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outcomes: evidence for South Africa**

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Bank business model identification, evolution and outcomes: evidence for South Africa

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Abstract

This paper presents the findings of an investigation of the type, evolution and impacts on performance of bank business models in South Africa. We identify the various business models used by South African banks using data on the monthly balance sheets of commercial banks made available by the South African Reserve Bank between 1993 and 2022. We cluster banks into different business models based on the composition of their balance sheets. Based on these clusters, we identify business models oriented to *wholesale* and *retail* funding, as well as to *universal*, *investment* and *interbank* activities. Overall, our clustering exercise returns six distinct business models. We observe large differences in terms of business size, performance and risk profiles across the business models. We also analyse the evolution of business models over time. The results suggest that banks exhibit relatively stable business models, but where transition exists it tends to be between certain business models. Increased risk is associated with a higher probability of banks shifting business models.

JEL classification

G21, L21

Key words

Business models, clusters, financial intermediation, South African banking

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1. Introduction

Banks play an important role in the economy by allocating funds from savers to borrowers, reducing information asymmetries, lowering transaction costs, creating liquidity and diversifying risk (Gorton and Winton 2003; Goddard and Wilson 2016). Banks perform these roles via various business models, which evolve over time to adapt to changing market conditions, economic shocks, regulatory change and technological advances (DeYoung and Rice 2004a, 2004b; Bord and Santos 2012).

The Global Financial Crisis (GFC) of 2007–09 highlighted vulnerabilities in certain forms of business models, some of which are believed to have been core to the distress experienced by banks (Avisoa et al. 2018). In the aftermath of the GFC, business model analysis has become an important framework for many regulatory authorities (including the European Banking Authority) to understand key vulnerabilities embedded in banks' strategic behaviours. Consequently, business model analysis allows managers a better understanding of the possible consequences of strategic decisions via their prevailing business models. Regulators and supervisors are also able to effectively identify and assess future risks through the analysis of business models.

The aim of this paper is to:

1. Identify the different types of business models used by banks in South Africa;
2. Examine how these business models evolve over time;
3. Evaluate the impact of various business models on bank profitability, risk taking and financial stability.

We present the results of an empirical analysis in which we use clustering algorithms to identify bank business models. This is augmented with a detailed analysis of the characteristics and dynamics of these business models. Specifically, we examine what types of bank choose to adopt certain business models, and whether and how often banks migrate to other business models. To achieve this, we collect and analyse the monthly balance sheets of all banks (including branches and subsidiaries of foreign banks) in South Africa between January 1993 and October 2022 using publicly

available data from the South African Reserve Bank (SARB 2022a). The balance sheet information available for all banks at individual bank level allows us to capture the business models of banks across the entire size distribution. As such, we augment prior evidence on other aspects of South African bank behaviour, which is for the most part focused on larger banks.

In the first stage of our empirical analysis, banks are clustered into different business models on the basis of the composition of their respective balance sheets. To do this, we execute the following steps:

- Select a set of input variables pertaining to bank activities and funding composition that reflect strategic managerial choices.
- Apply a clustering algorithm and run a series of trials using combinations of the selected input variables to identify distinct business models.
- Narrow the number of input variables based on how well identified clusters distinguish between various business models across our sample of banks.
- Produce a final set of clusters that defines the various business models.

When we have defined the various bank business models, we investigate heterogeneities across business models using a selection of balance sheet variables, comprising variables that proxy for the size of bank business activity as solvency risk, liquidity risk and loan concentration. Our findings suggest that:

- Bank business models in South Africa differ to a large extent as a result of how the banks are funded.
 - We find considerable heterogeneity across bank business models in terms of funding/liabilities.
- Bank business models are much more homogenous in terms of business activities related to bank assets (rather than liabilities).
 - The business activities of most business models focus on lending, while investment in securities is less prevalent.

- The six bank business models our study identifies also differ in terms of their size and risk profiles.
- Our analysis of the evolution of business models over time reveals interesting patterns:
 - Some banks exhibit stable business models and only rarely migrate to other business models, while other banks are more likely to transition.
 - Transitions between certain business models (such as from *wholesale* business model to *universal* and *investment*, and vice versa) are more common than others (such as transitions from the *interbank borrower* business model).
 - Overall, business model migration is moderate, with most banks settling on a specific type of business model over time.

The remainder of this paper is structured as follows. Section 2 provides a brief literature review on bank business models. Section 3 provides background to the present study and outlines the empirical methods used. In section 4 we present the empirical results. Section 5 provides a conclusion and a roadmap for further research.

2. Literature

Despite a common definition, business models have received intermittent attention over the years (Zott, Amit and Massa 2011; Baden-Fuller and Haefliger 2013). Common themes have emerged from the salient literature. First, business models constitute a unit of analysis in the evaluation of how firms create and capture value in the way they do business (Baden-Fuller and Haefliger 2013). Second, business models transcend product, firm, industry and networks in explaining firm performance, growth and competitive advantage (Zott, Amit and Massa 2011). Third, activities of the firm translate into variables used in the conceptualisation of business models (Shafer, Smith and Linder 2005). These common themes are evident to some degree in most recent research on business models.

Business models have also been applied in the literature to explain differences in bank performance. Early work on bank business models emphasises the identification of strategic groups (Passmore 1985; Amel and Rhoades 1988). Banks share structural

similarities (with regard to business activities, risk characteristics, risk of default, profitability or balance sheet structure) that can be used as a basis for classifying them in clusters of strategic groups commonly referred to as bank business models (Grossman and Scholz 2017). Banks with a similar business composition are identified as having the same business model. This allows for a more granular approach when comparing heterogeneities in the performance of firms within a specific industry.

Prior to the GFC, the share of non-interest income was used as a key distinguishing feature of bank business models. This reflected the declining popularity of the traditional retail model of financial intermediation as banks shifted to more complex business models involving the substantial generation of non-interest income through investment banking and trading activities (Bord and Santos 2012; Stiroh 2015). Generally, combining activities that generate interest and non-interest income is expected to diversify income streams and reduce risk, although evidence suggests that increasing the share of non-interest income offers benefit only at very low levels (Dermiguc-Kunt and Huizinga 2010) and that non-interest income derived from trading activities is volatile (DeYoung and Roland 2001; Stiroh 2004; Stiroh and Rumble 2006).

Business model analysis has advanced since the GFC, with researchers employing systematic quantitative approaches that use a myriad of input variables simultaneously. Researchers have sought to identify business models based on the asset and liability composition of banks (Ayadi et al. 2011, 2014, 2016, 2017; Roengpitya, Tarashev and Tsatsaronis 2014, 2017; Farnè and Vouldis 2021). The business models identified are then evaluated with respect to a broad set of performance, risk exposure, loan growth and internationalisation indicators. The approach focuses on balance sheet composition rather than bank revenue mix.

Cluster analysis of banks based on asset and liability composition has been used to evaluate the business models of European banks. The results of an early investigation suggest that European banks follow three bank business models: retail, investment

and wholesale (Ayadi et al. 2011).¹ More recent evaluations using larger samples of European banks converge on four business models: focused retail banks, diversified retail banks, investment banks and wholesale banks (Ayadi et al. 2014; Farnè and Vouldis 2021). Retail banks are found to have performed better during the GFC than their investment and wholesale counterparts. A comparison of business models based on bank risk shows that the diversified retail model performs better during a crisis, while the investment model carries higher risk and volatility (Ayadi et al. 2011; Roengpitya, Tarashev and Tsatsaronis 2017).

Cluster analysis has also been used to identify business models in the United States (US) banking sector. Based on business activities and funding strategies, four bank business models are identified in US banking. These are wholesale-oriented, retail (type I), retail (type II) and investment-oriented. The retail (type I) model exhibits greater diversification of business activities than the retail (type II) model and is more profitable than the other business models (Ayadi et al. 2017). An evaluation of the business models of cooperatives reveals three business models: retail type I, retail type II and retail type III. The retail type I and II business models focus on traditional deposit loan intermediation, while the retail type III business model has a higher share of interbank deposits and lending. Banks in the US rely heavily on deposit funding but differ in the share of assets they allocate to business activities and investments (Ayadi et al. 2017). An evaluation of the interaction between bank size and business models shows that the retail business model is popular among small- and medium-sized banks, while the wholesale-oriented business model is more popular among large banks.

The bank business models identified above do not differentiate between the effects of long-term and short-term management choices on the composition of assets and liabilities. Furthermore, the approach assumes business models are discrete groups. Mergaerts and Vander Vennet (2016) argue that long-term management choices are more significant in explaining variations between banks relative to changes within

¹ In essence, retail-based banks are active in lending to customers and fund their activities with customer deposits. Investment banks are active in substantial trading activities, in combination with other activities. Wholesale banks source most of their funding from wholesale debt markets.

banks. They identify business models based on factor analysis that can account for mixed business models. Their approach identifies two business models for European banks: retail and diversification. The retail business model performs better in the long run and is more stable. The performance of retail banks is driven by a reliance on customer deposits and higher capital ratios. The diversified model is most profitable.

The literature discussed thus far indicates the superior performance of the retail banking business model. Retail banks are more stable and were less likely to require support from taxpayer funds during the GFC. In contrast, wholesale banks performed worst during the GFC due to their reliance on short-term market funding. Investment banks perform better than wholesale banks but accumulate significant losses from trading activities. Hence, their performance is significantly below that of retail banks (Dermiguc-Kunt and Huizinga 2010; Ayadi et al. 2011; Beltratti and Stulz 2012; Köhler 2015; Roengpitya, Tarashev and Tsatsaronis 2017). However, there is evidence to suggest that the performance of the retail business model is not superior to other business models. Using a dataset covering 65 countries, Hryckiewicz and Kozłowski (2017) find that investment banks had the lowest individual risk during the GFC. The retail banking model has the worst performance in the post-GFC period (Bonaccorsi di Patti, Felici and Signoretti 2016; Hryckiewicz and Kozłowski 2017). The main factors driving bank profitability in the post-GFC period are economic growth, the yield curve, credit and sovereign default risk.

3. Research setting and empirical methods

3.1 Research setting

The banking industry in South Africa is the largest in Africa, with combined assets of R7 288 billion in January 2023, amounting to 110% of GDP (SARB 2023; S&P Global Ratings 2024). As of January 2023, there were 18 registered banks in South Africa, 4 mutual banks, 5 co-operative banks, 12 local branches of foreign offices and 30 foreign banks with approved local representative offices (SARB 2023). The sector is highly concentrated, with the largest five banks (Standard Bank, First National Bank, Absa, Nedbank and Capitec) accounting for 90% of the banking system's total assets. The sector has consolidated, with a resultant decline in the number of banks over the past decade from 41 in 2001 to 18 at the end of 2021. These banks are supervised by the

Financial Sector Conduct Authority (FSCA) and the Prudential Authority (PA) of the SARB.

In the early 2000s, South Africa introduced the Basel framework (Basel I) as part of its efforts to strengthen its banking system and align with global practices in international bank regulation. In 2007, South Africa adopted Basel II, a set of international banking regulations passed by the Basel Committee on Banking Supervision. Basel II introduced new requirements for bank capital, risk management and disclosure, with the aim of promoting greater stability and transparency in the banking system. For South Africa, Liu and Seeiso (2012) find that Basel II behaves more procyclically than Basel I. In 2011, South Africa also adopted Basel III – a set of regulatory standards developed in response to the GFC. Basel III introduced new requirements for bank capital, liquidity and leverage to further enhance the resilience of the banking system.

The South African banking system weathered the GFC relatively well (although a sharp decline in commodity prices led to a sharp reduction in GDP growth, followed by an increase in reported impaired loans by non-financial firms and households; the banking sector was subsequently impacted by an increase in credit losses and a decline in profitability). This was in part due to the country's conservative banking practices and strong regulatory framework. During the GFC, South Africa's major banks remained well-capitalised and maintained high levels of liquidity. They also had relatively low levels of exposure to the US subprime market that caused distress through much of the global financial system. Like many central banks, the SARB implemented a number of support measures, including liquidity assistance and the lowering of interest rates. As a result, the South African banking system did not experience any major bank failures.

Nevertheless, banking supervision and regulation in South Africa underwent major reforms following the GFC (for a review, see Abugre et al. 2022). For instance, South Africa introduced its Twin Peaks regulatory framework for financial services in 2018. The framework is based on the idea of two pillars of regulation, with each pillar responsible for different aspects of financial regulation to enhance accountability and transparency and to prevent regulatory overlap. With the introduction of the Twin Peaks model, a new prudential regulator, the PA, and a new market conduct regulator,

the FSCA, were created. The SARB acts as the PA and oversees the safety and soundness of financial institutions. The PA is responsible for the prudential regulation and supervision of financial institutions. The FSCA is responsible for protecting consumers, market conduct regulation and supervision of all financial institutions, including banks, insurers and other financial service providers.

The South African banking system, like many banking systems in the world, was affected by the COVID-19 pandemic. As elsewhere, a key change brought about by social distancing measures during the pandemic was a significant increase in the use of digital banking channels, such as mobile and online banking (Carletti et al. 2020). This led to an increase in the demand for digital banking services and accelerated the plans of South African banks to introduce new digital services and enhance existing ones. The pandemic was also marked by an increase in loan defaults, as many individuals were made redundant or faced a reduction in income. Rising loan defaults put pressure on bank profitability, which was further constrained by the low interest rate environment.

To support the economy during the pandemic, the SARB cut interest rates several times between March 2020 and March 2021. While this reduced borrowing costs for bank customers, it also put pressure on bank profitability. To alleviate some of the pressure on banks, the SARB made a number of regulatory changes. These measures included lower capital requirements, additional liquidity provision, a lowering of reporting requirements and extended reporting deadlines, advice on prudent dividend distributions, payment holidays for bank customers and the introduction of a \$10 billion credit guarantee scheme for businesses (SARB 2021, 2022b).

Given the major reforms in South African banking, particularly after the GFC, and the differing degrees to which banks with different business models (as reviewed in the literature) contribute to systemic risk, it is important to conduct an in-depth empirical analysis of bank business models to inform policies on safety and soundness in the financial sector. The next section discusses the methodology used to identify bank business models.

3.2 Selected characteristics of the South African banking sector

Banking ecosystem in South Africa

The banking sector in South Africa compares favourably with banking sectors in many developed countries given its mix of domestic banks with international offices and foreign banks that operate through either a branch or representative office (Mboweni 2004). Commercial banks are the most prevalent financial institution in South Africa. They are organised under controlling companies that manage and direct their activities as set out by the Financial Institutions Amendment Act 101 of 1976 (Verhoef 2009). Financial services are also provided through mutual banks and cooperative banks.

The entities that make up the banking sector are governed by different statutes. Commercial banks initially performed the functions of deposit-taking and lending. However, due to stringent requirements introduced by the Banks Act 38 of 1942 relating to capital, liquidity and reserve requirements, commercial banks diversified their operations into other areas, such as leasing, hire purchase and the provision of short-term credit (Verhoef 2009).² The operations of commercial banks in these different business segments are consolidated under controlling companies (Singleton and Verhoef 2010). Modern-day commercial banks in South Africa conduct business in corporate banking, retail banking, wealth management, private banking, micro lending, commercial property finance and trade finance (Verhoef 2009).

The restrictions on foreign bank operations in South Africa were lifted after the abolition of apartheid in 1994. Under the terms of the Deposit-taking Institutions Act 94 of 1990 (later amended through the Banks Amendment Act 26 of 1994), foreign banks are permitted to conduct business via a branch or a representative office (Singleton and Verhoef 2010). A foreign institution opening a branch can carry out the business of banking normally carried out by incumbent commercial banks. Branches of foreign banks are limited to wealth management, mergers and acquisition advisory services

² The Banks Act 23 of 1965 sought to reclassify banks according to functional operations: commercial banks, merchant banks, hire purchase banks, discount houses, general banks and savings banks. However, commercial banks expanded their operations into hire purchase, leasing and the provision of short-term credit through their controlling companies, which acquired controlling shares in the intermediaries offering such services.

and brokerage. Representative offices of foreign banks do not typically engage in banking activities but instead serve as a point of contact with the parent of the foreign bank.

Mutual banks primarily serve the needs of their members by accepting deposits and extending loans (especially mortgages). These banks are regulated through the Mutual Banks Act of 1993. Cooperative banks offer deposit taking, money transfer, trust and custody services and lending services to members. They are smaller in size than commercial banks, in part due to their cooperative structure, which constrains their ability to raise capital. The Co-operatives Act 14 of 2005 (later amended through the Co-operative Act 6 of 2013) sets out the functions of cooperative banks and cooperative financial institutions.

Number of banks and branches

The end of South Africa's isolation from global markets in 1994 brought about significant changes in the banking sector as the country transitioned from apartheid-era policies to a more open and globally integrated economy. Restrictions on the participation of foreign banks were lifted to align South Africa with the global market (Verhoef 2009). Subsequently, foreign banks were permitted to operate in South Africa either through branches or representative offices, resulting in the entry of several international banks into the country. The number of banks increased from 1994 until 2000 (Hawkins 2004), with 31 foreign banks opening local registered offices and foreign bank branches increasing from 4 to 15.

A banking crisis that commenced in 2001 led to a notable decline in the number of small- and medium-sized banks. These banks either failed, deregistered or were acquired by larger banks. The crisis was triggered by an announcement by one of the largest banks (Absa) of losses in its microlending subsidiary (Unifer) of R1.7 billion, eroding the group's capital by 10.9% (Havemann 2020). Many small and medium banks pursuing a similar lending model also failed. South Africa's seventh-largest bank (Saambou Bank) failed in February 2002 and was followed by 12 small banks that same year (Hawkins 2004). Other small banks, such as Imperial Bank, Mercantile Lisbon and McCarthy Bank, were acquired by larger banks. Four additional banks

chose not to renew their licences as depositors became reluctant to place deposits with them (Mboweni 2003). At the end of 2002, the number of banks in South Africa had declined by 28% (Hawkins 2004).

The GFC contributed to a decline in the number of banks and a reconfiguration of the banking industry. The number of representative offices of foreign banks had increased to 46 by 2007 but declined to 41 by 2010 and to 31 by 2017 (SARB 2017). This decline suggests that some foreign banks operating through representative offices chose to cease operations in South Africa. Branches of foreign banks also declined from 14 in 2007 to 13 in 2010. This is in part attributed to the acquisition of ABN AMRO Bank NV, Johannesburg branch by the Royal Bank of Scotland NV. The number of local commercial banks decreased from 19 in 2007 to 17 in 2010. Imperial Bank Limited was acquired by Nedbank in 2010 (SARB 2010a). Figure A1 in the Annexures shows the number of banks from 1995 to 2017.

Size developments

The aggregate assets of the banking sector in South Africa increased by 138%, from R344.6 billion in 1994 to R819.2 billion in 2000 (Mboweni 2004; SARB 2002). Aggregate total assets experienced modest growth between 2001 and 2002, a period marked by the failure of numerous small and medium banks. Aggregate total assets only increased by 5% in 2002, from R1 050 billion in 2001 to R1 100.8 billion (SARB 2002). Prior to the onset of the GFC, aggregate total assets had reached R2 075.1 billion. By 2008, aggregate total assets had increased to R3 177 billion (SARB 2009a). However, the turmoil was clearly visible by 2009, when aggregate total assets declined by 6.6% to R2 967 billion (SARB 2009a).

The importance of the banking sector in South Africa is also reflected in its size relative to GDP. Aggregate banking sector assets relative to GDP stood at 55% in 1994 and at 71.9% in 2001 and declined to 55.8% in 2002. However, aggregate banking sector assets relative to GDP stood at 71.5% of GDP in 2006 and increased to 76% in 2007 and to 76.3% in 2009. While banking sector assets declined between 2008 and 2009, GDP growth was negative (-1.8%) during this period. The improvement in the ratio of aggregate assets to GDP during this period thus partly reflects the downward pressure

on GDP (Kumbirai and Webb 2010). Figure A2 in the Annexures shows the aggregate assets of banks relative to GDP.

Market structure

The banking sector in South Africa is dominated by a small number of large banks and is consequently highly concentrated. Imperial (mostly British) banks have dominated the banking industry since the discovery of minerals in the country in 1860. The profits accumulated by these banks were used to further increase their size via the external acquisition of local banks (Jones 1998). Banking crises between 1865 and 1890 further reduced the number of local banks, while British banks survived via strong ties to London (Verhoef 2009). By the start of the 19th century, British Standard Bank and Barclays Bank controlled 90% of the industry (Verhoef 2009). This domination of the banking sector led to an increase in rivalry between British and Afrikaner interests, and several financial entities were established to promote Afrikaner interests and participate in the banking industry (Jones 1998). The largest conglomerates to emerge were Nedsual and Volkskas. Together with two British banks (Standard Bank and Barclays), these conglomerates have dominated the banking sector post-1994 (Singleton and Verhoef 2010).

These four largest banks have faced increasing rivalry from foreign banks and niche players since 1994. After foreign banks were allowed to participate in the banking sector in South Africa, the market share of the top four banks declined from 84% in 1994 to 75% in 2001 (Hawkins 2004). After 2002, a period characterised by the failure and acquisition of many small and medium banks, the market share of the four largest banks again exceeded 80% – where it remains (Simatele 2015). While foreign banks and niche players have made significant gains in market share after changes in regulation, they participate primarily in the corporate and high net-worth market segments. This is in large part because these banks were prohibited by regulation from opening accounts for natural persons with deposits of less than R1 million (Verhoef 2009). The retail market segment has remained under the control of the four largest banks (Competition Commission of South Africa 2008), each controlling one or more retail segments (credit cards, current accounts, mortgage lending, leasing and instalment sales).

Concentration

Industry concentration is commonly measured using the Herfindahl-Hirschman Index (HHI), which considers both the number and size distribution of banks. It is calculated by squaring the market share of each bank (determined by total assets) and then summing the squared values (SARB 2011a). The SARB considers the banking sector to be highly concentrated when the HHI exceeds 0.18 (SARB 2011a). The entry of foreign banks and niche players post-apartheid reduced concentration from 0.17 in 1995 to 0.136 in 1998 (Simatele 2015). The HHI remained stable between 1998 and 2001 and increased after the failure and forced acquisition of many small and medium banks in 2002. In 2002, the HHI again reached the levels observed before the liberalisation of the banking industry, indicating that consolidation had taken place (Mboweni 2003). The HHI stood at 0.175 after the merger of one of the four largest banks (Nedcor) with Board of Executors (Hawkins 2004). During the GFC, concentration in South Africa's banking sector reached a level that is considered highly concentrated. The HHI exceeded 0.18 between 2007 and 2009 but declined to 0.17 in 2015. Figure A3 shows the evolution of industry concentration between 2002 and 2020.

Competition in the South African banking sector

Competition plays a crucial role in the banking sector and has far-reaching implications for capital allocation, consumer welfare, monetary policy and innovation. Banks intermediate between savers and borrowers, and competition in the banking sector ensures that the allocation of funds is efficient and benefits the overall economy. An uncompetitive banking industry can hamper economic growth and development by restricting the ability of businesses to access finance for productive investment opportunities (Claessens and Laeven 2004). This is particularly acute in economies where banks are the main providers of finance. Competition compels banks to become more efficient, leading to gains for customers by way of reduced fees and better services (Mlambo and Ncube 2011). An uncompetitive banking environment may also hamper the effectiveness of monetary policy that seeks to control financial prices and quantities, as banks may be unresponsive to such policies. A competitive environment

can spur innovation, resulting in products that better address the needs of customers (Organisation for Economic Co-operation and Development 2009).

The structure-conduct-performance hypothesis suggests that competition is likely to be lower where there is high concentration. This has raised concerns of possible anti-competitive behaviour among the largest banks. Two inquiries consequently investigated competition (or lack thereof) in the South African banking industry. The Banking Enquiry of 2008 was commissioned by the Competition Authority as an extension of the work done by the 2004 task force group appointed by National Treasury to look at competition in South Africa's banking industry (Competition Commission of South Africa 2008). These studies focus on the market structure and general performance of South African banks. Overall, their findings show that large banks in South Africa avoid vigorous competition on product pricing. Consequently, new banks are unable to compete with incumbents in all but small niche areas.

The investigations into banking competition in South Africa did not find evidence that any of the four large banks acted individually as a monopoly. However, the investigations concluded that together the four banks behave as a complex monopoly. In particular, the ability of the four large banks to maintain stable returns on equity over the business cycle pointed to the use of market power to extract desired earnings from bank charges by increasing the charges to make up for any shortfall in net interest income at times of downward pressure. The fees charged by banks were not solely indicative of costs; they also indicated the structure of the industry, market power of the major banks, barriers to entry and difficulties in achieving economies of scale. These inquiries also found that disclosure requirements on interest rates on lending, bank charges and interest payable on savings accounts were not adequate and hampered customers' ability to compare bank products. The findings also show that the banks implemented complex pricing structures to determine fees, which served to lock in customers and discourage competition.

Asset and liability structure

Financial intermediaries perform a critical function in the financial system by facilitating the flow of funds from savers to borrowers. The core functions of financial

intermediaries in the process of intermediation are reflected in aggregate asset and liability categories.

The assets of South African banks comprise mainly gross loans and advances, investments, and trading securities (mainly government and government securities) and short-term negotiable securities (SARB 2022b). Loans and advances form the core of banking sector assets in South Africa. Gross loans and advances declined by 2.6%, from R2 316 billion in 2008 to R2 257 billion in 2009 (SARB 2009b, 2010b). While households were reluctant to borrow given the worsening conditions in the domestic market, banks also tightened lending standards (SARB 2010c). Home loans and term loans form the largest component of gross loans, accounting for 50% in total; lease and instalment debtors represent 10.5% of all gross loans and advances; and commercial mortgages represent 9.7% of gross loans and advances. Gross loans and advances further declined by 3.2% in 2010 (SARB 2010b, 2011b).

On the liability side, deposits are the main source of funding. Deposits are considered a more stable source of funding than short-term wholesale funding, making them a reliable source of liquidity for banks. Prior to the GFC, deposits formed 65.2% of all banking sector funding (SARB 2009b). At the end of 2009, total deposits constituted 85.4% of all banking sector liabilities. Deposits from corporate customers comprised 42.6% of all deposits, followed by deposits from retail customers (22.3%) and interbank deposits (13.7%).

Profit and loss structure

Earnings in the banking sector are a critical component of banking sector stability. Good banking sector earnings enable banks to withstand losses, maintain capital adequacy and support lending activities.

Driven by the downturn in domestic economic conditions, banking sector profitability declined between 2008 and 2010. Operating profit declined by 19%, from R44 billion in 2008 to R35.5 billion in 2009 (SARB 2009b, 2010b). While gross income received a significant boost from non-interest income, which increased by 6% to R75.6 billion in 2009 from R71.4 billion in 2008, interest income decreased by 5% over the same

period. Operating profit was weighed down by a rise in credit losses and operating expenses (SARB 2009b). Credit losses for which specific impairment was raised increased by 20%, from R29.7 billion in 2008 to R35.5 billion in 2009 (SARB 2009b, 2010b). Operating expenses increased by 4% to R76.5 billion in 2009 from R73.4 billion in 2008. There was an improvement in banking sector profitability in 2010 as credit losses declined (SARB 2010c).

3.3 Research methods

Stage one of our empirical analysis identifies the business models used by banks in South Africa. Cluster analysis is commonly used to identify business models in the literature on bank business models (e.g. Ayadi et al. 2014). The cluster analysis approach typically comprises four steps, which we follow in the present study. In the first step, we select input variables with the potential to differentiate bank business models. We start with a set of eight input variables pertaining to bank activities and funding compositions that reflect strategic managerial choices. In the second step, we apply a cluster algorithm and run three trials using different combinations of these input variables. In the third step, we decrease the number of input variables based on how well the clusters identified by the algorithm distinguish between different groups of banks. In the fourth and final step, we compare and contrast the identified set of business models by looking at several outcome variables.

Step 1: Selection of input variables for cluster approach

Following the literature on bank business models (e.g. Roengpitya, Tarashev and Tsatsaronis 2017), we choose eight balance sheet ratios most commonly used in studies of bank business models as the input variables for our cluster analysis. These variables comprise four items from the asset side and four items from the liability side of bank balance sheets. Specifically, we select *gross loans*, *trade book*, *trade* and *interbank borrowing* as well as *interbank lending*, *wholesale debt*, *stable funding* and *retail deposits*. All inputs are expressed as a share of total assets. For full definitions, see Table 1. We regard these variables as reflecting a set of long-term, strategic managerial choices. *Gross loans*, defined as gross loans to total assets, captures the extent to which a bank engages in traditional banking activities centred around the issuance of loans. The input variables *trade book* and *trade* both capture the extent to

which banks are exposed to trading; while *trade book* comprises securities held for trading, *trade* captures investment in securities. *Interbank borrowing* and *interbank lending* both capture the extent to which banks borrow from or lend to other banks. *Interbank borrowing*, together with other liability-side input variables such as *wholesale debt*, *stable funding* and *retail deposits*, give an indication of how banks choose to be funded. *Wholesale debt* is defined as the sum of other deposits, short-term borrowing and long-term funding as a share of total assets. To construct the variable *stable funds*, we use the sum of customer deposits and longer-term funding to total assets. For *retail deposits* we focus exclusively on retail deposits. Our funding variables partly overlap but are well suited to capture banks' exposure to various funding sources. This is also reflected in the correlation matrix (see Table 2), which shows that some of the funding variables have correlations of 50% or higher.

Step 2: Trial runs

We run three trials using different combinations of the input variables. The first trial, Trial A, uses all eight input variables. In Trial B, we use six of the eight input variables, excluding *trade book* and *stable funds* from the original set of input variables. Trial B uses *gross loans*, *securities*, *interbank lending*, *interbank borrowing*, *wholesale debt* and *retail deposits* as inputs. In Trial C, we use four of the eight input variables, excluding *trade book*, *interbank lending*, *stable funds* and *interbank borrowing*. Trial C uses *gross loans*, *securities*, *wholesale debt* and *retail deposits* as inputs.

To conduct our three trials, we rely on Ward's statistical classification algorithm (Ward 1963), which uses a clustering technique to group observations (e.g. bank-month pair) into clusters based on a number of ex ante bank-level characteristics. As a stopping rule, we use the pseudo F-index developed by Calinski and Harabasz (1974). Observations share similarities within their assigned cluster but differ across clusters. The clusters identified using the stopping rule are used to allocate banks to business models.

Step 3: Allocation of banks to business models

While most of the clustering approach is data-driven, it also contains some judgemental elements (Roengpitya, Tarashev and Tsatsaronis 2017). The

researchers' judgement is key to determining how well the clusters obtained from the cluster analysis describe and discriminate between various bank business models. Banks allocated to the same cluster should share some similarities that are in part determined through the combination of input variables. For instance, a cluster may describe a group of banks whose business model is based predominantly on wholesale funding with a strong emphasis on trading activities, or it may identify a group of banks that are more oriented toward retail funding and lending.

Step 4: Characteristics of business models

In the final step, we analyse bank business models by comparing and contrasting bank business models on several outcome variables. This typically entails a comparison of key characteristics from bank income statements. However, given current data limitations, we are not in a position to compare the performance, costs or diversification of income sources of the set of our identified business models. As this information is not available to us, we choose as alternative attributes the following six variables: size of the business, size of affiliated businesses, market share, liquidity, solvency and asset concentration. We define the size of the business as a bank's total assets (in millions of rands) and the size of affiliates as the sum of equity holdings in subsidiaries and associates. These two variables capture the actual size of the business and the extent to which the affiliates constitute a significant part of the business. We define market share as the size of the bank (in total assets) relative to the market (sum of total assets of all banks). We use this variable as a crude proxy for bank market power and systemic relevance.

Next, we include several risk measures. We use liquidity, defined as cash as a share of total assets. This variable captures how liquid a bank is. The variable solvency is defined as bank equity capital as a share of total assets and indicates the level of capitalisation of the bank. Finally, we use loan concentration, a proxy for the concentration across loan categories, using the HHI. We calculate the index as the sum of the square of each loan category expressed as a share of total assets. The dataset comprises 10 different loan categories, including credit cards, mortgage advances and foreign currency loans. On the basis of this set of attributes, we discuss where business models are distinctively different and where they overlap. This allows

us to better isolate and understand certain characteristics related to the size and risk of these business models.

We calculate additional risk and performance measures. Numerous empirical studies have used methods based on accounting ratios, such as non-performing loans to total loans, due to their simplicity and the widespread availability of data (Mare, Moreira and Rossi 2017). We use loan loss provisioning, defined as the ratio of credit losses to total loans, and loan growth, defined as the percentage change in total loans. Another widely employed and more comprehensive accounting ratio is the Z-score (Lepetit and Strobel 2013, 2015). In its unaltered state, the Z-score serves as a solvency metric that indicates the likelihood of an individual financial institution experiencing losses greater than its capital base. A higher Z-score signifies a reduced risk of insolvency, indicating enhanced stability, while a lower Z-score suggests heightened instability and an increased risk of insolvency. The Z-score integrates information on performance (e.g. return on assets (ROA)), leverage (equity to assets) and risk (standard deviation of ROA). A financial institution is deemed less stable or closer to insolvency if it exhibits poor performance, is inadequately capitalised or demonstrates greater variation in returns. The Z-score is calculated as the sum of the ROA and the capital ratio, all divided by the variability of the ROA.

To measure bank performance, we use net interest margin, ROA, return on equity (ROE) and efficiency. The net interest margin is a financial metric that captures the difference between the interest income a financial institution earns from its interest-earning assets (such as loans and investments) and the interest expenses it incurs on its interest-bearing liabilities (such as deposits and borrowings). In essence, it represents the net interest income generated by the institution as a percentage of its interest-earning assets. ROE and ROA are key financial metrics used to assess the profitability and efficiency of a bank. ROE measures a bank's profitability by evaluating how well it generates a return on shareholders' equity – a higher ROE is generally considered favourable as it indicates efficient use of equity capital. ROA helps gauge the efficiency of a bank in generating profits relative to the size of its asset base – a higher ROA suggests better use of assets to generate earnings. The efficiency ratio, defined as operating expenses over revenue ratio, is a financial metric that measures the cost-effectiveness of a financial institution in relation to its revenue. A lower

efficiency ratio is generally considered more favourable, as it indicates that a smaller proportion of the revenue is being consumed by operating expenses. In contrast, a higher efficiency ratio suggests that a significant portion of the revenue is being used to cover operating costs, potentially signalling reduced cost-effectiveness.

4. Data and business model allocation

4.1 Data

To analyse bank business models in South Africa, we collect monthly bank balance sheets from the SARB's Banking Sector Information (Form BD900) between January 1993 and October 2022 (SARB 2022a). The SARB first made this balance sheet data publicly available in January 1993, and October 2022 was the last month of data available when this project was started. This dataset has two major advantages. First, the balance sheet information is available for all banks at individual bank level, which allows us to capture the business models of banks across the entire size distribution rather than having to focus on large banks only. Second, the balance sheets provide detailed information on different asset and liability sub-categories, which facilitates our experimentation with various input trials to estimate bank business models.

4.2 Business model allocation

4.2.1 Trial run analysis

In this section we describe the three trial runs (see section 3.2) and discuss their outputs. The objective of running trials is to eliminate cluster outputs that do not discriminate well among different groups of banks. In Trial A (see Report Trial A in the Annexures) we make use of all eight input variables (see Table 3 for input definitions), and the cluster algorithm returns only two clusters. The summary statistics (illustrated by radar charts shown in Report Trial A for easier interpretation) suggest that the two clusters are distinctively different from one another. In Trial B (see Report Trial B in the Annexures), we drop two input variables, one from each side of the balance sheet. Our decision to drop *trade book* (asset side) is based on the observation that the variable appears to have little relevance to discriminating clusters in Trial A. Our decision to drop *stable funding* (liability side) is based on the high correlation (correlation coefficient > 0.99, Table 2) and similarity of this input with *retail deposits*.

In running Trial B, we are presented with six individual clusters. Summary statistics and radar charts suggest that the six identified clusters are fairly distinctive, suggesting that a set of two clusters (as returned by Trial A) may be too limited to satisfactorily discriminate the business models of South African banks. We complete our trial-based approach with Trial C (see Report Trial C in the Annexures for more details), in which we drop two additional variables from the set of input variables. Specifically, we drop *interbank lending* and *interbank borrowing*. This leaves us with four input variables that capture bank activities associated with the traditional intermediation function of banks (issuing loans financed by deposits) and the extent to which banks deviate from these activities by investing in securities or by being funded by wholesale debt.

Trial C returns a set of four distinct clusters. Summary statistics and radar charts indicate that Clusters 1 and 3 are similar in their attribute structure, a pattern we also observe for clusters in Trial B. Notably, some of the distinct clusters identified in Trial B appear to be unidentified in Trial C. For instance, in Trial B, Cluster 6 describes a cluster of banks predominantly funded via the interbank market. Dropping interbank market input variables from the list of input variables results in the loss of this fairly distinctive business model.

Overall, our analysis of the cluster patterns returned by our three trial runs suggests that the approach taken in Trial B captures most accurately any clusters that are present in our dataset of South African banks.

4.2.2 Business model allocation

Having successfully identified an appropriate cluster approach through our trial runs, we allocate banks to their business models. As a first step, we group and name our six clusters using business model categories commonly used in the literature on bank business models.

Our bank business model allocation and summary statistics and radar charts are reported in Box 1. The first business model we identify is categorised as *wholesale*. Banks in this category are primarily financed by wholesale funds and to a lesser extent by retail deposits. Cluster 1 of Trial B best fits this category. Banks in this business

model are funded by both retail deposits and wholesale debt and engage in lending as well as trading. Banks in Cluster 2 are characterised by a strong tendency to funding based on retail deposits and engage in both lending and trading activities. As such, Cluster 2 banks are identified as *retail* banks. Having assigned Cluster 1 and Cluster 2 to the universal and retail business models, we assign Clusters 3, 4 and 5. Cluster 3 demonstrates a strong tendency to trading activities and relies on wholesale funding, albeit to a lesser extent than Clusters 1 and 2. Banks in Cluster 3 best fit the category of *investment-oriented* banks. Banks in Cluster 4 engage in lending as well as trading activities and are funded by retail deposits, wholesale and interbank markets. We consider Cluster 4 to best fit the category of *universal* banks. Clusters 5 and 6 are much more integrated with the interbank market. Banks in Cluster 5 strongly engage with interbank markets as lenders. We refer to this cluster as the *interbank lender* business model. Conversely, banks in Cluster 6 have a strong tendency to interbank borrowing to fund business activities, and we refer to this as the *interbank borrower* business model.

We summarise our allocated business models and their corresponding clusters as follows: Cluster 1 – *wholesale-funded* banks; Cluster 2 – *retail-deposit-funded* banks; Cluster 3 – *investment-oriented* banks; Cluster 4 – *universal* banks; Cluster 5 – *interbank lender*; Cluster 6 – *interbank borrower*.

4.2.3 Business model description

In the following section, we provide a more detailed discussion of each business model, using the 12 outcome variables related to business size and risk (see section 3.3) to compare bank business models. Our discussion centres on findings reported in Tables 3 and 4 and elements from our earlier allocation of business models. Table 3 reports the summary statistics of the outcome variables for each cluster. Table 4 reports the ownership and subsidiary and branch structures of the business models.

Wholesale (Cluster 1)

This business model is funded by both wholesale and retail deposits, but with a stronger tendency to wholesale debt. Banks in this cluster are fairly large, which is reflected in their market presence. These banks count among the second lowest in

terms of capitalisation but have a more moderate risk profile with regard to liquidity risk and loan concentration. Wholesale banks have the highest Z-score among the six business models, indicating overall low risk. Loan growth and loan loss provisioning are comparable to investment and universal banks. Ownership forms that operate under the wholesale business model are fairly balanced. Domestic banks make up a share of 57.2%, while foreign banks' share is 42.8%. Of foreign wholesale banks, 40.9% choose to operate as a branch, while 59.1% operate as a subsidiary. As shown in Figure 1, Panel A, risk (as measured by the Z-score) of the average bank in the wholesale business model saw an overall improvement (albeit from an already relatively high level) from 2010. Other characteristics remained fairly stable between 2008 and 2020 (see Panels A and B).

Retail (Cluster 2)

Like the previous business model, the retail-oriented business model is characterised by its use of both retail deposits and wholesale debt, but with a stronger tendency to retail deposits. Banks in this business model are much smaller, which is also reflected in a much lower market share. These banks count among the most liquid of the identified business models and have fairly average capitalisation and loan-concentration risk profiles. Retail banks have the highest loan loss provisioning rate among the six business models. Their overall risk as indicated by the Z-score is relatively moderate. Retail banks have the lowest loan growth (negative) and highest net interest margin, which reflects their retail-oriented business. The retail model is primarily populated by domestic banks (68.5%), with foreign banks making up only 31.5% of the model. Foreign retail banks operate exclusively under a subsidiary structure. As shown in Figure 1, Panel A, the average bank in the retail business model saw a steep improvement in overall risk (Z-score) from 2010. Loan growth and loan concentration declined slightly, while loan loss provisioning increased. Retail banks significantly improved their capital and liquidity positions, which is also reflected in higher net interest margins, ROA and ROE (see Panel B). In terms of efficiency, retail banks remained fairly consistent between 2008 and 2020 but continued to incur high operating expenses relative to total revenue.

Investment (Cluster 3)

Banks in this cluster are characterised by their orientation to trading activities. These banks have considerable affiliated business but are generally fairly average in size and have much less exposure to lending activities. As shown in Figure 1, Panel A, the average bank in this business model has not grown much in size over time. In terms of risk, investment-oriented banks have average capitalisation and liquidity but are among the banks with a fairly low loan concentration. Banks that operate as investment banks have the lowest Z-score, indicating relatively high risks compared to other business models. Investment-oriented banks are primarily of foreign ownership (64.4%), with 97.6% of these foreign investment banks operating under a branch structure. As shown in Figure 1, Panel A, the average bank in the investment business model saw a relatively steep drop in capital (solvency) in 2012. Overall risk (as measured by the Z-score) has improved steadily since 2009 but remains at relatively low levels. Returns on assets and equity have declined since 2017, in line with a drop in efficiency (Panel B).

Universal (Cluster 4)

Banks in this cluster are funded by wholesale debt and retail deposits and engage in lending as well as trading activities. In terms of size, these banks count among the second largest but are far from the business size of wholesale-funded banks. Again, this is reflected in their market share, where they are the second-largest banks. Notably, universal banks have the largest affiliated business among the business models, suggesting that banks that use this business model have considerably higher holdings of subsidiaries and associates. In terms of risks, universal banks have average capitalisation and are considerably liquid. They also have high loan concentration relative to other bank business models. Universal banks have the second lowest Z-score, indicating relatively high risks. However, universal banks count among the most efficient of the six business models. Foreign banks dominate the universal business model cluster (79.6%), while domestic banks are less likely to operate under this model (20.4%). Foreign banks that adopt the universal model typically operate under a branch structure. As shown in Figure 1, Panel A, universal banks improved their solvency from 2016 after several years of downward-trending capital ratios. The loan concentration of universal banks rose sharply from 2017. ROA

and equity declined steadily between 2008 and 2020 (see Panel B). The efficiency of universal banks also improved sharply after 2017.

Interbank lender (Cluster 5)

Banks in this category are well integrated with the interbank market and act primarily as lenders in this market. They are the smallest in terms of overall business size and affiliated business size. Banks in this cluster are the most capitalised but the least liquid. These banks have a fairly high concentrated loan portfolio. The interbank lender has a high growth in loans and a moderate loan loss provisioning rate. The Z-score is relatively high, indicating low risk. The interbank lender is the least efficient and has negative ROA and ROE. Banks that operate as interbank lenders are typically of foreign ownership (72.9%) in the form of a branch.

Interbank borrower (Cluster 6)

The interbank borrower business model is characterised by banks that source most of their funding from interbank markets. In terms of size, these banks are the third largest, which is reflected in their market share. They are the least well-capitalised banks and are fairly liquid. Notably, these banks have the most concentrated loan portfolio. Banks that adopt the interbank borrower business model are of both domestic ownership (57.7%) and foreign ownership (42.3%).

5. Business model migration

5.1 Literature

Our analysis of bank business models is thus far quite static and does not provide insights into how banks choose business models over time. Most bank business model studies do not consider business model dynamics, with the exception of recent studies by Roengpitya, Tarashev and Tsatsaronis (2017), Ayadi et al. (2021) and Joao et al. (2022). Roengpitya, Tarashev and Tsatsaronis (2017) use a sample of 178 banks across 34 countries between 2005 and 2015 to identify and track the evolution of bank business models. The authors identify four business models, comprising retail 1 (retail banking business model using deposits to fund lending); retail 2 (retail banking business model using wholesale funding to fund lending); trading (large securities portfolios funded by interbank and wholesale borrowing); and universal (a business

model encompassing the characteristics of the retail 1, retail 2 and trading business models). The authors observe that few banks transition in or out of the trading business model. Most transition (especially in the post-GFC period) is from the retail 2 to the retail 1 business model.

Ayadi et al. (2021) evaluate the impacts of bank business model transitions in the European banking industry between 2010 and 2017. The authors identify five business models, comprising focused retail (using deposits as primary source to extend loans); diversified retail I (retail-oriented, but with more asset-side diversification than focused retail banks); diversified retail 2 (retail-oriented, but with more liability-side diversification than focused retail banks); wholesale (wholesale-oriented and reliant on interbank loan markets); and investment (substantial trading and investment banking activities). These business models are generally stable over the sample period. However, where transition does take place, it appears to be driven by size (smaller banks were more likely to change business model than their larger counterparts), profitability (less-profitable banks were more likely to switch business model than their better-performing counterparts) and risk (riskier banks were more likely to change their business model than their less-risky counterparts).

Joao et al. (2022) investigate the evolution of bank business models for a sample of 299 European banks between 2008Q1 and 2018Q2. The authors identify six business models, comprising domestic retail lending; fee-focused retail lending; market-oriented universal banking; international corporate lending; domestic diversified; and international diversified lending. The authors observe that over the period investigated, the international diversified lending and domestic retail lending business models grew in importance, while the market-oriented universal banking, international corporate lending and domestic diversified business models declined in importance. The importance of the fee-focused retail lending model remained relatively unchanged. Business model transitions were driven primarily by profitability and capital considerations.

5.2 Patterns in business model migration

Adopting a more dynamic approach can provide important insights into how bank business models evolve in response to crises, fluctuations in economic activity, entry into the market of foreign banks, geographic expansion and industry consolidation.

To examine how business models have developed over time in South Africa and whether banks migrate across bank business models, we follow Ayadi et al. (2021) and track the business model of each bank. We start by reporting bank business model transitions for each of the 43 banks between 1993 and 2022 (Figure 2). For ease of interpretation and space, we consider only business models as observed at year end and disregard any intra-year business transitions. From Figure 2, we observe that some banks have fairly stable business models and rarely migrate to other business models, while other banks are more likely to transition. The pattern of less-frequent to no migration is particularly present among the largest domestic banks, such as Absa, Nedbank and Firststrand. On average, this group of banks tends to engage very little in business model migration from one year to another. This finding is in line with those presented by Ayadi et al. (2021), which finds that large European banks are the least likely to migrate business models.³

To examine transition patterns in a more systematic way, we next use a business model transition chart (Figure 3), which maps the transitions across business models and their rate of occurrence. To produce the chart we consider all transitions (inter-year as well as intra-year) between January 1993 and October 2022.⁴ The transition chart provides us with more detailed insights into patterns of in- and out-migration. From Figure 3, we observe that transitions between certain business models happen more frequently than transitions between other business models. For instance, banks of the wholesale business model are more likely to transition to business models

³ Joao et al. (2022) find that European banks frequently change business models. The contrasting findings likely result from differences in the choice of input variables used to identify bank business models. Like this study, Ayadi et al. (2021) rely exclusively on bank balance sheet data, whereas Joao et al. (2022) use income statement data to identify differences in bank business models (e.g. fee-based income versus interest-based income).

⁴ We calculate the rate of occurrence of a business model transition as the number of transitions from one business model to another (e.g. wholesale to investment) divided by the total number of transitions during the sample period.

classified as universal and investment and vice versa. Here, the rates of occurrence range from 10.7% to 15.5%. Transitions across other business models occur at much more moderate rates and typically range between 3% and 6%. We do not observe any transition pattern for some business models. For instance, the interbank borrower business model displays one of the lowest in-migration rates (banks transitioning into the business model at a rate of 1.1%) and presents no out-migration. Overall, the chart shows that the migration tendency of banks in South Africa is fairly moderate and that migration is limited to a few business models. The occurrence rates peak at a maximum of 15.5%, suggesting that business model migration is moderate. This finding is in line with Ayadi et al. (2021), who find that European banks change business models infrequently and that migration is limited to a few business models.

We next examine the occurrence of business model migration patterns across time to determine whether business model migration is more likely to occur during certain periods. Figure 4 plots the total number of business model migrations observed in a given year between 1993 and 2022, showing two peaks of business model migration frequency. The first peak is around 2000 and is preceded by a period of ever-more frequent business model transitions. The second, lower peak occurs around the time of the GFC. This period was marked by many bank failures and by international banks pulling out of foreign markets. Finally, for the COVID period, we observe little business model migration activity. Overall, the patterns we observe in Figure 4 suggest that a number of bank-specific as well as non-bank factors are likely to determine business model migration.

Next, we look at bank-specific factors that may explain the drivers of business model transitions. We first look at foreign versus domestic banks and then at subsidiaries and branches. Figure 5, Panel A, shows the number of transitions in a given year for domestic and foreign banks. Foreign banks are clearly more likely to migrate business models than domestic banks. Panel B shows that migration is more likely to occur in branches than in subsidiaries. This suggests that foreign branches – which are typically more legally integrated with the parent bank and are subject to centralised liquidity and capital management – may pursue strategic business model transitions dictated by the needs of the international group. Subsidiaries, on the other hand, may operate more independently from the parent and act more like domestic banks, which show a much

lower tendency to change business models. Figure 5, Panel A, also shows that in the aftermath of the GFC in 2008, foreign banks changed their business model less frequently, while domestic banks changed their business model more frequently.

We complete our analysis by looking at business model popularity over time. Figure 6 plots the share of banks (relative to the total number of banks) that have adopted one of the six identified business models at time t . We observe that the share of banks adopting the wholesale model declines after the GFC but the share of banks adopting the investment model increases. These trends are clearly driven by foreign banks. The share of domestic banks remains relatively more stable over time across the two business models.

5.3 Business model migration, performance and risk

As a final step, we examine the link between bank risk, performance characteristics and business model migration. To investigate this link, we use a probit model and estimate the following equation:

$$Pr(BMM_{i,t} = 1) = f(\alpha_0 + \alpha_1 X_{i,t-1} + \epsilon_{i,t})$$

where i ($= 1, \dots, N$) is the bank (N is the number of banks), t ($= 1993m1, \dots, 2022m10$) is the index representing the month, $BMM_{i,t}$ is a variable that is equal to the value of one if a bank changes the business model and to zero otherwise. Following Ayadi et al. (2021), we only consider longer-term changes (> 1 quarter) in business models and drop short-term migrations between business models (< 1 month). $Pr(\cdot)$ is the probability that $BMM_{i,t}$ takes the value of one, and the function f represents the cumulative distribution function of the standard normal distribution. The main test variables are $X_{i,t-1}$, comprised of the following attributes: solvency, liquidity, asset concentration, loan loss provisioning, Z-score, loan growth, net interest margin, ROA, ROE and efficiency. Our empirical approach uses lagged test variables for solvency, liquidity, asset concentration, loan loss provisioning, Z-score, loan growth, net interest margin, ROA, ROE and efficiency to mitigate endogeneity concerns arising from reverse causality. Table 1 presents definitions of the variables used.

Table 5 reports the results. The coefficient of the Z-score is negative and statistically significant at the 5% level. The coefficients for asset concentration and net interest margin are weakly statistically significant, while other coefficients are not statistically significant. The results suggest that higher risk and asset concentration, as well as higher margins from interest-related activities, are associated with changes in business models.

6. Summary of results and policy discussion

After the GFC, supervisors adopted business model analysis (BMA) to proactively assess banks' sustainability. BMA is a crucial part of supervisory frameworks and helps bank supervisory authorities identify vulnerabilities early, ensuring the financial sector's safety and soundness. BMA assesses the extent to which strategic decisions taken by banks are consistent with risk appetite, resource allocation and execution. BMAs have microprudential implications, enabling bank supervisors to adjust strategies for sustainability, and macroprudential implications, informing system-wide policies to address structural issues and maintain financial stability. Comprehensive BMA frameworks have an understanding of a bank's income sources, expense levels, growth strategy and risk management.

An effective BMA framework relies on the availability of detailed and high-quality data, as well as robust data aggregation capabilities and expert judgement. This framework is built on the premise that banks can generate and consolidate financial data across the entire banking group, including each main business unit and line. These data encompass recent performance and profitability information, forming the basis for an evaluation of a bank's capacity to fairly compensate stakeholders and sustain balanced future development. Additionally, some data points are forward-looking, reflecting the bank's adaptability and potential advantages in the face of changes. Regardless of the nature of the information, a successful BMA involves a combination of quantitative and qualitative assessments.

Authorities structure BMAs differently within their supervisory frameworks, which affects their capacity to act based on BMA findings. A key distinction lies in how business risk is identified and evaluated. In some jurisdictions, business risk is treated as a distinct element in the supervisory review process, assessed at the overall bank

or group level. Other jurisdictions opt to evaluate business risk separately for each individual business line, alongside assessments of governance and risk management specific to that activity. While both approaches have their merits, incorporating business risk as a standalone element in the supervisory review process appears to facilitate early supervisory intervention. This is because it establishes a more direct link between shortcomings in banks' business models and the potential consequences for their safety and soundness.

In this paper we present the findings of an analysis of business models used by South African banks, using a comprehensive dataset sourced from the website of the SARB. Our analysis identifies six clusters among commercial banks based on their business model: *wholesale*, *retail*, *investment*, *universal*, *interbank lending-oriented* and *interbank borrowing-oriented*. We find considerable heterogeneity across bank business models in terms of funding. In terms of business activities related to bank assets, bank business models are much more homogenous. The business activities of most business models focus on lending, while investment in securities is less prevalent.

One of our main objectives was to examine how banks generate profits and manage risks. After scrutinising historical data pertaining to revenue sources, operational expenditures, their distributions, and economic capital allotments across the six business models, we find considerable differences in terms of performance and risks. The following list provides a brief overview of the key characteristics of the identified business models.

Cluster 1: *wholesale*

- Funded by both wholesale and retail deposits, leaning towards wholesale.
- Fairly large banks with strong market presence.
- Second-lowest in capitalisation but moderate risk profile in liquidity and loan concentration.
- Highest Z-score among the six models, indicating low overall risk.
- Commonly a balanced mix of domestic and foreign ownership.

Cluster 2: *retail*

- Relies on both retail deposits and wholesale debt, with a tendency to the former.
- Smaller banks with a lower market share.
- Most liquid of the business models, average risk profiles in capitalisation and loan concentration.
- Highest loan loss provisioning rate, moderate overall risk indicated by Z-score.
- Dominated by domestic banks, with a smaller share of foreign banks operating solely as subsidiaries.

Cluster 3: *investment*

- Primarily oriented towards trading activities, less exposure to lending.
- Average-sized banks with considerable affiliated business.
- Average capitalisation and liquidity, low loan concentration – but lowest Z-score, indicating higher risk.
- Predominantly foreign-owned, with the majority operating as branches.

Cluster 4: *universal*

- Funded by wholesale debt and retail deposits, involved in both lending and trading.
- Second-largest banks, with a considerable market share.
- Fairly average capitalisation, high liquidity, loan concentration.
- Second-lowest Z-score, indicating relatively high risks, but considered among the most efficient.
- Dominated by foreign banks, especially operating as branches.

Cluster 5: *interbank lender*

- Well-integrated with the interbank market, acting primarily as lenders.
- Smallest banks in terms of overall business size.
- Most capitalised but least liquid, with a concentrated loan portfolio.

- High growth in loans, moderate loan loss provisioning rate and a relatively high Z-score, indicating low risk.
- Mostly foreign-owned, typically in the form of branches.

Cluster 6: *interbank borrower*

- Banks source most funding from interbank markets.
- Third largest in size, with a moderate market share.
- Least well-capitalised, fairly liquid and the most concentrated loan portfolio.
- A mix of domestic and foreign ownership.

We observe that some banks have fairly stable business models and rarely migrate to other business models, while other banks are more likely to transition. The pattern of less-frequent to no migration is particularly present among the largest domestic banks, such as Absa, Nedbank and FirstRand. On average, this group of banks engages in very little business model migration from one year to another. Foreign banks are also more likely to migrate business models than domestic banks. We further observe two peaks of business model migration frequency, around the year 2000 and around the time of the GFC. Overall, our analysis indicates that the migration tendency of banks in South Africa is moderate and limited to a few business models and periods. Using a probit regression model, we observe that riskier banks and banks with higher net interest margins are more likely to transition between business models.

The analysis presented in this paper has revealed that each bank business model has distinct funding and risk profiles – an insight that improves our understanding of the dynamics of South African banks.

Tables and figures

Table 1: Definitions of variables

Variable name	Definition	Data source
Gross loans	Loans plus loan loss reserves as a share of total assets	SARB website
Securities	The sum of trading assets and liabilities net of derivatives, as a share of total assets	SARB website
Trade book	The sum of trading securities as a share of total assets	SARB website
Interbank lending	The sum of loans and advances to banks, reverse repos and cash collateral, as a share of total assets	SARB website
Interbank borrowing	Deposits from banks plus repos and cash collateral, as a share of total assets	SARB website
Wholesale debt	The sum of other deposits, short-term borrowing and long-term funding, as a share of total assets	SARB website
Stable funding	The sum of total customer deposits and long-term funding, as a share of total assets	SARB website
Deposits	Retail deposits, as a share of total assets	SARB website
Size	Total assets (in millions of rands)	SARB website
Size of affiliated business	Sum of equity holdings in subsidiaries and in associates including joint ventures, as a share of total assets	SARB website
Market share	Total assets relative to market assets (sum of total assets of all banks)	SARB website
Solvency	Equity capital as a share of total assets	SARB website
Liquidity	Cash as a share of total assets	SARB website
Loan concentration	Herfindahl-Hirschman Index: sum of the square of each loan category (loan1 to loan10) as a share of total assets	SARB website
Loan loss provisions	Credit losses/total loans	SARB dataset
Z-score	$(ROA+CAR)/\sigma ROA$ σROA : over three periods	SARB dataset & website
Loan growth	$(\text{Loan current period} - \text{loan previous period})/\text{loan previous period}$	SARB website
Net interest margin	Net interest income/total assets	SARB dataset
ROA	Return on assets, net income/total assets	SARB dataset & website
ROE	Return on equity, net income/equity	SARB dataset & website
Efficiency	Operating expenses/total revenue	SARB dataset & website

Table 2: Correlation matrix of input variables

	Gross loans	Trade	Trade book	Interbank lending	Interbank borrowing	Wholesale debt	Stable funding	Retail deposits
Gross loans	1.0000							
Trade	-0.0688	1.0000						
Trade book	-0.2929	0.0225	1.0000					
Interbank lending	0.1751	-0.0140	-0.0853	1.0000				
Interbank borrowing	0.1274	-0.0290	-0.0201	-0.0973	1.0000			
Wholesale debt	0.1044	0.0809	-0.1213	-0.0421	-0.3297	1.0000		
Stable funding	0.0837	0.0642	-0.2265	-0.0188	-0.2336	0.5973	1.0000	
Retail deposits	0.0675	0.0640	-0.2210	-0.0156	-0.2360	0.5952	0.9908	1.0000

Note: This table reports the correlation coefficients for the eight variables used as inputs for the cluster analysis.

Table 3: Summary statistics for each business model

Variables	Wholesale		Retail		Investment		Universal		Interbank lender		Interbank borrower	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
<i>Size</i>												
Business size	14 294	28 861	669	1 954	4 417	11 661	814	1 433	302	647	1 581	1 813
Affiliated bus. size	0.41	1.11	0.26	0.55	1.64	5.12	0.71	4.15	0.09	0.69	0.29	0.71
Market share	0.52	0.79	0.01	0.03	0.16	0.42	0.03	0.04	0.02	0.03	0.06	0.05
<i>Risk</i>												
Solvency	10.28	7.76	14.72	9.03	15.42	16.50	17.32	13.65	38.31	31.33	7.38	3.60
Liquidity	2.26	1.63	3.67	4.55	2.17	3.35	1.82	1.55	1.37	2.67	1.77	0.72
Loan concentration	28.44	13.77	28.86	12.38	13.17	8.26	39.60	19.21	44.43	21.38	49.97	7.87
LLP*	0.08	0.20	0.32	1.70	0.05	0.24	0.04	0.22	0.13	0.08	-	-
Z-score*	3.27	2.19	2.85	2.45	2.08	2.16	2.14	1.72	3.00	3.27	-	-
Loan growth	1.71	8.19	-0.06	5.28	1.56	17.03	1.74	9.75	3.35	1.71	-	-
<i>Performance</i>												
Net interest margin*	0.29	0.30	0.64	0.34	0.14	0.25	0.22	0.31	0.55	0.424	-	-
Return on assets*	0.16	0.27	0.15	0.41	0.00	1.13	0.16	0.37	-0.60	4.621	-	-
Return on equity*	1.42	2.54	0.94	2.74	0.83	2.69	0.86	1.61	-0.97	6.991	-	-
Efficiency*	51.46	338.5	69.45	19.47	71.43	977.5	39.57	92.51	218.9	653.7	-	-

Note: This table provides the summary statistics (mean and standard deviation (SD)) of the six outcome variables for each cluster: size of the business, size of affiliated businesses, market share, liquidity, solvency and asset concentration. The size of the business is defined as a bank's total assets (in millions of rands) and the size of affiliates is defined as the sum of equity holdings in subsidiaries and associates. Market share is defined as the size of the bank (in total assets) relative to the market (sum of total assets of all banks). Liquidity is defined as cash as a share of total assets. Solvency is defined as bank equity capital as a share of total assets. Loan concentration is measured using the Herfindahl-Hirschman Index. We calculated the index as the sum of the square of each loan category expressed as a share of total assets. We use 10 different loan categories, including credit cards, mortgage advances and foreign currency loans. LLPs are loan loss provisions, defined as credit losses to total loans. The Z-score is the sum of ROA (return on assets) and CAR (capital ratio: capital/total assets). The sum is divided by the volatility of ROA. Volatility is measured over a period of three months. The Z-score measures the bank's distance to default – a higher value indicates lower risk. Loan growth is the monthly percentage change in loans. Net interest margin is defined as net interest income to total assets. Return on assets is defined as net income to total assets, and return on equity is net income to equity. Efficiency is defined as operating expenses to total revenue. See Table 1 for definitions of the variables. Variables with a * are calculated based on income statement data from 2008 to 2018. The business model "interbank borrower" was not observed during that time period.

Table 4: Table 4: Foreign ownership and subsidiary/branch status of each business model

	Wholesale	Retail	Investment	Universal	Interbank lending	Interbank borrowing
Domestic	57.2%	68.5%	35.6%	20.4%	27.1%	57.7%
Foreign	42.8%	31.5%	64.4%	79.6%	72.9%	42.4%
Branch	40.9%	0.0%	97.6%	92.8%	98.4%	100.0%
Subsidiary	59.1%	100.0%	2.4%	7.2%	1.6%	0.0%

Note: This table shows the percentage of banks with domestic and foreign ownership in each of the six business models (top rows). The bottom row shows the percentage of foreign banks that operate as a subsidiary or a branch in each business model.

Table 5: Business model migration, performance and risk

Variables	BMM
Solvency	-0.0404 (0.0265)
Liquidity	0.0544 (0.0449)
Loan concentration	0.0276* (0.0157)
LLP	-0.941 (0.998)
Z-score (log)	-0.421** (0.167)
Loan growth	-0.00154 (0.0116)
Net interest margin	2.201* (1.131)
ROA	0.245 (0.777)
ROE	0.0158 (0.118)
Efficiency	0.000108 (0.000426)
Observations	1 990
Number of banks	17
LR chi2(10)	15.37
Prob > chi2	0.119

Note: This table shows the output of the probit model. See Section 5.3 for a discussion. See definitions of the variables in Table 1. Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

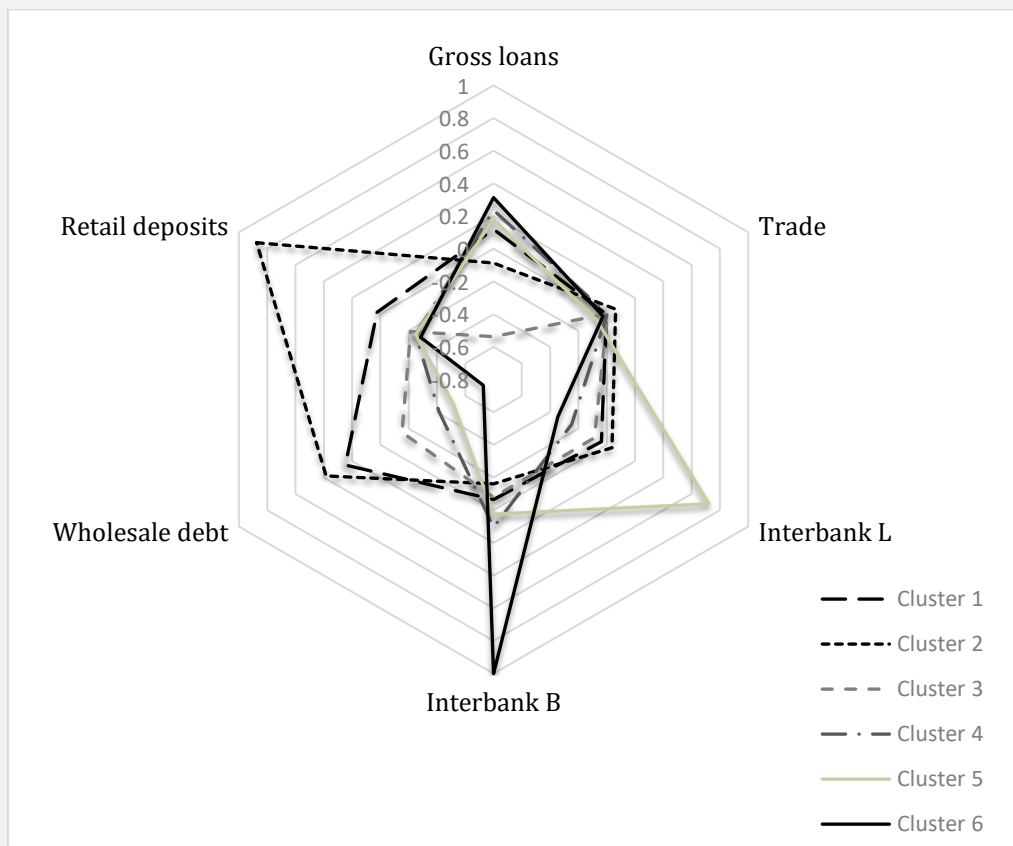
Box 1: Business model allocation

Summary statistics of input variables

Variables	Cluster 1		Cluster 2		Cluster 3		Cluster 4		Cluster 5		Cluster 6	
	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean
Gross loans	4 886	0.30	1 201	-0.22	2 062	-1.34	1 583	0.59	1 086	0.45	196	0.78
Trade	4 886	-0.01	1 201	0.16	2 062	0.02	1 583	0.01	1 086	-0.18	196	-0.07
Interb. lending	4 886	-0.10	1 201	0.09	2 062	-0.22	1 583	-0.62	1 086	1.80	196	-0.86
Interb. borrow	4 886	-0.16	1 201	-0.40	2 062	-0.20	1 583	0.26	1 086	0.06	196	2.50
Wholesale debt	4 886	0.62	1 201	0.96	2 062	-0.38	1 583	-1.03	1 086	-1.28	196	-1.82
Retail deposits	4 886	0.06	1 201	2.19	2 062	-0.53	1 583	-0.62	1 086	-0.62	196	-0.71

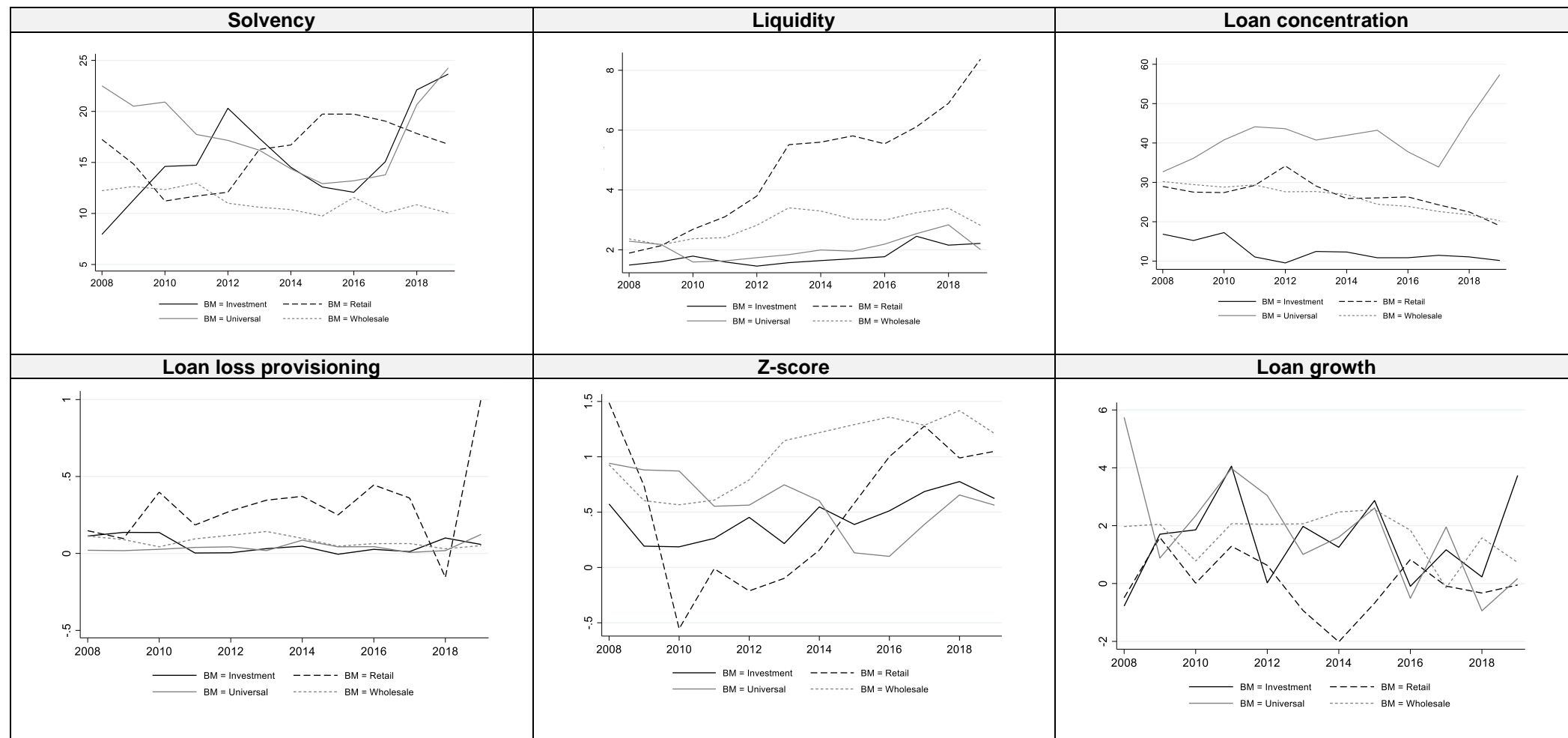
Note: This table provides information on the number of observations for each identified cluster and the standardised mean for each input variable. Trial B input variables: gross loan; trade; interbank lending; interbank borrowing; wholesale debt; retail deposits.

Radar chart



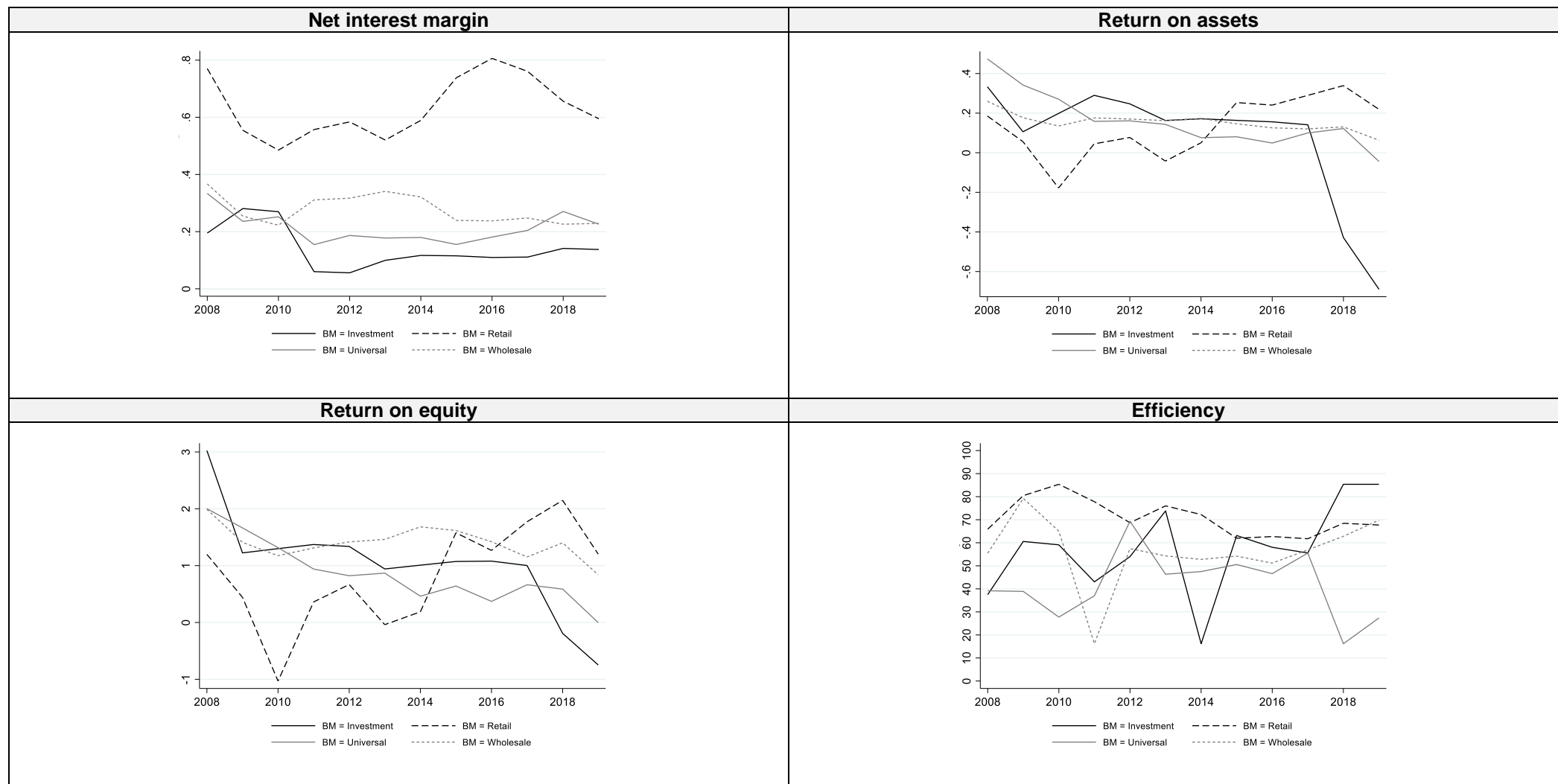
Note: This figure shows radar charts for each identified cluster. The radar charts map the *standardised* mean of the six input variables onto an axis. Higher values are located further toward the outer radars, while smaller values are located further toward the middle.

Figure 1 (Panel A): Key characteristics of business models 2008–2018



Note: This figure plots key characteristics by business models (wholesale, retail, investment, universal) from 2008 to 2018. Solvency is defined as bank equity capital as a share of total assets. Loan concentration is measured using the Herfindahl-Hirschman Index. We calculated the index as the sum of the square of each loan category expressed as a share of total assets. We use 10 different loan categories, including credit cards, mortgage advances and foreign currency loans. Loan loss provisions are defined as credit losses to total loans. The Z-score is the sum of ROA (return on assets) and CAR (capital ratio: capital/total assets). The sum is divided by the volatility of ROA. Volatility is measured over a period of three months. The Z-score measures the bank’s distance to default – a higher value indicates lower risk. Loan growth is the monthly percentage change in loans. Net interest margin is defined as net interest income to total assets. Return on assets is defined as net income to total assets, and return on equity is net income to equity. Efficiency is defined as operating expenses to total revenue. See Table 1 for definitions of the variables.

Figure 1 (Panel B): Key characteristics of business models 2008–2018



Note: This figure plots key characteristics by business models (wholesale, retail, investment, universal) from 2008 to 2018. Net interest margin is defined as net interest income to total assets. Return on assets is defined as net income to total assets, and return on equity is net income to equity. Efficiency is defined as operating expenses to total revenue. See Table 1 for definitions of the variables.

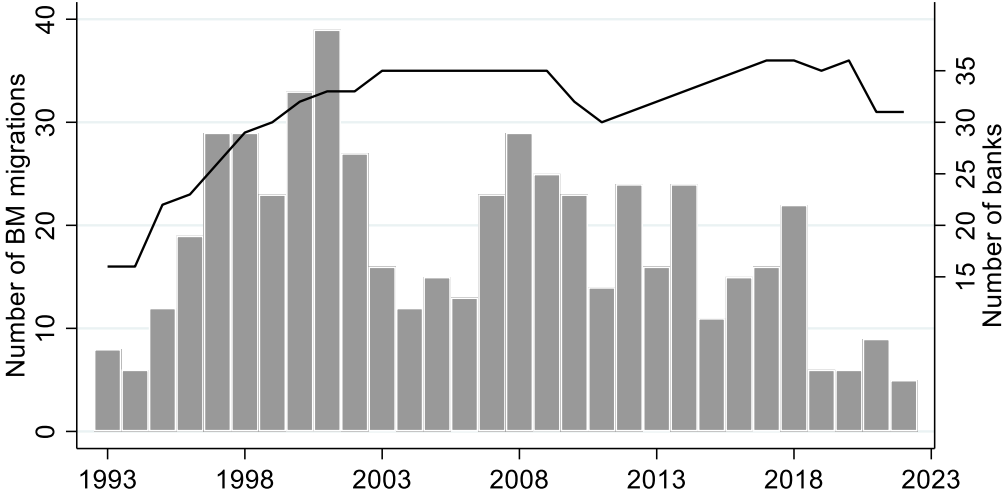
Figure 2: Bank-level business model migration, 1993–2022

Name	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	
Absa Bank Ltd	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
Nedbank Ltd	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
Mercantile Bank Ltd	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
Firststrand Bank Ltd	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	1	1	1	1	1	1	1	1	1	1	1	1	1	
The Standard Bank of South Africa Ltd	1	1	1	1	1	1	1	1	1	1	3	3	3	1	1	3	3	3	1	1	1	1	1	1	1	1	1	1	1	1	
Grobank Ltd	1	1	1	1	1	1	1	3	1	1	1	1	1	1	1	1	1	1	1	4	4	4	4	4	4	4	1	1	1	3	
African Bank Ltd	1	1	1	1	4	1	4	4	4	1	4	1	1	1	1	1	1	1	1	4	4	4	4	4	4						
Meeg Bank Ltd	1	1	4	1	1	1	1	1	1	1	1	1	1	1	1	1	1														
Al Baraka Bank Ltd	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
Bidvest Bank Ltd	2	2	2	2	2	2	2	2	5	5	5	5	5	4	4	4	4	1	3	3	3	3	3	3	3	3	3	3	3	2	
Habib Overseas Bank Ltd	3	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
Crédit Agricole Corporate and Investment Bank	3	3	3	1	5	1	5	5	5	1	1	1	1	1	1	3	3	3	3	3											
Investec Bank Ltd	3	3	3	3	1	3	3	3	3	3	1	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
Société Générale – Johannesburg Branch	4	5	5	5	4	1	4	1	1	5	6	1	1	1	5	5	5	5	5	5	5	5	3	3	3	3	3	3	3	3	
Bank of Taiwan – South Africa Branch	5	4	4	6	4	4	4	4	6	6	6	6	6	4	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	
GBS Bank	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
Grindrod Bank		5	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	
Imperial Bank Ltd				4	4	4	1	4	4	6	6	6	6	6	6	6	6	6	6												
Commerzbank Aktiengesellschaft				4	4	4	4	4	4	1	3	3	1	1	3	3	3														
HBZ Bank Ltd				5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
Citibank NA				5	1	1	4	4	4	3	1	1	1	1	1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	
The Royal Bank of Scotland				5	1	5	5	5	5	5	1	4	1	1	4	1	3														
VBS Mutual Bank				1	1	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1				
Regal Treasury Private Bank Ltd				5	5	5	1	4	2	2	2	2	2	2	2	2	2														
JP Morgan Chase Bank – Jbg Branch				5	5	1	5	1	5	1	3	3	3	3	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	
Bank of Baroda				5	5	4	5	5	5	5	5	5	5	5	1	1	1	1	1	1	1	1	1	1	1	1	4	4	4	4	
State Bank of India				5	5	5	5	4	5	4	5	4	4	4	4	4	4	4	1	4	4	4	4	4	4	4	4	4	4	4	
Capitec Bank				4	4	4	5	5	5	5	3	3	3	3	3	1	3	1	1	1	1	1	2	2	2	2	2	2	2	2	
Deutsche Bank AG				5	3	5	1	3	1	1	1	1	1	1	1	1	1	1	3	3	3	3	3	3	3	3	3	3	3	3	
Sasfin Bank Ltd				3	1	1	1	1	1	1	1	1	1	1	1	1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	
Bank of China Ltd – Johannesburg Branch							3	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	
China Construction Bank Corporation – Jbg Branch							5	5	4	4	4	4	4	4	4	4	4	1	4	1	4	4	3	4	3	3	3	3	3	3	
Ubank Ltd							5	5	5	5	5	5	5	5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Standard Chartered Bank							1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	3	3	3	3	3	3	3	
HSBC Bank Plc – Johannesburg Branch							4	4	4	4	4	4	4	4	4	4	4	1	3	3	3	3	3	3	3	3	3	3	3	3	
Finbond Mutual Bank																						3	2	2	2	2	2	2	2	2	
BNP Paribas – South Africa Branch																						5	5	5	3	3	3	3	3	3	
Bank of India – Johannesburg Branch																						5	5	5	5	5	5	5	5	5	
Canara Bank																							5	5	5	5	5	5	5	5	
lci Bank Ltd																							5	5	4	5	4	4	4	4	
African Bank Ltd																								5	5	4	4	4	4	4	
Tyme Bank Ltd																										3	3	3	2	2	
Discovery Bank Ltd																										3	3	3	2	2	

Wholesale 1
 Retail 2
 Investment 3
 Universal 4
 Interbank lender 5
 Interbank borrower 6

Note: This figure shows bank business model choice for individual banks between 1993 and 2022. The left-hand side lists the names of the banks. Different colours indicate business model choice in a given year (at year end). See legend for further details on business model type.

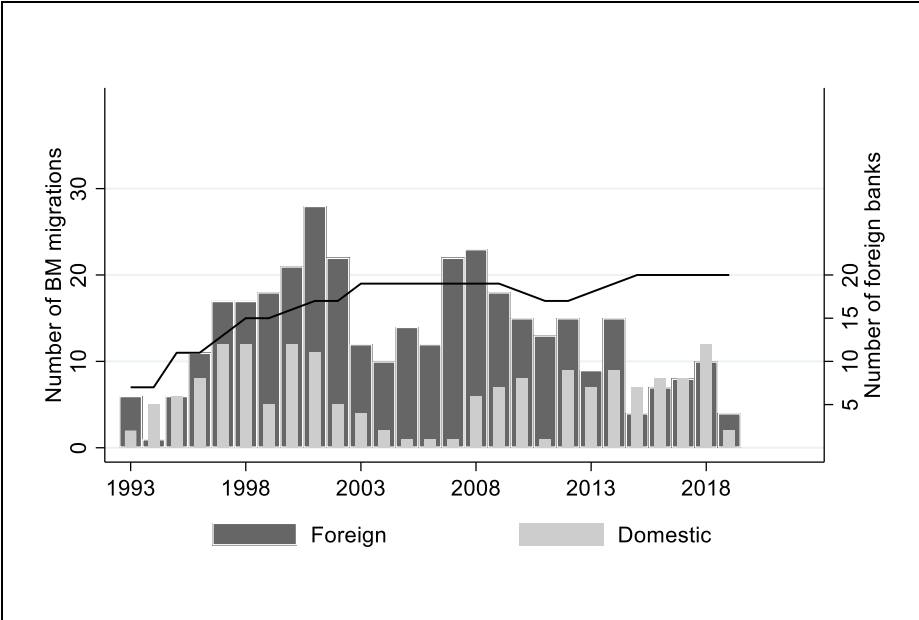
Figure 4: Number of business model migrations over time



Note: This figure shows the number of bank business model migrations per year for all banks from 1993 to 2022 (LHS, bar) and the number of banks (RHS, line).

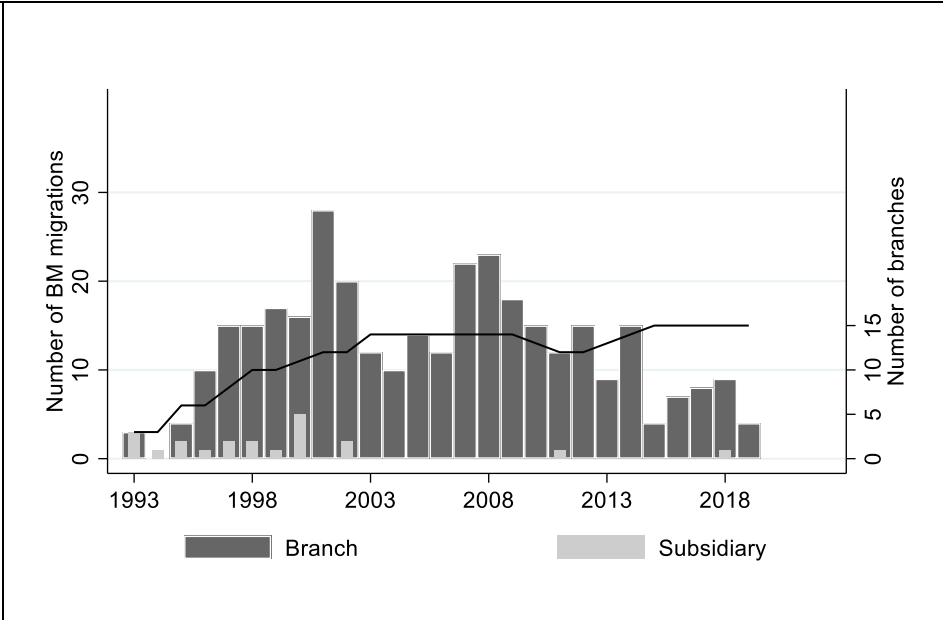
Figure 5: Business model migration over time by type of bank

Panel A



Note: Panel A shows the number of bank business model migrations per year for foreign and domestic banks from 1993 to 2018 (LHS, bar) and the number of foreign banks (RHS, line).

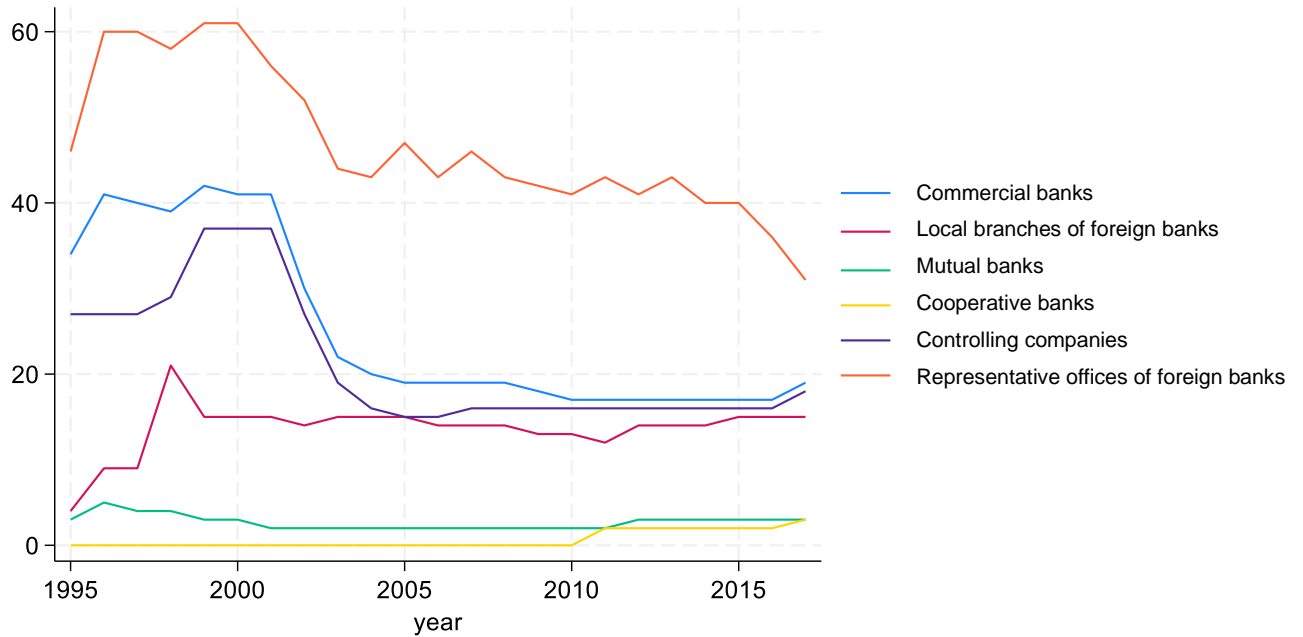
Panel B



Note: Panel B shows the number of bank business model migrations per year for branches and subsidiaries from 1993 to 2018 (LHS, bar) as well as the number of branches (RHS, line).

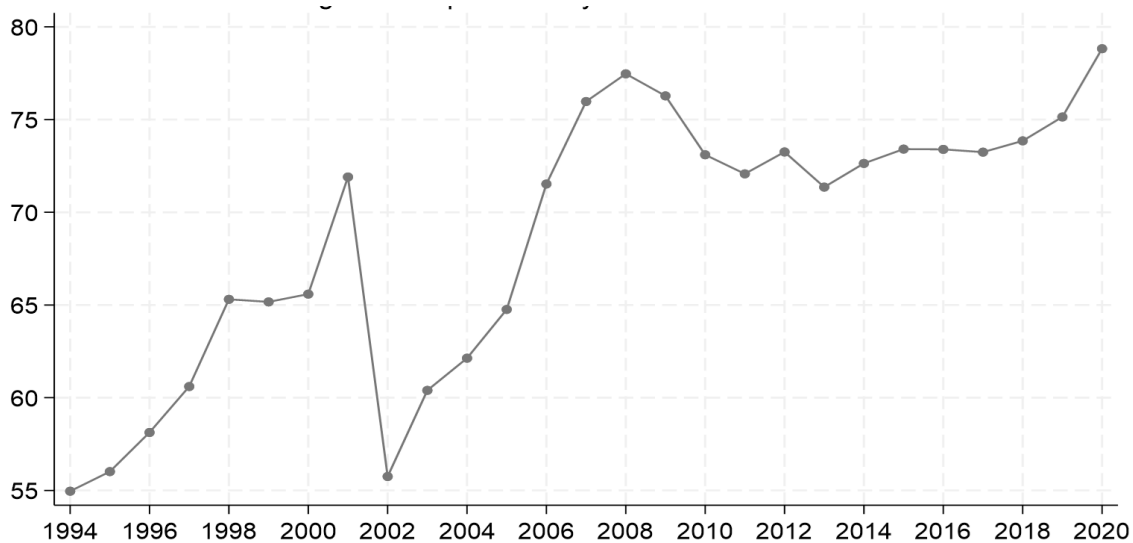
Appendix

Figure A1: South African banking sector – Number of registered entities



Note: This figure shows the number of registered entities (y-axis) between 1995 and 2020. Source: SARB BSD Annual Reports 1995–2020.

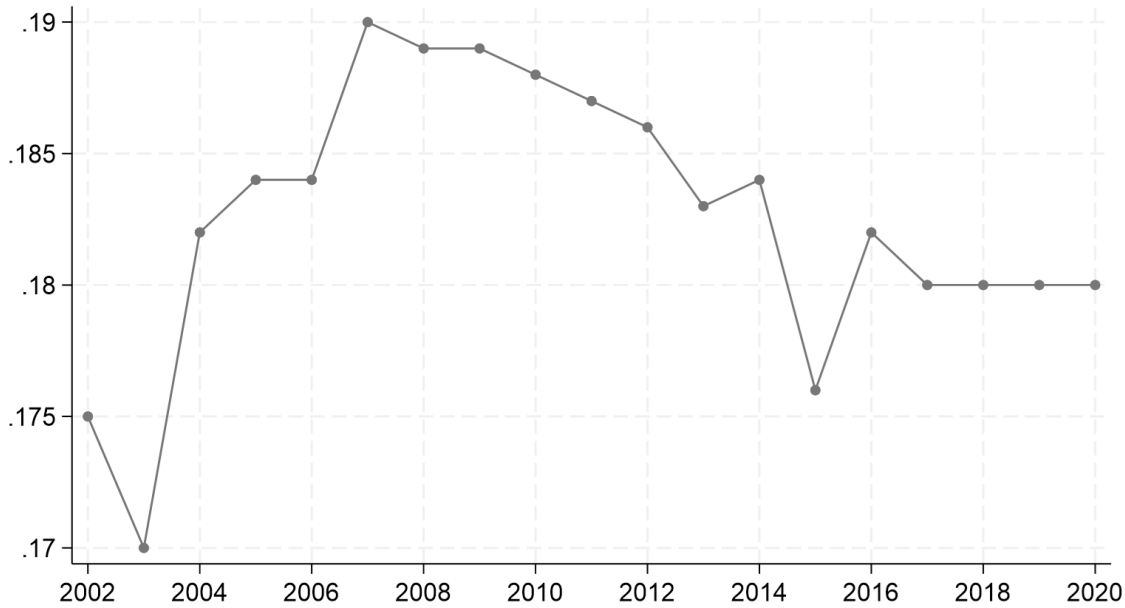
Figure A2: Bank assets to GDP



Note: This figure shows bank assets to GDP (in percent) for deposit money banks for the period 1994 to 2020. Deposit money banks comprise commercial banks and other financial institutions that accept transferable deposits such as demand deposits.

Source: IMF's International Financial Statistics. Deposit money bank assets (IFS lines 22, a–d, FOSAG, FOSAOG, FOSAON and FOSAOP); GDP in local currency (IFS line NGDP).

Figure A3: Concentration – Herfindahl-Hirschman Index (HHI)



Note: This figure shows the HHI for the South African banking sector between 2002 and 2020.
Source: IMF's International Financial Statistics.

Report: Trial A

Input variables

- Gross loan
- Trade
- Trade book
- Interbank lending
- Interbank borrowing
- Wholesale debt
- Stable funding
- Retail deposits

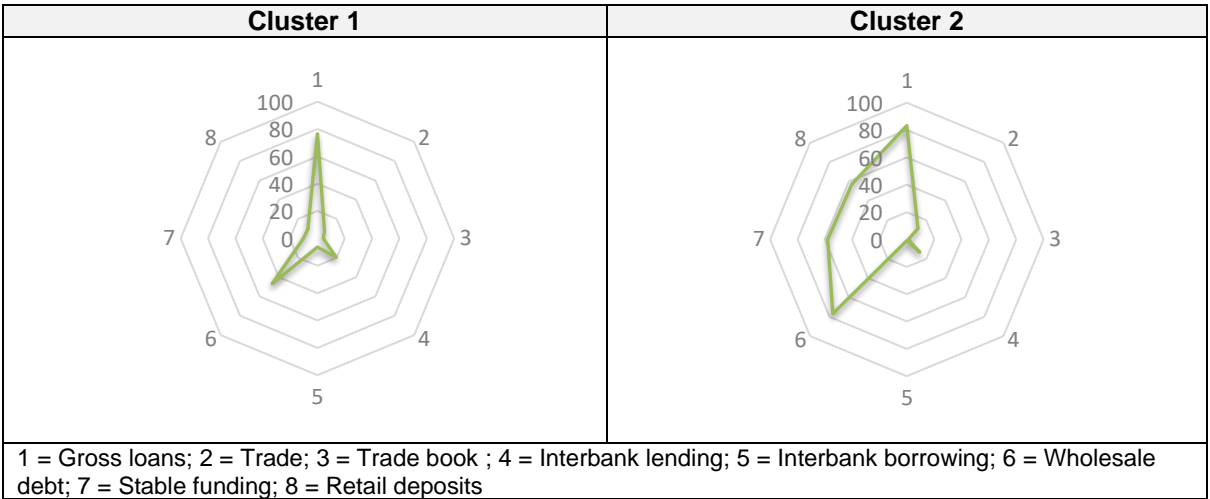
Identified clusters: 2

Summary statistics of input variables

Variables	Cluster 1		Cluster 2	
	N	Mean	N	Mean
Gross loan	8 202	76.49	2 812	83.25
Trade	8 202	7.307	2 812	11.40
Trade book	8 202	4.278	2 812	1.021
Interbank lending	8 202	19.53	2 812	13.31
Interbank borrowing	8 202	6.391	2 812	0.841
Wholesale debt	8 202	46.83	2 812	76.73
Stable funding	8 202	10.27	2 812	57.88
Retail deposits	8 202	9.943	2 812	57.08

This table provides information on the number of observations in each identified cluster and the mean for each input variable.

Radar charts



Note: This figure shows radar charts for each identified cluster using information from the above summary statistics table. The radar charts map the mean of the eight input variables onto an axis. Higher values are located further toward the outer radars, while smaller values are located further toward the middle.

Report: Trial B

Input variables

- Gross loan
- Trade
- Interbank lending
- Interbank borrowing
- Wholesale debt
- Retail deposits

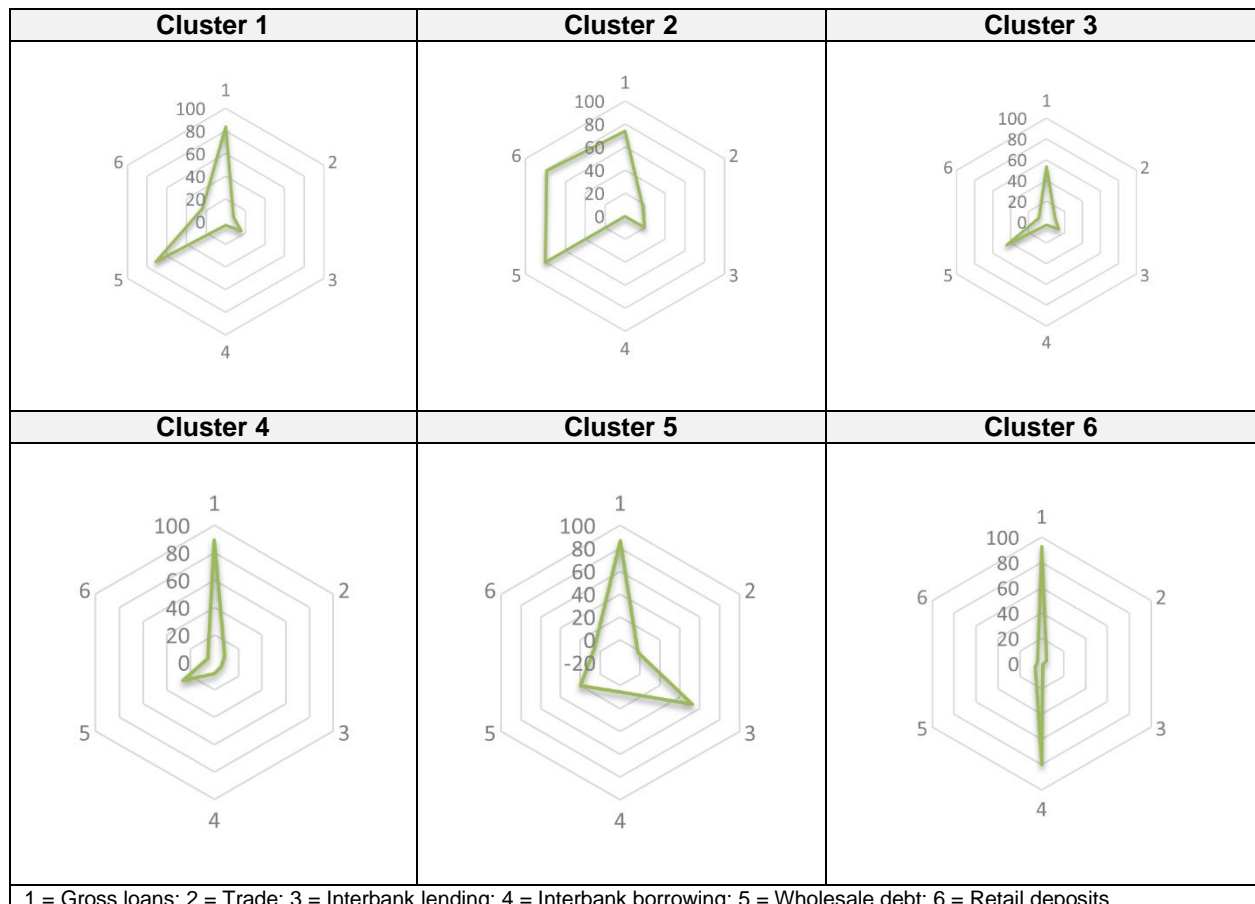
Identified clusters: 6

Summary statistics of input variables

Variables	Cluster 1		Cluster 2		Cluster 3		Cluster 4		Cluster 5		Cluster 6	
	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean
Gross loans	4 886	83.76	1 201	74.10	2 062	53.21	1 583	89.21	1 086	86.64	196	92.80
Trade	4 886	8.004	1 201	17.63	2 062	9.321	1 583	8.794	1 086	2.120	196	4.473
Interb. lending	4 886	16.10	1 201	19.75	2 062	13.72	1 583	5.946	1 086	52.72	196	1.321
Interb. borrow	4 886	2.994	1 201	0.074	2 062	2.560	1 583	8.134	1 086	5.703	196	80.20
Wholesale debt	4 886	71.10	1 201	80.20	2 062	44.18	1 583	26.68	1 086	20.03	196	5.561
Retail deposits	4 886	23.46	1 201	78.60	2 062	8.151	1 583	5.803	1 086	5.838	196	3.571

This table provides information on the number of observations for each identified cluster and the mean for each input variable.

Radar charts



Note: This figure shows radar charts for each identified cluster using information from the above summary statistics table. The radar charts map the mean of the six input variables onto an axis. Higher values are located further toward the outer radars, while smaller values are located further toward the middle.

Report: Trial C

Input variables

- Gross loan
- Trade
- Wholesale debt
- Retail deposits

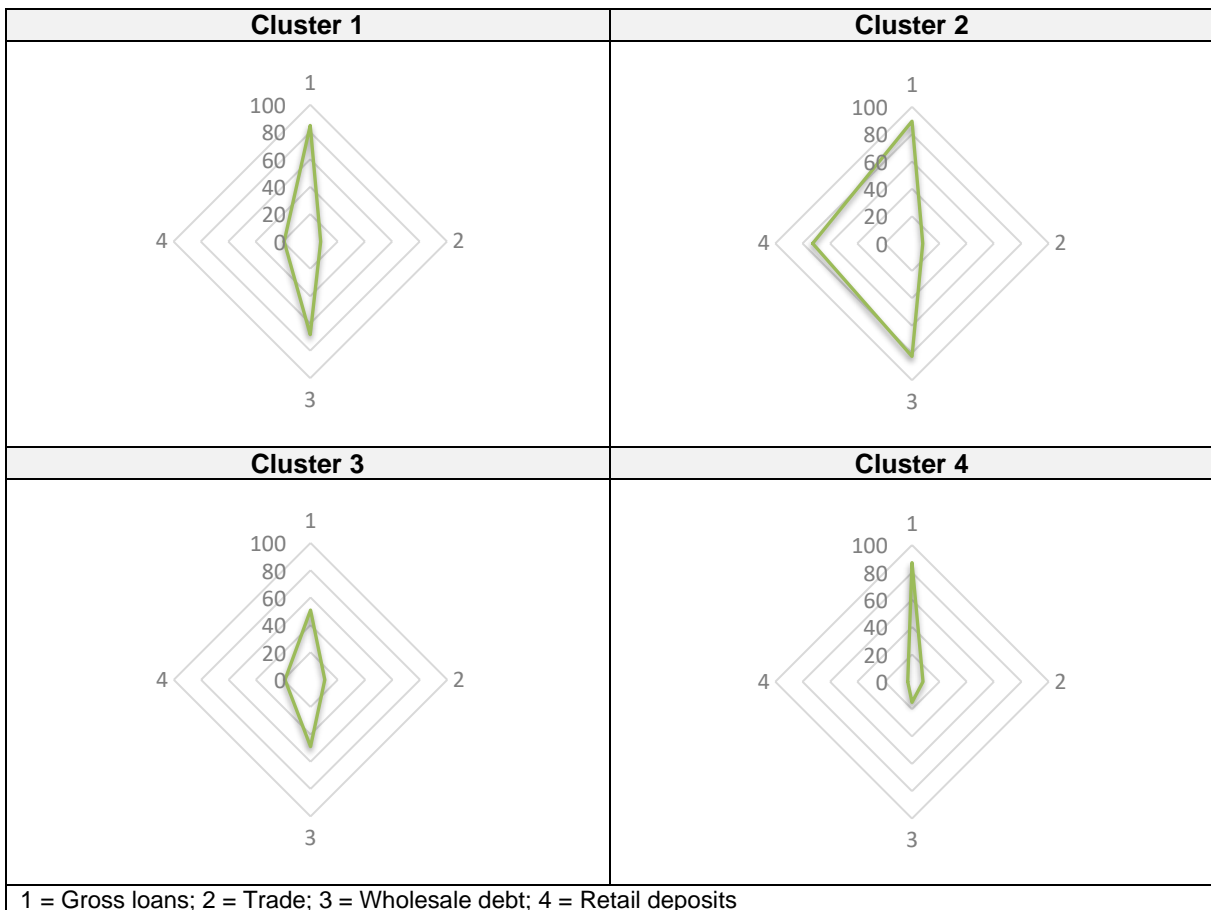
Identified clusters: 4

Summary statistics of input variables

	Cluster 1		Cluster 2		Cluster 3		Cluster 4	
	N	Mean	N	Mean	N	Mean	N	Mean
Gross loan	4 956	84.80	1 292	89.46	2 473	50.88	2 293	87.13
Trade	4 956	7.612	1 292	7.831	2 473	10.43	2 293	8.000
Wholesale debt	4 956	68.15	1 292	82.53	2 473	48.93	2 293	15.04
Retail deposits	4 956	19.10	1 292	72.70	2 473	18.69	2 293	3.165

Note: This table provides information on the number of observations in each identified cluster and the mean for each input variable.

Radar charts



Note: This figure shows radar charts for each identified cluster using information from the above summary statistics table. The radar charts map the mean of the four input variables onto an axis. Higher values are located further toward the outer radars, while smaller values are located further toward the middle.

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