profit efficiencies, which warrants their strategic decision.

Finally, as banks allocate substantially higher resources to IT (Mai et al., 2012), researchers have actively debated the productivity paradox (see Solow, 1987), claiming that bank investments in technology may fail to improve firm performance (Beccalli, 2007). However, literature investigating the phenomenon in the E.U. banking market present mixed results *(for a detailed literature review, please refer to section 5.2)*. The present study highlights a significant shortcoming in prior studies and establishes that the relationship between banks' investments in IT and profitability is non-monotonic. Thus, the impact of IT on performance will vary depending upon the quantum of banks' IT sunk cost investments.

The findings have important implications for the banking literature. The results establish that assuming a linear relationship between IT sunk cost investments and bank performance is incorrect. As managerial choice in selecting IT ESC investments is firm-specific, heterogeneity in the structural relationship across observations cannot be ruled out.

Banking literature assumes concentration as a proxy of competition and extensively debates its influence on the sector's stability, especially since Keeley, 1990, and later Boyd and De Nicoló

[93] The GFC adversely impacted the E.U. banks, forcing governments and the union to bail out banking institutions and provide guarantees and capital to avert a systemic collapse (Hahn et al., 2022). The expected volume of the rescue package pumped into the E.U. banking system during the crisis years is over 4 trillion euros (European Commission, 2012; Matousek et al., 2015).

(2005), made conflicting predictions about the relationship between the two. Notably, studies evaluating the competition-stability (or competition-fragility) argument do not assess the endogeneity of market structures. The present research contributes to the banking literature by establishing the importance of ESC investments in shaping market concentration and evaluating their role in bank performance. The study posits that ESC investments, on the one hand, increase competition among existing market participants. On the other hand, incumbent banks lower potential competition from new entrants by creating entry barriers. As a result, a stable market structure is achieved at the expense of efficiency – as banks heavily invest in ESC. Thus, the study presents a nuanced approach to assessing competition, efficiency, and stability issues within banking markets, where managerial decisions in ESC investments play a critical role in configuring market structures.

6.5 Limitations of the Study

Although I made significant efforts to realise the study's goals, there are some limitations in terms of data, methodology, and the study's scope. Unfortunately, these limitations are beyond my control. This section outlines these shortcomings.

The first limitation is the small sample size utilised in assessing the Australian banking market. According to APRA (2019), 97 banks are operating in Australia, of which four are identified as major banks, 38 as other domestic banks, seven as foreign subsidiary banks, and 48 as foreign branch banks. However, only nine of them are listed. As the data for IT sunk cost investments is not readily available on any reliable database,[94] the study manually collects information on IT investments and other missing variables from publicly available annual reports. Collecting data for unlisted entities is challenging, and it was impossible to obtain past

[94] The data for IT investments by Australian banks was searched on popular databases: FitchConnect®, DataStream® and MorningStar®.

annual reports for even mainstream international unlisted banks.[95] While the sample banks examined in the study represent over 85 per cent of the total banking assets in Australia, the results apply to the larger banking firms and possibly not to ADIs offering partial banking services or operating with a partial banking licence. Additionally, the lack of data impedes my ability to utilise advanced econometric tools (for instance, single-step efficiency measures) to investigate the issue in further depth.

The second limitation is the study period. During my doctoral research, the health pandemic rattled the global economy. A substantial part of the dataset utilised in the study was collected before the outbreak. Thus, the analysis does not incorporate the period of extreme shocks. As the health crisis triggered strict lockdowns globally, the impact of ESC investments (specifically in branching and IT) on bank operations and performance could have presented deeper insight.

The third limitation of the study is the region. The study examines the Australian and E.U. banking markets. The findings indicate that the ESC investments impact the cost and profit efficiencies in the two markets very differently; thus, the results cannot be generalised to the global banking industry.

6.6 Recommendations for Future Research

The present study offers a deep insight into the operation of Sutton's (1991) theory of ESC investments in the banking industry, throwing light on a critical issue concerning rising concentration in global banking markets (Cerutti & Zhou, 2018). However, the limitations outlined in the preceding section offer possible areas that deserve further investigation.

[95] A couple of banks were approached for past annual reports, for instance, HSBC and ING, but they directed to their group reports in which Australian operations were reported but lacked sufficient depth to be incorporated into the dataset.

First, the present research uses econometric tools and critical information that researchers can use to analyse ESC investments in different banking markets. Therefore, similar studies exploring the role of ESC in fostering concentration in other economic clusters and country-level banking markets are highly desirable. As the two banking markets examined in the study highlight a significant difference in managerial motivations driving ESC investments, such investigations in other banking markets may uncover different behavioural patterns, adding to the literature.

Second, the study period does not cover the critical phase of Covid-19, which presented unprecedented challenges for the global banking system. Due to the lockdowns implemented worldwide, banks with better IT capabilities might have outperformed their peers with a more significant physical presence (through branching), possibly offering a unique insight into the issues concerning the IT productivity paradox and bank performance.

Third, while the regulatory efforts have harmonised banking markets across the E.U., some researchers have documented differences across member states’ regulatory and competitive environments. However, the current analysis does not bifurcate the E.U. banking industry into different segments, and hence a deeper cross-country analysis of the E.U. market with a larger dataset is recommended to outline the precise operation of ESC.

Fourth, Chapter 5 establishes that the relationship between bank profitability and IT sunk cost investment is non-monotonic and complex. Notably, banks can be classified into different categories according to the quantum of their strategic investments in IT, reflecting a range of effects on bank profitability. Therefore, future investigations examining the impact of IT investments on bank performance must consider the threshold effect in their evaluation. In addition, an extension of the prescribed model that allows for heteroscedasticity and random effects is highly desirable for a sharper unravelling of the widely documented IT productivity paradox in the banking industry.

Finally, the present study analyses the influence of ESC on the performance of the sample banks in the two banking markets. However, there are more banking-related issues where the prescribed models can be applied; for example, the role of ESC in fostering bank stability and loan quality.

6.7 Concluding Comments

Concentration in the banking sector has been of interest to academics, policymakers, and other stakeholders since the 1990s. Admittedly, researchers have presented conflicting views; nonetheless, the present study highlights a critical shortcoming in the extant literature. Prior studies assume that incumbent banks lack the will and ability to configure the structure of the banking markets. However, applying Sutton's intuition to the banking markets of Australia and the E.U., the present research debunks this untenable assumption, adding a new dimension to the decades-old argument.

The rigorous analysis undertaken in the current study highlights the relevance of ESC in the assessment of bank performance. ESC is a critical product differentiation strategy that firms use to configure the market structure, especially in industries where non-price (quality) competition is a defining characteristic, and incumbent firms can achieve the perceived quality mainly through fixed investments. Scholars have tested Sutton's intuition in several industries (including banking) and established the ability of firms to counter conventional economic wisdom, which suggests that a rise in market size will introduce new competition and result in a fragmented market structure.

Integrating Sutton's theory with other dominant banking philosophies, the study supplements literature with insight into divergent consumer behaviour in the lending and deposit segments and managerial motivations in selecting such massive outlays in quality. In addition, the study pioneers in uncovering the non-monotonicity in the relationship between IT sunk cost investments and banks' profitability, also contributing to the literature assessing the IT productivity paradox in banking.

To this end, I conclude the discussion and hope that my research helps scholars explore core banking issues with added knowledge.

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Appendices

6.4 Appendix 1: Evolution of the Australian Banking Industry

This segment outlines the evolution of the Australian banking sector and various regulatory changes observed by the industry, offering a glimpse into how the competitive landscape has changed over the years.

The free banking system of the 19th century

During the latter half of the 19th century, the Australian banking sector was regarded as one of the perfect examples of a *free banking system*. Australia's banking system was largely unregulated and had minimal legal barriers to entry. There were neither any branching restrictions nor regulations on assets, liabilities, or bank capital. Finally, neither legally-established price control mechanisms existed nor any central bank (Hickson & Turner, 2002). In 1893, Australia's laissez-faire banking system experienced a significant crisis after a speculative boom, which resulted in massive increases in real-estate prices and stocks of land, land finance, and mining companies. Between 1891 and 1892, several deposit-taking building or land finance companies failed. As Australian commercial banks heavily financed these enterprises, their widespread bankruptcies, coupled with rampant deposit outflows, placed an enormous strain on the commercial banks in the early 1890s (Hickson & Turner, 2002, p. 149).

The financial crisis of the 1890s triggered several mergers throughout the early part of the 20th century, which created a smaller and more concentrated banking market in Australia. The number of operating banks further reduced at the beginning of World War I. Eventually, the Australian banking industry was left with just nine entities by World War II (Wright, 1999, p. 18).

The Royal Commission of 1937

In response to considerable agitation from critics about the banks' poor performance during the Great Depression, the Royal Commission was set up in 1935. Chaired by Judge Napier, the committee was evidently influenced by the then-prevalent environment favouring increased government control over the sector. As a result, the committee's final recommendations navigated the Australian banking industry towards being a heavily guarded and concentrated sector (Abbott, Wu, & Wang, 2013; Edwards & Valentine, 1998).

Some of the prominent measures undertaken following the recommendations from the Royal Commission to increase the control of the authorities over the private banks included: the introduction of licensing provisions, which prohibited "carrying on the business of a bank" by any organisation without prior authorisation from the Commonwealth Treasurer; initiation of the variable primary reserve requirement, to control the volume of credit; and implementation of numerous reporting requirements, for greater transparency (Edwards & Valentine, 1998).

Over the years, additional restrictions were introduced to further regulate the Australian banking sector, and the policy stance was clearly against any competition in the banking industry. For instance, the *Banks (Shareholdings) Act 1972* prohibited individuals from controlling more than 10 per cent of the voting shares of a bank (without prior approval of the Federal Treasurer), and any approach by an entity to obtain a new banking licence or to take over an existing Australian bank were turned down (Wright, 1999).

The post-World War II period was a time of growth and prosperity for most economies (Wright, 1999). During this period, substantial household wealth improvements and increased demand for consumer finance resulted in massive non-bank financial sector growth, such as building societies, finance companies, and merchant banks. As the regulated banks were unable to satisfy the growing demand for higher-yielding deposit instruments and credit, their market share gradually depleted from 88 per cent in 1953 to 58 per cent in 1980 – subsequently diminishing the effectiveness of the central bank's monetary policy (Singh, 1992).

The Campbell committee

Over the decades, as the Australian financial markets and institutions matured due to increased liquidity, reduced volatility, and greater professionalism, regulations emerged as a constraint that hampered the sector's future development. Consequently, widespread discontent arose with the functioning of the system of regulation. There was a common consensus that the rules were not achieving their objectives and were having an unintended and tenacious impact on the Australian banking industry (Edwards & Valentine, 1998).

In response to widespread dissatisfaction with the system of regulations' functioning, the Campbell committee was set up by a coalition government in 1979. The committee was tasked to look into regulations and make policy recommendations to improve the financial system's functioning, in line with "the Government's free enterprise objectives" (Edwards & Valentine, 1998). Considering the increasing dominance of the free market paradigm at the time, it is not surprising that the committee submitted that "… the most efficient way to organise economic activity is through a competitive market system which is subject to a minimum of regulation and government intervention" (Campbell, 1981, p. 1).

Some of the prominent recommendations of the committee, which the Hawke/Keating Labor Government implemented, included: the removal of ceilings on deposit and loan rates; permitting new banks, including foreign-owned entities, to enter the Australian banking industry; deregulation of the foreign exchange market; and relinquishment of direct monetary controls and reliance on interest rates as the principal instrument of monetary policy (Edwards & Valentine, 1998). Thus, the Campbell committee's recommendations and the subsequent

Martin Report's review led to far-reaching deregulation of the Australian financial system (Wright, 1999).

The Financial System Inquiry (1997) – Wallis report

In June 1996, the Federal Treasurer initiated the Financial System Inquiry under prominent executive Stanley Wallis' direction. Expressed simply, the purpose of the Wallis Committee was to: a) achieve greater competition in more areas of the financial system; b) attain more efficient outcomes and lower costs for users; whilst at the same time c) improving or maintaining the safety and stability of the system (Wallis, 1997).

The report emphasised improving the system's contestability by creating opportunities for newcomers to challenge and compete with the established players in the market. The committee recommended opening access to banking and other financial services (including the payment system) to encourage new entrants at all levels and dimensions of the sector Wallis (1997).

The report also highlighted that the cost to Australia's financial system users in 1995 was approximately $41 billion annually,[96] which is relatively high when compared internationally. According to Wallis (1997), more than half of the financial system's cost ($22 billion annually) is related to banking. The report suggested that the Australian financial system has not been subjected to continued competitive pressures, making it less efficient.

The Wallis report recognised that computerisation improved the firms' capabilities in the financial sector to manage information much more effectively. Consequently, due to economies of scope, functions and products of traditionally discrete industries in the financial system, i.e., banking, insurance, and funds management, were no longer distinct, and firms in the sector have emerged as more general financial services providers.

[96] The claims made in the Wallis committee report pertaining to the cost to users of the financial system has been challenged by Brown and Davis (1997).

To accommodate the changing landscape of the financial sector, some of the prominent recommendations of the committee were: 1) the removal of industry-specific criteria for participation in different markets; 2) neutral regulatory treatment of competitors from diverse institutional sectors; 3) single market conduct and disclosure regulator for the financial industry; and 4) a single prudential regulator (the Australian Prudential Regulation Commission – APRC) separate from the Reserve Bank of Australia (Quigley, 1997).

The report focused on improving the financial system's efficiency by promoting greater competition and strengthening the regulatory framework. Over the years, the Wallis committee's recommendations led to a significantly modernised regime for the uniform regulation of various financial services in Australia (Peckham, 2015).

The Financial System Inquiry (2014) – Murray report

A series of financial collapses and investor frauds[97] from 2005 onwards demonstrated that the financial services reform program (commonly known as FSR), which culminated from the Wallis report's recommendations, was deficient in several aspects (Peckham, 2015). As a result, in March 2014, the then-Treasurer, Joe Hockey, appointed an international advisory panel for an independent inquiry into the financial system (Murray et al., 2014). The terms of reference of the 2014 investigation were to report on the consequences of developments in the Australian financial system since the 1997 Financial System Inquiry and the Global Financial Crisis (GFC) (Murray et al., 2014).

[97] Some of the prominent financial collapses and investor frauds from 2005 are: 1) The Westpoint collapse (estimated loss to investors: $388 million); 2) The Storm Financial collapse (estimated loss to investors: $830 million) and 3) The Trio Capital fraud (estimated loss to investors: $176 million). Refer Peckham (2015) for details.

The Murray report assessed the entire Australian financial system and submitted a comprehensive report with 44 recommendations. Some of the most prominent recommendations concerning the banking sector were:

Recommendation 1 – The inquiry noted that Standard & Poor's classified the major Australian banks' capital ratios as "adequate" but not "strong". The panel found that the major Australian banks were well-capitalised but were not in the top quartile of internationally active banks. Hence, the report recommended that APRA raise the capital requirements for Australian ADIs, especially for entities that pose a systemic risk or access funding from overseas markets (Murray et al., 2014, p. 41).

Recommendation 2 – APRA has accredited the four major banks and Macquarie Bank to use internal ratings-based (IRB) models, which allows them to self-determine their risk weights for credit exposure. IRB risk weights are much lower than standardised risk weights, which allowed accredited banks to use a much smaller portion of equity funding for mortgages than their fringe counterparts (which use standardised risk weights). The panel noted that the arrangement was adversely impacting the competitiveness of smaller ADIs and recommended raising the average IRB mortgage risk weight to narrow the difference between the two different types of risk measurement approaches.

Recommendation 16 – The panel recognised that the framework regulating the retail payments system in Australia is complex – as relevant provisions are spread across numerous laws, regulations, and instruments administered by ASIC, APRA, and the Payment System Board (PSB). The inquiry recommended developing a separate two-tier prudential payment regime for purchased payment facilities (PPFs)[98] – as the then-prevalent system posed high compliance

[98] PPFs hold stored value relating to payment systems but are not traditional ADIs. For example, PayPal.

costs on the PPFs and failed to provide competitive neutrality, impeding innovation in the industry (Murray et al., 2014, p. 161).

Recommendation 20 – The inquiry underpinned the importance of data. It recommended a voluntary comprehensive credit reporting (CCR) regime, allowing credit providers to share an individual's "positive" credit history data (such as loan-repayment history). The recommendation aimed to foster competition between lenders and improve access to, and reduce the cost of, credit for borrowers, including small and medium enterprises (SMEs) (Murray et al., 2014, p. 190).

It is important to note that the Murray report identified high concentration in the Australian banking sector as a "source of added risk" (Murray et al., 2014, p. 44). Considering the prominent recommendations regarding the banking sector, it is evident that, like their predecessors, the panel also advocated greater competition in the banking sector to ease market concentration.

The Royal Commission of 2019 – Hayne inquiry

Following a spate of alarming press revelations about large Australian financial institutions misconduct, in late 2017, the Liberal-led government faced mounting pressure to intervene. As a result, in November 2017, Prime Minister Malcolm Turnbull and Treasurer Scott Morrison announced the formation of a Royal Commission to investigate the extent of misconduct and behaviour by financial services (Davis, 2019; Gilligan, 2019; Singleton & Reveley, 2020).

Chaired by Justice Kenneth Hayne (2019), the commission's final report was released in early February 2019. According to Hayne (2019), the commission's central task was to report on "whether any conduct of financial services entities might have amounted to misconduct and whether any conduct, practices behaviour or business activities … fell below community standards and expectations." The conduct identified and described in the report has often "broken the law. And if it has not broken the law, the conduct has fallen short of the kind of behaviour the community not only expects of financial services entities but is also entitled to expect of them" (p.1).

Some of the prominent misconducts noted by the commission during its year-long proceeding included fees charged by banks for no services, failure to disclose to customers the value of commissions to mortgage brokers, and charges to the deceased for life insurance (Casson, 2019). The commission drew 76 recommendations in all (see Hayne, 2019). However, there were 17 specific recommendations for the Australian banking sector, all aiming to tighten the noose on major Australian banks and protect the interests of bank customers.

6.5 Appendix 2: Harmonisation of the E.U. Banking Market

While the re-regulation of the E.U. banking started in earnest in 1973, the cornerstone of the single market program (SMP) in banking was the enactment of the Second Banking Directive (1989) in 1993 (Molyneux, Lloyd-Williams, & Thornton, 1994). The directive has three major components (Evans, Hasan, & Lozano-Vivas, 2008; Maudos & Vives, 2019; Murphy, 2000):

1. First, it clearly defines what is meant by "banking". Across different E.U. member states, there was a difference in the activities banks could undertake. To eliminate differences in the organisational structure of the banks across the union, the directive explicitly outlined the banking activities (Murphy, 2000). These are:
    - deposit-taking and other forms of borrowing
    - lending (including consumer credit, mortgage credit factoring, invoice discounting, and trade finance)
    - financial leasing
    - money transmission services
    - payments services (including credit cards, electronic funds transfer, point of sale, travellers' checks, and bank drafts)
    - providing guarantees and commitments
    - trading on their own account or for customers in money-market instruments, foreign exchange, financial futures and options, exchange and interest rate instruments, and securities
    - participating in share issues and providing services related to such issues (for shares, bonds, and other securities), including corporate advice and arranging mergers and acquisitions
    - money brokering
    - portfolio management and advice

- safekeeping of securities
- offering credit reference services
- safe-custody services.

2. Second, a critical component of the directive is the principle of *home-country control* or *mutual recognition.* This element meant that the banks would be regulated by and would conform to the regulation and legislation of their home country. In effect, if a bank operates in another E.U. country, the regulators of the host country recognise the pre-eminence of the home nation.
3. Finally, the directive introduced the concept of a *single passport* in the E.U. banking market. It meant that a bank licensed to do business in any E.U. nation could freely operate in any other E.U. nation on whatever basis it considered most advantageous. Specifically, the host country is not allowed to impose any restrictions on the bank.

As a result of the *mutual recognition* (second component) and the *single passport* (third component), a bank located in a jurisdiction with permissive laws could freely set up operations in a country that restricted the scope of banking activities, putting domestic banking firms at a competitive disadvantage. Thus, the directive incentivised member states to adopt the E.U.'s definition of banking (first component) and enact legislation making universal banking the norm of the entire E.U.

Additional directives fostering harmonisation in the E.U. banking market

The amount of capital held by a bank can affect its competitiveness and profitability. In the absence of capital standards, banks with a low capital ratio can price loans aggressively, distorting fair competition. Considering the importance of capital in banking, the E.U. promulgated a series of directives to eliminate differences in capital standards across the member states to further harmonise the E.U. banking market. Notably, the Own Funds

Directive and the Solvency Ratio Directive outlined the meaning of bank capital and introduced uniformity in the level of capital adequacy E.U. banks were required to maintain.

As the monopoly rents extinguished across various E.U. banking markets, amidst extensive deregulation to develop a common banking market, banks' incentives to act prudently reduced (see Keeley, 1990, p. 1198).[99] To counter the problem, E.U. regulators strengthened prudential regulations. First, the directive on Monitoring and Controlling Large Exposures of Credit Institutions restricted maximum exposure to a single client and mandated reporting of exposures exceeding 10 per cent (Murphy, 2000). Further, the E.U. issued a Deposit Guarantee Scheme Directive (effective 1st July 1995), mandating member states to provide deposit protection for all banks within member nations. The scheme incentivised regulators in each member state to exercise strict supervision and further streamlined competition[100] (Paul, Iftekhar, & Ana, 2008).

[99] According to Keeley (1990), anticompetitive restrictions that bestow greater market power to banks (and hence monopoly rents) induce them to act prudently to protect their charter value.
[100] The single passport could have caused difficulties for differences in deposit protection schemes in relation to competition. Banks operating in member states where deposit protection is lower than that of their home country would have a competitive advantage over domestic banking firms in the host market, undermining the spirit of a single market. The Deposit Guarantee Scheme Directive placed a floor on coverage (€20,000 per depositor) and also terms of disbursement of guarantee if their deposits became "unavailable".

6.6 Appendix 3: Estimation of Exogenous Variable: LERNER

The present study utilises the Lerner Index ($LERNER$) to model the toughness of the price each sample Australian bank faces. The Lerner Index measures the disparity between price and marginal cost expressed as a percentage of the price and can be algebraically expressed as:

$$LERNER_{it} = \frac{P_{it} - MC_{it}}{P_{it}} \quad \text{(A3.1)}$$

Where P_{it} is the output price, proxied by the ratio of total revenues to total assets for bank i in time t. MC_{it} is the marginal cost of total earning assets calculated using the SFA procedure, as outlined below.

To derive the marginal cost, following Kumbhakar et al. (2015), the following translog cost function using the general form of the stochastic cost frontier is estimated:

$$C = C(w, y)e^{n}, n \geq 0, \quad \text{(A3.2)}$$

where C is the total cost of the sample bank, w is a vector of the price of the factors of production, defined as: $w_1$the price of funding (total interest expense/total funding), w_2 is the price of labour (total personnel expenses/total assets), and w_3 is the price of physical capital (non-interest expenses/total non-earning assets); and y denotes total earning assets.

For each sample bank, the translog cost frontier model can be expressed as follows:

$$lnC_{it} = \alpha_0 + \alpha_1 lny_{it} + \frac{1}{2}\alpha_2(lny_{it})^2 + \frac{1}{2}\sum_{m=1}^{3} \emptyset_m\, lny_{it} lnw_{m,it} + \sum_{m=1}^{3} \beta_m lnw_{m,it}$$

$$+ \frac{1}{2}\sum_{m=1}^{3}\sum_{n=1}^{3} \rho_{mn} lnw_{m,it} lnw_{n,it} + lnu_{it} + \varepsilon_{it} \quad \text{(A3.3)}$$

where ε is the error term. The marginal cost (MC) is then calculated as follows:

$$MC = \frac{\partial C}{\partial y} = \frac{\partial lnC}{\partial lny} \times \frac{C}{y} = \left[\alpha_1 + \alpha_2(lny) + \frac{1}{2}\sum_{m=1}^{3} \emptyset_m lnw_m\right] \times \frac{C}{y}, \qquad \text{(A3.4)}$$

6.7 Appendix 4: List of Sample E.U. Banks Analysed in the Study

ID	Name of bank	Country
1	Alior Bank SA	Poland
2	Banca Carige SpA Cassa di Risparmio di Genova e Imperia	Italy
3	Banca Monte dei Paschi di Siena SpA	Italy
4	Banca Popolare di Sondrio ScpA	Italy
5	Banca Transilvania SA	Romania
6	Banco Bilbao Vizcaya Argentaria SA	Spain
7	Banco BPI SA	Portugal
8	Banco Comercial Portugues SA	Portugal
9	Banco de Sabadell SA	Spain
10	Banco di Desio e della Brianza SpA	Italy
11	Banco Santander SA	Spain
12	Bank Handlowy w Warszawie SA	Poland
13	Bank Millennium SA	Poland
14	Bankinter SA	Austria
15	BNP Paribas Bank Polska SA	Poland
16	Bper Banca SpA	Italy
17	BRD Groupe Societe Generale SA	Romania
18	Credito Emiliano SpA	Italy
19	Banca Piccolo Credito Valtellinese SpA	Italy
20	Deutsche Bank AG	Germany
21	Erste Group Bank AG	Austria
22	Intesa Sanpaolo SpA	Italy
23	Komercni Banka as	Czech
24	OTP Bank Nyrt	Hungary
25	Piraeus Financial Holdings SA	Greece
26	Raiffeisen Bank International AG	Austria
27	Santander Bank Polska SA	Poland
28	Skandinaviska Enskilda Banken AB	Sweden
29	Svenska Handelsbanken AB	Sweden
30	Swedbank AB	Sweden
31	Sydbank A/S	Denmark
32	Tatra Banka as	Slovakia
33	UniCredit SpA	Italy
34	Unione di Banche Italiane SpA	Italy

6.8 Appendix 5: List of Sample Australian Banks Analysed in the Study

ID	Name of bank
1	Australia and New Zealand Banking Group (ANZ)
2	Bank of Queensland (BoQ)
3	Bendigo Bank (BEN)
4	Bank of Sydney (BoS)
5	Commonwealth Bank of Australia (CBA)
6	ING Bank (ING)
7	Macquarie Bank Limited (MBL)
8	National Australian Bank (NAB)
9	Westpac Banking Corporation (WBC)