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## **Foreign bank diversification and efficiency prior to and during the financial crisis: Does one business model fit all? — [Source link](#)**

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**Foreign bank diversification and efficiency prior to and during the financial crisis:****Does one business model fit all?****Claudia Curi****Faculty of Economics and Management****Free University of Bolzano****Universitätsplatz 1 - Piazza Università 1****39100 Bozen-Bolzano Italy****Claudia.Curi@unibz.it****Corresponding author****Ana Lozano-Vivas****University of Malaga****Campus El Ejido s/n****29071 Málaga (Spain)****avivas@uma.es****Valentin Zelenyuk****School of Economics and Centre for Efficiency and Productivity Analysis****The University of Queensland****St Lucia****Brisbane Qld 4072****Australia****v.zelenyuk@uq.edu.auItalyAbstract**

Diversified and focused business models may affect foreign bank efficiency differently. We investigate whether there is an optimal business model along three business dimensions—assets, funding and income—and which business model is optimal for foreign banks in a financial center. We apply recently developed non-parametric methods with bootstrap to estimate group efficiency, to test for differences across groups and finally to analyze the link between bank efficiency and diversification measures. Using Luxembourg bank data that include the financial crisis, we find that there is no unique business model. The most efficient business model appears to be a focused asset, funding and income strategy. Banks' organizational forms play a role;

branches may be preferable to subsidiaries prior to the financial crisis, whereas bank subsidiaries perform better than branches during the financial crisis. However, branches diversified in assets, funding and income exploit efficiency advantages during the financial crisis.

**JEL classification:** C14; F23; G21; G28

**Keywords:** Foreign banks; Organizational form; Branch; Subsidiary; Asset, Funding and Income Diversification; Financial Crisis; DEA Group-Efficiency; Heterogeneous Bootstrap.

ACCEPTED MANUSCRIPT

## 1. Introduction

The recent global financial crisis has introduced major changes into the financial landscape. For instance, the financial crisis led to the demise of large investment banks and a sharp interruption in the steady increase of the banking industry's internationalization during the past few decades in terms of both cross-border capital flows and cross-border entry in banking sectors. These major changes in the financial scenery, along with the particularly powerful effect of the increased globalization of the financial markets in the propagation of the crisis, have rekindled the interest of regulators, policy-makers and scholars in discussing the optimal banking models.

Although the conventional wisdom in banking argues that diversification enhances bank performance, the recent financial crisis raises serious concerns about this statement. Indeed, theory provides conflicting predictions about the optimal asset and liability mix of an institution. Moreover, a wide range of empirical studies analyzes the link between diversification and bank performance without reaching a general consensus. Among these studies, few analyze the business model of foreign-owned banks; most adopt the perspective of global banks (at the consolidated level). However, in countries where foreign banks are the main component of the banking system, as is the case of financial centers, the analysis of the link between the business model and bank performance becomes an important issue. In view of the pressure on foreign banks to maintain market shares and remain competitive due to the technological advancements and the globalization of the financial system, along with the important role of foreign banks to guarantee the access to financial services of the country configured as a financial center (see Clarke et al., 2003; Claessens, 2006; Chopra, 2007; Cull and Martinez Peria, 2011), this type of analysis is worth undertaking to discover the optimal bank business model that allows for the subsistence of foreign banks in the market.

The main goal of this paper is to provide empirical evidence of the optimal business models adopted by foreign banks operating in a peculiar banking system, i.e., the financial center, and to evaluate whether their business models adjusted during the financial crisis. The paper also attempts to analyze whether optimal business models for foreign banks are related to their organizational form.

To identify an efficient or "optimal" business model, we use technical efficiency measures to assess how well management deploys technology, staff and other resources to produce a given level of output. Technical efficiency has also been closely linked to the likelihood of a bank

default (Wheelock and Wilson, 1995), so we assume that better business models will be associated with higher technical efficiency. Because foreign banks are exposed to intense competition globally, technical efficiency is a foreign bank-chosen objective because it is a necessary condition for ensuring their sustenance in the market.

We follow the academic literature in using diversification measures to analyze bank business models, and we evaluate the effect of diversification strategies on firm performance using the focus index, which is based on the sum of squares of shares in different bank balance sheets and income mix items. Although most existing studies analyze bank business models in terms of the asset mix and/or income mix,<sup>1</sup> in this paper, we also consider the funding mix, adding a third dimension to the analysis of the bank business model. The role played by the bank funding strategy was recognized as crucial for bank intermediation activities as soon as the banking industry became significantly more complex, global and dependent on financial markets' developments due to the structural changes brought by financial deregulation and financial innovation. As Borio (2009) notes, changes in funding strategies can be triggered by weaknesses on the asset side.

We analyze the financial center of Luxembourg, which has the highest presence of foreign banks and foreign banks assets in Europe (Claessens and Van Horen, 2012).<sup>2</sup> We test whether there is a single business model that improves the performance of all foreign-owned banks within this financial center and whether the financial crisis led foreign banks to alter their business model. Moreover, given the differences between the two forms of foreign bank organization (branch and subsidiary), another question addressed in the paper is whether the trade-off between diversification and specialization depends on the bank's organizational form.

Regarding the topic of optimal business models and organizational forms, it is worth noting that an important aspect of foreign banks is the type of organizational form (branches vs. subsidiaries) chosen to operate in their intermediation activity abroad. The two organizational forms might provide different incentives towards the diversification (or specialization) of the intermediation activities. From an economic point of view, branches and subsidiaries may not benefit equally from diversification, which has consequences for the optimal corporate structure. However, despite the clear legal distinction between branches and subsidiaries, in practice, they

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<sup>1</sup> The EU Second Banking Directive (1989/646/EEC) prompted many banks to revise their business models, increasing their share of noninterest income and non-traditional activities.

<sup>2</sup> Initially encouraged by tax and regulatory advantages, the Luxembourg financial center increasingly concentrated expertise in different aspects of international banking (OECD, 2010). Most recently, it developed as a center for private banking, investment fund domiciliation and liquidity management within multinational banking groups.

may be operated and managed similarly.<sup>3</sup> Nevertheless, for now, it is not yet clear how cross-border banking groups choose between these different forms to organize their business model.

Our empirical approach relies on a combination of the non-parametric test of equalities of distributions, group-based data envelopment analysis (DEA), truncated regression and the bootstrap method. First, we study the cross-section distribution of bank diversification to assess the extent of divergence in business models across banks. Because our analysis spans from 1995 to 2009, we also check whether the cross-section distribution changed over time using the Li test adapted to the DEA context (Simar and Zelenyuk, 2006), which allows us to detect whether the business model changed during the crisis. If in this first analysis different business models appear, then we group banks and estimate their group efficiency and relative confidence intervals by combining DEA and the group-wise heterogeneous bootstrap (Simar and Zelenyuk, 2007), where the statistical significance about the equality of group efficiency is tested using the Li test. Finally, to quantify the relationship between the business model and efficiency and to disentangle the possible effects of other variables, we employ a semi-parametric approach using DEA with a truncated regression and a bootstrap (Simar and Wilson, 2007). In this last analysis, the estimated individual technical inefficiency score is linked with bank-specific characteristics including the degree of diversification and the organizational form. Overall, the combined methodologies are used not only to allow the identification of possible heterogeneity in the bank business model but to provide statistical significance tests of the results obtained.

The remainder of the paper is structured as follows. Section 2 reviews the prior literature on diversification in the banking and on financial centers. Section 3 describes the empirical research strategy, and Section 4 presents the data sample and variables. Section 5 discusses the empirical results, and Section 6 concludes.

## 2. Literature review

We separate the literature review into two sections: (i) literature on the effect of the business model on bank performance and (ii) literature on the banking industry in financial centers.

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<sup>3</sup> In practice, large bank groups might operate abroad through their own branches or subsidiaries depending on cross-country differences between the home parent country and the host country in terms of regulation, tax regime and the business model at the parent-bank level.

### *2.1. Literature on the effect of the business model on bank performance*

The existing literature on bank performance using diversification measures to identify the business model is characterized by two important limitations: (i) It has used a wide variety of bank performance measures, and (ii) it has used many measures of bank diversification. Perhaps as a result, there is still no consensus despite the volume of literature.

Some studies explore whether markets value diversified banks more highly by using asset and income-based measures of diversification. The empirical evidence is mixed. Baele et al. (2007) find a strong positive relationship between franchise value and the degree of functional diversification for European banks over the period 1989-2004. However, Laeven and Levine (2007) find that worldwide financial conglomerates have lower market value than stand-alone institutions that produce the same financial services. Schmid and Walter (2009) support this finding for U.S. financial conglomerates (including non-bank institutions). Elsas et al. (2010) reach the opposite conclusion, finding that income diversification does not reduce shareholder value and actually improves bank profitability.

Other studies explore whether diversification can reduce earnings volatility by combining traditional intermediation and non-interest income activities. For the U.S. banking sector, several authors provide evidence that there are no significant benefits for earnings or earnings volatility (risk; e.g., DeYoung and Roland, 2001; Stiroh, 2004; Stiroh and Rumble, 2006). This is because fee-based activities increase the volatility of bank income and because net interest income and non-interest income are increasingly correlated. For European banks, the evidence is mixed. Some find that increased reliance on non-interest income has stabilized profits (Smith et al., 2003; Chiarozzo et al., 2008). However, Lepetit et al. (2008) show that expanding into non-interest income activities raises the risk of volatility and insolvency. This positive link with risk is most clear for small banks and is essentially driven by commission and fee activities.

In terms of asset measures of diversification, the findings are also mixed concerning the effect on bank returns and risk. Acharya et al. (2006) find no evidence that diversification in loan mix is associated with higher return and/or lower risk, whereas Rossi et al. (2009) find that asset diversification raises profit efficiency by reducing bank risk and cost efficiency. Curi et al. (2013) find evidence that asset diversification is positively associated with the technical efficiency of foreign banks operating in a financial center. However, Elyasiani and Wang (2012) show the opposite for a sample of U.S. bank holding companies over the period 1997-2007.

Finally, a few recent papers extend the diversification concept to banks' funding strategies. Demirgüç-Kunt and Huizinga (2010) use the share of non-deposit funding to measure



diversification and find risk benefits from raising it from low levels. However, at higher levels of non-interest income and non-deposit funding, further increases in diversification result in higher bank risk. Berger et al. (2010) found that specialization in deposits (as along with loans and assets) was associated with higher profit and cost efficiency for a sample of Chinese banks; however, this paper neglects the income diversification.

In the above literature, no paper uses technical efficiency to measure bank performance, and none jointly analyzes the three dimensions we consider (asset mix, income mix and funding mix). Considering the importance of banks' funding strategies on their performance, few papers have extended the diversification concept to consider the funding mix, and those that have done so have analyzed only some funding sources. Finally, most papers focus on bank holding companies. The financial crisis has not—to our knowledge—been systematically examined.

## *2.2. Literature on the banking industry in financial centers*

The empirical literature that analyzes banking in financial centers is limited and focuses on international financial centers located in Europe (Switzerland, Liechtenstein and Luxembourg) or in Asia (Hong Kong and Singapore). All of the studies mentioned below focused on analyzing the production process. Particularly, mostly of them analyze operational, cost or profit efficiency, and productivity more rarely evaluated.

Rime and Stroh (2003) found that both specialized and universal banks in Switzerland operate with relatively large cost and profit inefficiencies. Size plays a crucial role; whereas small and mid-size banks experience cost scale economies, the largest universal banks do not. Larger banks do not benefit substantially from economies of scale or product diversification. Burgstaller and Cocca (2011) find that banks in Liechtenstein perform better than their Swiss counterparts. In the two financial centers, relatively large technical and scale inefficiency are linked to specialization and investment but not to bank size. Curi et al. (2013) link technical efficiency in Luxembourg banks to specific characteristics such as size, organizational form, and home- and host-country characteristics. They find that the organizational form plays a crucial role and that banks have higher technical efficiency on average if their parent bank is located in the euro area. Kwan (2006) finds that the cost inefficiency of Hong Kong banks is large but declines over time. Large banks seem less cost-efficient than small banks, although the former tend to converge with the latter over time. Finally, Sufian and Majid (2007) find that scale inefficiency outperforms pure inefficiency in Singapore banks, although the average efficiency

level is high. Increasing bank size has become the greatest source of bank inefficiency in Singapore.

The only work that analyzes bank productivity in a financial center used data on banks in Luxembourg. Mixed results reflect different econometric approaches and sample periods. Guarda and Rouabah (2007, 2009) analyzed the quarterly productivity growth of Luxembourg banks prior to the financial crisis and found positive productivity growth since the mid-1990s, with persistent and pro-cyclical dynamics. Larger banks are found to be more productive, and a Malmquist index analysis suggests that efficiency change dominates technical change. Curi and Lozano-Vivas (2013) examine the productivity of Luxembourg banks, accounting for organizational form, size and nationality. The results indicate that banks responded to the financial crisis with technological improvements. In normal times (before the crisis), branches and subsidiaries followed a similar productivity path. Technical change seems to be the main source of productivity improvements.

None of the papers above considered the business model of foreign banks in financial centers or whether the type of organizational structure can moderate the effect of diversification on performance.

### **3. Empirical research strategy**

In a nutshell, this paper aims to unveil evidence on the most technically efficient business model for foreign banks operating in a financial center. To do so, we apply a multi-step methodology.

First, we study the cross-section distribution of bank diversification to assess the extent of heterogeneity in business models across banks. Given that the sample covers different periods, we also check whether the cross-section distributions changed over time. Because the financial crisis is included in the period under analysis, the study of the cross-section distribution changes over time should give some insight into whether the banks adjusted their business models during the crisis period.

The cross-section distribution is estimated using the kernel density estimator with optimal bandwidth selected by the Sheather and Jones (1991) method, and banks are categorized as either focused or diversified using thresholds located between peaks in the estimated distributions. This analysis distinguishes whether there is a single business model that can fit all banks.

Among several possible tests, we follow Li (1996) to test the null hypothesis of equal distributions against the alternative hypothesis of different distributions.<sup>4</sup> Intuitively, the Li-test measures the lack of overlap between the masses of any two distributions, and therefore it can detect differences in all the moments simultaneously. For this reason, the Li-test is generally superior than using other moment-based criteria. Testing for equality is based on the null hypothesis that two distributions are equal. To ensure more accurate inference, we apply consistent bootstrap suggested by Li (1999) and adapted by Simar and Zelenyuk (2006) to the case of DEA context. Specifically, we estimate the bootstrap-based *p-value* as  $\frac{1}{B} \sum_{b=1}^B \mathfrak{I}(\hat{j}^b > \hat{j})$ , where  $\mathfrak{I}(\hat{j}^b > \hat{j})$  is an indicator function yielding 1 if  $(\hat{j}^b > \hat{j})$  is true and 0 otherwise,  $B$  is the number of bootstrap replications,  $\hat{j}$  is the Li (1996) test statistic given above, adapted to DEA context using Algorithm 2 from Simar and Zelenyuk (2006), and  $\hat{j}^b$  is its bootstrap analogue in bootstrap replication  $b$ . A consistent bootstrap involves re-sampling under the null hypothesis by drawing randomly from the largest group in the sample using the empirical distribution function (see Li, 1999 for more details).

In our second step, we use the concept of technical efficiency<sup>5</sup> to identify the most efficient or “optimal” business model.

We estimate operational efficiency at the bank level using a non-parametric estimator referred to as data envelopment analysis (DEA).<sup>6</sup> Operational efficiency for each bank is the distance from the actual observation to the DEA-estimated, best-practice production frontier (of technology), computed using the Farrell-type (Farrell, 1957), output-oriented measure.<sup>7</sup> This measure provides a score that is bound between unity and infinity, where a score of unity indicates a bank on the estimated technology frontier (technical efficiency 100%) and a score

<sup>4</sup> See Atkinson (1970), Shorrocks (1978), Quah (1996), Bianchi (1997), Maasoumi et al. (2007) for similar analyses in other contexts.

<sup>5</sup> Three main reasons explain our choice of technical efficiency as benchmark bank performance measure to identify optimal business model: (i) Because foreign banks in a financial center are exposed to intense competition globally, being technically efficient is a necessary condition not only to guarantee their subsistence in the market but also to prevent imbalances in the process of developing the economy; (ii) as Berger et al (2007) note, using economic efficiency in place of technical efficiency for the special case of foreign banks may be misleading because externalities affecting their parent bank may prevent them from optimally choosing their minimal cost or maximum profits; (iii) the available data sets on foreign banks generally include information on the performance of the bank but not on the entire multinational organization. At this point, we would like to note that as extension of our analysis, it would be interesting to adopt a risk-adjusted production model such as the one proposed by Hughes (1999) as an anonymous referee recommends.

<sup>6</sup> DEA avoids assumptions on the functional form of the production technology and allows multiple inputs and outputs.

<sup>7</sup> The Farrell measure satisfies a set of desirable mathematical properties for an efficiency measure, requires relatively simple computation and allows for a straightforward interpretation of technical efficiency. This measure is the reciprocal of the Shephard (1970) output distance function.

greater than unity represents a bank below the frontier. The reciprocal of the Farrell-type, output-oriented efficiency measure indicates the efficiency level of the bank relative to the estimated best-practice frontier. This measure can also be used as the relative efficiency rank of the bank within the sample.

If different banks in the sample operate with several business models, given the results obtained in our first step, then it is relevant to estimate aggregate or group efficiency and their confidence intervals by combining DEA with the group-wise heterogeneous bootstrap (Simar and Zelenyuk, 2007).

To test whether banks with different business models are equally efficient, we construct a weighted efficiency score ( $WGE$ ) for each group (i.e., each business model), with “within” weights derived from the aggregation structure based on economic optimization (see Färe and Zelenyuk, 2003; Simar and Zelenyuk, 2007). For each  $WGE$ , we then study sensitivity to sampling variation, estimating confidence intervals and corrections for the bias inherent in the DEA procedure by implementing the heterogeneous sub-sampling bootstrap algorithm. Lastly, to statistically test whether the estimated  $WGE$ s for each group are different, we perform the pairwise tests of the null hypothesis that  $WGE$ s are equal across bank business models. In performing such a test, let us suppose we have diversified and focused business models; then, the null hypothesis of interest is,

$$H_0: WGE^F = WGE^D,$$

where  $WGE^F$  is the weighted efficiency score for the group of “focused” banks, and  $WGE^D$  is that for the group of “diversified” banks. The test is based on the relative difference (RD) statistic, defined as:

$$\widehat{RD}^{F,D} = WGE^F / WGE^D, \quad (1)$$

where the null hypothesis (equal efficiency) is rejected (at a selected level of confidence) if the bootstrapped confidence interval for  $\widehat{RD}^{F,D}$  does not contain unity. If so, the null hypothesis would be rejected in favor of the alternative hypothesis that the diversified banks are more inefficient (more efficient) as a group than are focused banks if  $\widehat{RD}^{F,D} < 1$  (if  $\widehat{RD}^{F,D} > 1$ ). It is important to recall that this analysis is extended to check whether banks with different organizational forms, given their business models, are equally efficient.

Finally, the third step of our empirical strategy is to estimate a multivariate relationship between business models and efficiency controlling for other bank-specific characteristics, including organizational form. This type of examination enables us to banish the doubt of

whether the relationship between efficiency and business models disappear due to effects related to the bank's organizational form, along with several other bank-specific characteristics.

To perform the analysis, we follow the truncated regression with bootstrap approach, suggested by Simar and Wilson (2007), to analyze the following relationship:

$$TE_{k,t} = \alpha + DIV_{k,t}\beta + OF_{k,t}\gamma + CSV_{k,t}\delta + u_{k,t}, \quad k = 1, \dots, n; \quad t = 1, \dots, T \quad (2)$$

where  $TE_{k,t}$  is the technical (in-)efficiency of bank  $k$  at time  $t$ ,  $DIV_{k,t}$  is the diversification variable,  $OF_{k,t}$  is a dummy variable for the organizational form, and  $CSV_{k,t}$  is a vector of control variables that capture bank-specific characteristics or structural variables that might have an effect on the efficiency. Lastly,  $u_{k,t}$  is a random error that must satisfy the theoretical restriction that  $TE_{k,t} \geq 1$ ; therefore,  $u_{k,t}$  is a truncated random variable such that  $u_{k,t} \geq 1 - Z_{k,t}\beta$ , for all  $k = 1, \dots, n; t = 1, \dots, T$ . To handle such a truncation problem, we use the truncated regression approach assuming  $u_{kt} \sim N(0, \sigma_u^2)$  such that  $u_{k,t} \geq 1 - Z_{k,t}\beta$ ,  $k = 1, \dots, n$  and  $t = 1, \dots, T$ , where  $\sigma_u^2$  is estimated along with the estimation of  $\beta$  using the maximum likelihood method. To improve accuracy of inference, confidence intervals around each element in  $\beta$  are obtained using bootstrap Algorithm II from Simar and Wilson (2007), where further details can be found.<sup>8</sup>

#### 4. Data sample and construction of variables

##### 4.1. Data sample

The data for this study were provided by the Luxembourg Central Bank (BCL) and encompass both balance sheet and profit and loss data on a quarterly basis from 1995Q1 to 2009Q4. These data have two major advantages relative to Bankscope. First, reporting data give information on both subsidiary and branch banks, whereas Bankscope does not. Second, reporting data contain more detailed information than Bankscope. We convert data from a quarterly frequency to an annual frequency to avoid seasonality variations, which may bias

<sup>8</sup> Note that the dependent variable in the regression is inefficiency; therefore, a negative value of the parameter implies a positive effect on efficiency (i.e., a negative effect on inefficiency).

efficiency estimates.<sup>9</sup> We use the GDP deflator to convert to constant prices with a base year of 1995.

We exclude domestic banks (two state-owned banks and two cooperative banks), a central securities depository with bank status and banks from emerging economies with a very limited market share. Lastly, for each period, we remove banks that have just entered operation.<sup>10</sup> The final sample is more homogenous, focuses on established foreign banks—because domestic banks operate on the local markets instead of the international market—and consists of 2087 bank-year observations, of which 1698 are subsidiary banks and 389 are branch banks, for the years 1995-2010.

## 4.2 Construction of variables

### 4.2.1 Measures of diversification

We measure asset, funding and income diversification with a modified Herfindahl-Hirschman Index (HHI). Following Elsas et al. (2010), we define diversification (DIV) by subtracting HHI from unity so that it increases with diversification. For asset diversification (ADIV), we focus on the most significant categories for foreign banks operating in financial centers, i.e., interbank loans (IBLOAN), customer loans (CLOAN), government securities (GSEC), fixed income securities (FISEC) and other securities (OSEC), including shares, participation and other variable income securities.<sup>11</sup> Therefore, for each bank  $i$  at time  $t$ , we calculate:

$$ADIV_{i,t} = 1 - \left( \left( \frac{IBLOAN_{i,t}}{EA_{i,t}} \right)^2 + \left( \frac{CLOAN_{i,t}}{EA_{i,t}} \right)^2 + \left( \frac{GSEC_{i,t}}{EA_{i,t}} \right)^2 + \left( \frac{FISEC_{i,t}}{EA_{i,t}} \right)^2 + \left( \frac{OSEC_{i,t}}{EA_{i,t}} \right)^2 \right) \quad (3)$$

where earning assets (EA) is the sum of the five numerators.

For funding diversification (FDIV), we consider equity (EQUI), short-term interbank deposits (IBDEP), customer deposits (CDEP), short-term money market funds, such as certificates of deposit (CERDEP), and long-term capital market funding, such as subordinated debts (SDEBT). Therefore, for each bank  $i$  at time  $t$ , we calculate:

$$FDIV_{i,t} = 1 - \left( \left( \frac{EQUI_{i,t}}{FUND_{i,t}} \right)^2 + \left( \frac{IBDEP_{i,t}}{FUND_{i,t}} \right)^2 + \left( \frac{CDEP_{i,t}}{FUND_{i,t}} \right)^2 + \left( \frac{CERDEP_{i,t}}{FUND_{i,t}} \right)^2 + \left( \frac{SDEBT_{i,t}}{FUND_{i,t}} \right)^2 \right) \quad (4)$$

<sup>9</sup> Stock variables from the balance sheets are averaged, and flow variables from the profit and loss statement are reported year-to-date.

<sup>10</sup> DeYoung and Hasan (1998), among others, argue that banks often suffer initial losses and low earnings during the first years of operation.

<sup>11</sup> Previous studies used other disaggregation, reflecting different research purposes and data availability. For instance, Berger et al. (2010) disaggregate loans into industry, commercial, real estate, agricultural and consumer loans. They disaggregate the total assets into total loans, loans to other banks, financial investments, total fixed assets and other assets.

where FUND is the sum of the five numerators.

Lastly, for income diversification, we consider interest income (II) and commission income (CI), net profit from other operations (NPFO), and other non-interest income (ONII), such as fiduciary income, service charges, trading income and other fees, as in Elsas et al. (2010). The denominator, total operating income (TOI), is the sum of the four numerators. Therefore, for each bank  $i$  at time  $t$ , we calculate:

$$IDIV_{i,t} = 1 - \left( \left( \frac{II_{i,t}}{TOI_{i,t}} \right)^2 + \left( \frac{CI_{i,t}}{TOI_{i,t}} \right)^2 + \left( \frac{NPFO_{i,t}}{TOI_{i,t}} \right)^2 + \left( \frac{ONII_{i,t}}{TOI_{i,t}} \right)^2 \right) \quad (5)$$

#### 4.2.2 Banking outputs and inputs for measuring technical (in-)efficiency

We model bank production with a modified version of the intermediation approach (Sealey and Lindley, 1977), which is common in the bank efficiency literature (Berger and Humphrey, 1997). Because our sample of foreign banks operates in financial markets and/or in the internal capital markets within multinational groups, we distinguish wholesale from retail lending (and funding). Thus, we include interbank loans, customer loans and securities (including government securities, fixed income securities, shares, participations and other variable income securities) as outputs. Because Luxembourg foreign banks devote significant resources to off-balance sheet activities (Curi et al., 2013) and this source of income is as important as the interest margin (Guarda and Rouabah, 2007), we extend the set of outputs to include directly charged services (summing commission income, gains from financial operations and other non-interest income). As inputs, we include (i) labor, measured by total labor expenses,<sup>12</sup> (ii) capital, measured by fixed assets, (iii) interbank deposits, including other liabilities, such as debt certificates and subordinated debts, and (iv) customer deposits. To account for the cost of producing the directly charged services, we extend the set of inputs to include purchased materials and services (including non-wage administrative costs and commissions paid).

#### 4.2.3 Definition of other variables

We first explore the link between bank efficiency and diversification (along the three dimensions), and we then test whether this link varies with organizational form, other bank-specific characteristics or time (given structural change in the industry).

<sup>12</sup> The use of labor expenses as a proxy of labor input is widely accepted and extended in the banking literature (see for instance Altunbas et al. (2001), Bonin et al. (2005), among others) when there is no availability of data about the number of workers, as is in our case. However, even if we had detailed information about labour inputs (e.g., hours worked for different type of labour), it would practically be more useful to use the aggregate proxy such as labour cost because it takes into account the value aspect of the labour input (aggregated from different types of labour) and does not overburden the DEA model with the curse of dimensionality problem.

Foreign banks are present in Luxembourg in two different forms: branch and subsidiary banks. Branch banks are a direct emanation of a parent bank abroad. Diversification strategies are often determined at the level of the parent bank, and few (or no) restrictions on intra-group transfers are established. On the contrary, the parent bank is directly responsible if the branch becomes distressed. Subsidiary banks, instead, are separate legal entities that are financially and operationally self-sufficient, locally capitalized and under the direct control of local regulators (Fiechter et al., 2011). Because the implications for diversification are likely to be different, we use a dummy variable equal to 1 for branches to control for these effects (*Branch*).

The banking literature suggests that in addition to the organizational form, diversification increases with the size of bank balance sheets (Demsetz and Strahan, 1997). We therefore include the logarithm of total assets (*Size*) and its square (*Sizesq*) to control for a potentially nonlinear relationship between bank size and efficiency. We also use a dummy variable (*Big*) to identify the four largest banks in terms of total assets. These global players have privileged access to international capital and money markets.

The literature suggests that higher capital ratios are associated with better management. We use the ratio of equity book value to total assets (*ETA*) as a proxy for risk. This is approximately equal to the bank's tier 1 capital ratio (Berger et al., 2010). A high ratio suggests low leverage and therefore lower risk (see Pasiouras, 2008, among others). Empirical evidence suggests that regulators may allow relatively efficient banks to operate with higher leverage (Hughes and Moon, 1997; Hughes and Mester, 1993; Hughes and Mester, 1998). Other studies, such as Altunbas et al. (2007), find that financial capital can significantly influence bank cost and profit efficiency. Curi et al. (2013) find that well-capitalized banks in Luxembourg tend to score higher in terms of technical efficiency.

Lastly, mergers and acquisitions (M&A) may moderate the effect of diversification on bank efficiency, and this is the case for Luxembourg banks, which underwent a broad consolidation process (Curi et al., 2011). There is extensive literature on the efficiency gains from European and U.S. bank deals (for an overview, see DeYoung et al., 2009). In addition, there is a substantial amount of literature that highlights possible time lags between the completion of a merger and the realization of gains (e.g., Rhoades, 1998; Calomiris and Karceski, 2000; Houston et al., 2001). For instance, according to Berger et al. (1998) a three-year gestation period is needed (on average) to restructure a merged bank, given difficulties in, e.g., refocusing lending policies and integrating data processing systems and operations. Following Focarelli and Panetta (2003), we distinguish the short-run and long-run effect of bank mergers on operational



efficiency. Thus, we include a dummy variable (*merge\_trans*) equal to 1 in the transitory period (which covers the year of the merger and the next two years) and another dummy variable (*merge\_compl*) equal to 1 in the completion period (which includes the subsequent years—from the third year to fifth year after the merger).

## 5. Empirical results

We structure our summary of the empirical analysis into three sections: (i) analysis of distribution, (ii) analysis of group efficiencies and (iii) regression analysis.

### 5.1. Analysis of distribution

First, we assess the cross-section distribution and the evolution of the diversification indexes over time. This analysis will give us insight into two important issues: (i) whether there is a unique business model for foreign banks and (ii) whether, due to the crisis and/or structural changes over the period under analysis, foreign banks adjusted their business model.

Our first step is to analyze the cross-section distributions of three diversification indexes over time using the kernel density estimator, where we use the Gaussian kernel and optimal bandwidth selected by Sheather and Jones method (1991). We categorize banks as either focused or diversified using the thresholds in the estimated distributions located between peaks. Figure 1 plots the cross-section distributions. More focused banks will appear on the left, and more diversified banks will appear on the right in each of the three dimensions (assets, funding and income).

In presenting the results, we will split the time period into three sub-periods to detect more accurately the possible changes in bank diversification given that structural changes might have occurred in the environment where the foreign banks under analysis are operating. Specifically, we divide the entire period into the period of the consolidation process in the banking industry of Luxembourg (1995-2000), the pre-crisis period (2001-2006) and the recent financial crisis period (2007-2009). Because the financial crisis period is included in the period under investigation, analyzing any change over time of the cross-section distribution will help us to detect whether the banks adjusted their business models during the crisis period. Indeed, as noted by Llewellyn (2013), bank business models are not static but evolve over time under the influence of a complex mix of pressures. In particular, given the crisis, banks face an unprecedented

combination of pressures in terms of balance sheets, liquidity and funding; the funding sources become difficult, and new regulatory pressures appear, focusing them on capital and liquidity requirements. All those pressures along with the weakness of the macroeconomic situation should contribute to change in the bank business model.

Observing plot (a) in Figure 1, in the asset dimension, the first sub-period (1995-2000) is characterized by two peaks, suggesting that one group of asset-diversified banks (peak near 50%) coexists with another group of focused banks (secondary peak near 20%). From 2001-2006, the right peak appears to split into two groups of diversified banks, whereas the left tail flattens, indicating more heterogeneity within the industry. During the financial crisis of 2007-2009, the main peak falls and shifts left to approximately 37%, suggesting less diversification. The threshold for activity diversification is approximately 0.35.

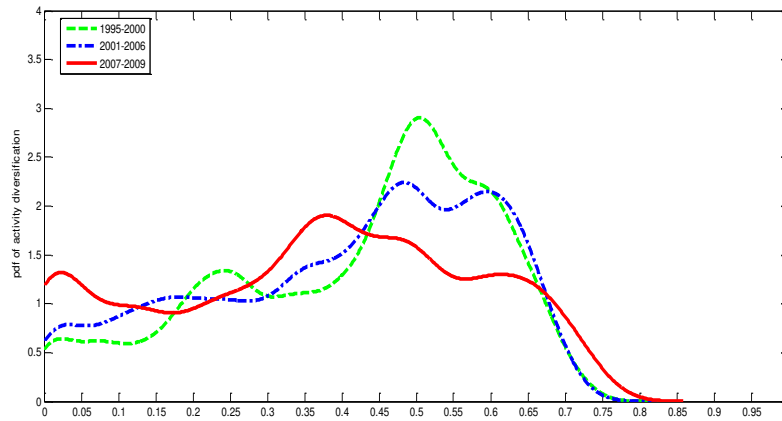
In the funding dimension, the more peaked pattern in plot (b) suggests more diversification than in the asset dimension. However, here, the distribution also becomes flatter over time, suggesting increasing heterogeneity across banks. The main peak, at approximately 50%, drops sharply from the 1995-2000 period to the 2001-2006 period and a bit further during the crisis, gradually shifting left each time (less diversification). The compensating rise in the left tail also suggests that many banks reduced their funding diversification. Thus, the threshold of funding diversification is also approximately 0.35.

Lastly, in the income dimension, plot (c) suggests the opposite pattern, with banks shifting towards higher diversification. The peak at the left in 1995-2000 drops dramatically in 2001-2008; some banks moved to higher diversification, which is made apparent by a new peak to the right at approximately 50%. During the financial crisis, the new peak on the right is virtually unchanged, but more mass has shifted from the left tail to higher levels of diversification. Thus, the threshold of income diversification is approximately 0.30.

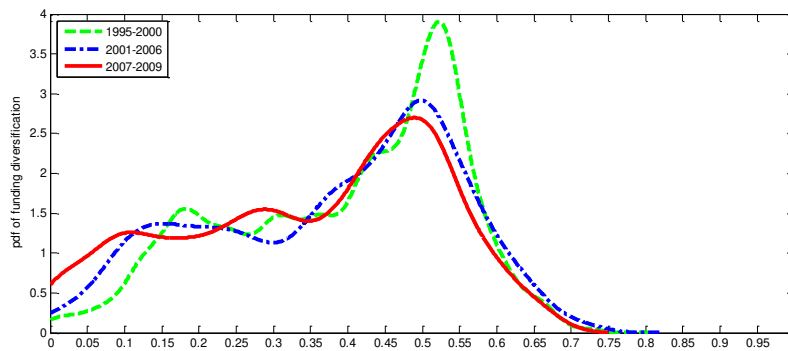
Overall, for each panel, we observe that there is no unique business model for all foreign banks in Luxembourg; diversified and focused foreign banks coexist in all three diversification dimensions. That is, not all foreign banks fit one unique business model.

Moreover, regarding the evolution of the diversification index over time, a shift can be observed to a more focused bank strategy in assets and funding but not in income.

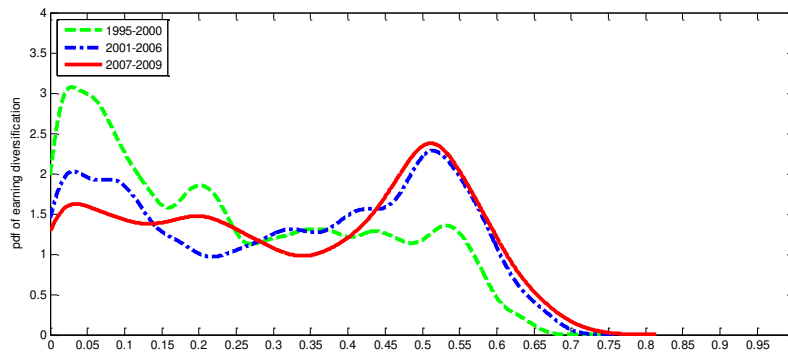
Figure 1: DIV Index Distributions



(a) Asset diversification (ADIV)



(b) Funding diversification (FDIV)



(c) Income diversification (IDIV)

To test whether these changes in the estimated distribution are statistically significant, Table 1 reports Li statistics and their bootstrapped  $p$ -value under the null hypothesis of equal distribution.

**Table 1: Test for Equality of Distributions across Three Periods**

Null Hypothesis ( $H_0$ )	Li Statistic	$p$ -value	Decision on $H_0$
<b>Asset diversification</b>			
$pdf(1995-2000)=pdf(2001-2006)$	2.885	0.009	<i>Reject</i>
$pdf(2001-2006)=pdf(2007-2009)$	6.356	0.000	<i>Reject</i>
<b>Funding diversification</b>			
$pdf(1995-2000)=pdf(2001-2006)$	4.184	0.002	<i>Reject</i>
$pdf(2001-2006)=pdf(2007-2009)$	0.702	0.344	<i>Do not reject</i>
<b>Income diversification</b>			
$pdf(1995-2000)=pdf(2001-2006)$	12.432	0.000	<i>Reject</i>
$pdf(2001-2006)=pdf(2007-2009)$	0.040	0.957	<i>Do not reject</i>

Note:  $pdf$  stands for probability density function.

The first two rows of Table 1 indicate that the changes over time in the distribution of asset diversification across banks are statistically significant (leading to the rejection of the null hypothesis with a  $p$ -value equal or close to 0). The middle panel reports that the distribution of funding diversification changed significantly from 1995 to 2000 and from 2001 to 2006 but that evidence of change during the financial crisis is not statistically significant. The bottom panel reflects the same result for the distribution of income diversification. In other words, the distribution of diversification in all three dimensions changed from 1995 to 2000 and from 2001 to 2006, but only asset diversification changed significantly from 2007 to 2009.

Overall, it seems that most of the business model changes observed from Figure 1 are supported by the Li test. Notably, the Li statistic shows that the real strategy followed by the foreign banks consists of changing their business model over time on the three distributions (assets, funding and income). They decide to become more focused on assets and funding, but they seem to have chosen to be more diversified in income. Moreover, during the financial crisis, the foreign banks appear to continue to change their business model but just in asset dimension, becoming more focused. Thus, the results seem to suggest that (i) there coexist two business models across time, and (ii) the foreign bank business model is not static. Therefore, apparently, the statement that the bank business model is not static over time can be confirmed (Llewellyn, 2013).

The results obtained encouraged us to analyze the sample further and to investigate whether the diversification strategy followed by the two organizational forms that foreign banks decide to adopt when they operate across borders is different. In other words, we next analyzed the likely

trade-off between diversification and organizational form. To check for this research question, the share of subsidiaries and branches in the diversified and focused categories (based on our thresholds) is reported in Table 2. In all three periods, approximately two thirds of all banks are diversified subsidiaries in the three dimensions in all periods, except for income diversification in the consolidation period, which is less than half. However, there also exists one significant share of subsidiaries that chooses a focused strategy. Prior to the financial crisis, Luxembourg branch banks developed both diversification and focused strategies in terms of assets and funding mix while maintaining focused strategies in terms of income mix. However, during the financial crisis, most of the branch banks refocused their strategies in assets and funding. Notably, although the subsidiaries tend to slightly decrease over time their share distribution in terms of a diversified business model on assets and funding, the amount of subsidiaries opting for a more diversified strategy in income increases remarkably. However, the number of branches that select a more focused strategy in assets increase over time, specifically during the financial crisis. The share of branches that adopt a diversified strategy on income is almost stable along the two periods before the crisis, although it increases slightly during the crisis. Finally, it seems that branches adopt dynamic behavior in the funding business model because they shift their business models from more focused to more diversified and then more focused along the entire period.

**Table 2: Breakdown into Organizational Form for Each Period**

Period	Bank	Focused			Diversified		
		ADIV	FDIV	IDIV	ADIV	FDIV	IDIV
Consolidation Period (1995-2000)	All	32.78%	35.87%	62.48%	67.22%	64.13%	37.52%
	Subsidiary	24.66%	26.31%	46.24%	54.78%	53.13%	33.20%
	Branch	8.12%	9.56%	16.24%	12.44%	11.00%	4.32%
Pre-crisis (2001-2006)	All	35.78%	38.66%	46.40%	64.22%	61.34%	53.60%
	Subsidiary	28.44%	32.63%	33.16%	55.70%	51.51%	50.98%
	Branch	7.34%	6.03%	13.24%	8.52%	9.83%	2.62%
Crisis (2007-2009)	All	43.02%	45.02%	46.15%	56.98%	54.99%	53.84%
	Subsidiary	28.49%	31.34%	32.19%	52.14%	49.29%	48.43%
	Branch	14.53%	13.68%	13.96%	4.84%	5.70%	5.41%

Overall, this preliminary analysis suggests that branches and subsidiaries run similar business models; i.e., focused and diversified strategies are followed by both types of organizational forms, despite their legal and regulatory differences. Thus, it appears that contrary to the general wisdom that branches usually follow a focused business model, we see that many branches also adopt a diversified business model just as subsidiaries usually do.

### 5.2. Analysis of group efficiencies

The findings obtained in the previous subsection regarding the coexistence of different business models—focused versus diversified—led us to address the main research question of the paper—i.e., the effectiveness of business model—using technical efficiency. As we note in the empirical research strategy section, when different business models appear, it is more appropriate to group banks and estimate their aggregate or group efficiency and corresponding confidence intervals. In particular, based on the results obtained in our first step, we now turn to estimate group efficiency for the diversified and focused banks in the three-diversification dimensions. Moreover, because our previous analysis suggests that the business model strategy of the foreign banks has changed over time, the effectiveness of the business model strategy is analyzed along the three time periods.

Table 3 reports the weighted group-efficiency estimates for diversified and focused banks. The weighted group-efficiency estimates and their confidence intervals and bias corrections are obtained following the Simar and Zelenyuk (2007) group-wise heterogeneous sub-sampling bootstrap approach with 2000 bootstrap replications. Because the aim of the analysis is to explain inefficiency, group-efficiency scores are reported à la Farrell; scores closer to unity are banks that are more efficient. However, in the discussion, we use brackets to report efficiency scores à la Shepard (1970), which are the reciprocals of Farrell-type efficiency scores and represent the relative level of efficiency in percentage terms. Table 4 presents the  $L_i$  statistics and relative  $p$ -values to test for efficiency equality between focused and diversified foreign banks.

In terms of asset diversification, the weighted group efficiencies (bias-corrected) show that during the consolidation period, diversified banks benefitted more from higher efficiency (85.9%) than did more focused banks (77.5%). Moving to the pre-crisis period, we observe that in contrast to the previous period, focused banks showed higher efficiency levels (89.4%) than diversified banks (86.7%). However, both groups improved their efficiency. During the financial crisis, both bank groups experienced an inefficiency increase; however, focused banks reached approximately 63%, whereas diversified banks limited deterioration to 69.7%. The analysis of the related confidence intervals suggests little overlap for each pairwise comparison, except for the pre-crisis period. This finding is confirmed by the RD statistics (Table 4); the confidence intervals of this statistic do not include 1 during the consolidation period and the financial crisis. On the contrary, such confidence intervals include 1 during the pre-crisis period, suggesting

there is no evidence of a statistically significant difference in the efficiency performance between the two groups.

Turning to the funding diversification, the weighted group efficiencies (bias-corrected) show that focused banks benefitted more from higher efficiency levels than did diversified banks over the three periods. During the consolidation period, focused banks are characterized by 89.2% efficiency, compared to 83.1% among diversified banks. During the pre-crisis period, focused banks improved their efficiency to 94.5%, compared to 85.6% for diversified banks. Both groups of banks suffered from efficiency loss during the financial crisis, but diversified banks reached 66.4% efficiency, compared to 73.9% for focused banks. In this case, the RD statistics confirm that the differences among focused and diversified banks are statistically significant in all three periods. Thus, banks with focused funding strategies are found to be persistently more efficient, although they also saw their performance deteriorate during the financial crisis.

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**Table 3: Weighted Group Efficiency**

Prospective	Period	Orientation	Weighted Group Efficiency (bias-corrected)	Lower Bound (95%)	Upper Bound (95%)
Asset	Consolidation Period (1995-2000)	Focused	1.290	1.254	1.313
		Diversif.	1.163	1.116	1.197
	Pre-crisis (2001-2006)	Focused	1.118	1.074	1.146
		Diversif.	1.154	1.130	1.169
	Crisis (2007-2009)	Focused	1.593	1.491	1.644
		Diversif.	1.435	1.323	1.494
Funding	Consolidation Period (1995-2000)	Focused	1.121	1.079	1.147
		Diversif.	1.204	1.160	1.232
	Pre-crisis (2001-2006)	Focused	1.058	1.020	1.084
		Diversif.	1.168	1.136	1.187
	Crisis (2007-2009)	Focused	1.353	1.226	1.415
		Diversif.	1.506	1.404	1.557
Income	Consolidation Period (1995-2000)	Focused	1.139	1.097	1.166
		Diversif.	1.363	1.326	1.385
	Pre-crisis (2001-2006)	Focused	1.116	1.079	1.141
		Diversif.	1.199	1.168	1.218
	Crisis (2007-2009)	Focused	1.322	1.218	1.371
		Diversif.	1.709	1.596	1.769

*Note:* Weighted Group Efficiency (bias-corrected) estimates are obtained by the Simar and Zelenyuk (2007) group-wise heterogeneous sub-sampling bootstrap method, with 2000 bootstrap replications both for bias correction and confidence intervals.



**Table 4: Relative Difference Statistics Comparing the Weighted Group Efficiency**

Period	Prospective	Relative Difference		Decision on $H_0$	
		Statistic (bias-corrected)	Lower Bound		Upper Bound
Consolidation Period (1995-2000)	Asset mix	1.115	1.08	1.151	Reject $H_0$
	Funding mix	0.926	0.89	0.963	Reject $H_0$
	Income mix	0.811	0.773	0.844	Reject $H_0$
Pre-crisis (2001-2006)	Asset mix	0.966	0.922	1	Do not reject $H_0$
	Funding mix	0.899	0.86	0.936	Reject $H_0$
	Income mix	0.925	0.885	0.96	Reject $H_0$
Crisis (2007-2009)	Asset mix	1.126	1.046	1.211	Reject $H_0$
	Funding mix	0.877	0.779	0.956	Reject $H_0$
	Income mix	0.723	0.643	0.81	Reject $H_0$

*Note:* The Relative Difference (RD) statistic is the ratio of the weighted group efficiency of focused banks over that of diversified banks. Values above unity suggest that diversified banks are more efficient than focused banks. If the bootstrapped confidence interval defined between the lower and upper bound values does not contain unity, then the null hypothesis of the equality of the two group-inefficiency estimates (focused vs. diversified) is rejected in favor of the alternative hypothesis that the diversified banks are more inefficient, as a group, than focused banks if  $RD$  (bias-corrected) < 1 and more efficient if  $RD$  (bias-corrected) > 1.

From the income diversification point of view, the weighted group efficiencies (bias-corrected) show that focused banks, as a group, attained higher efficiency levels than did diversified banks over the three periods. During the consolidation period, focused banks are characterized by 87.8% efficiency compared to 73.4% among diversified banks. During the pre-crisis period, focused banks improved their efficiency to 89.6%, compared to 88.4% for diversified banks. Both groups of banks suffered from efficiency loss during the financial crisis, but diversified banks reached 58.5% efficiency compared to 75.6% for focused banks. In this case, the RD statistics confirm that the differences among focused and diversified banks are statistically significant in all three periods. Thus, banks with focused income strategies are persistently more efficient, although they also saw their performance deteriorate during the financial crisis.

Overall, the results suggest that foreign banks operating in a financial center benefit from higher efficiency when they focus their funding and income strategies but diversify their asset mix. Thus, the more efficient business model for foreign banks in Luxembourg appears to be focused with regard to funding and income and diversified with respect to assets.

In conclusion, when the differences in group efficiency are used as benchmark to test for the most effective business model strategy, the results suggest that whereas diversification is the most effective business model for Luxembourg foreign banks in the asset dimension, the focused model is the optimal business model to adopt in the funding and income dimension. Regarding

those results and comparing them with the actual decision made for Luxembourg foreign banks, it can be stated that prior to the financial crisis, apparently, it seems that foreign banks made the right decision in terms of the most efficient business model only through their funding strategy. Prior the financial crisis, Tables 3 and 4 suggest that funding-focused and income-focused banks reach higher efficiency than funding- and income-diversified banks, and less evidence of technical efficiency superiority is found among asset-focused banks. However, Figure 1 suggests that foreign banks evolved towards more focused asset and funding strategies and a more diversified income strategy. During the financial crisis, Figure 1 suggests that banks adopted a more focused asset mix, and funding and income diversification remained largely unchanged with respect to the previous period, where foreign banks already moved toward a more focused funding and diversified income strategy. Regarding the optimality of this strategy decision in terms of technical efficiency, it seems that again, the focused funding strategy is the right one but not the income- diversified and asset-focused strategies.

Overall, the above results suggest that although foreign banks in Luxembourg choose their optimal business models in terms of funds over time, they decline to operate under their optimal business model in terms of income and assets because they opt to diversify their income and focus their assets, although both strategies seem to be non-optimal.

### *5.3. Regression analysis*

The efficiency analysis performed in the previous subsection indicates significant differences between diversified and focused foreign banks in the three diversification dimensions (except for the asset dimension from 2001-2006). Efficiency differences among foreign banks can be used as a benchmark of identifying the optimal business model strategy if there exist no specific characteristics of foreign banks that explain such efficiency differences. Thus, not taking into account foreign bank specific characteristics, which makes the business model strategy optimal, may wrongly attribute the efficiency differences that arise from the business model strategy. To address this issue, the third step is to estimate the relationship between diversification and technical inefficiency to disentangle the possible mitigating effects related to bank-specific characteristics along the bank organizational form, considering the latter as an important aspect of foreign banks. To perform this analysis, the truncated regression with bootstrap proposed by Simar and Wilson (2007) is used. Because DEA bias-corrected estimates are expressed à la Farrell (greater than unity), negative coefficients indicate a positive effect on efficiency.

First, we present the results obtained by taking into account organizational form, big banks, size, equity and the effect of mergers as bank-specific characteristics. The results are presented in Table 5 for the three periods, estimated separately for diversification in the assets, funding and income dimensions.

The first thing to note is that during the consolidation period, the coefficient of the ADIV index is negative and significant at the 1% significance level, whereas FDIV and IDIV are positive and significant. These results are consistent with the results of the test of the aggregate efficiency equality of diversified and focused foreign banks (Table 3), where specific banks characteristics were not controlled for. However, a diversified assets mix appears to increase foreign bank efficiency only during the consolidation period; this effect appears to reverse the sign during the pre-crisis period. During the financial crisis, the coefficient on asset diversification is positive but not statistically significant. Thus, during the consolidation and pre-crisis period, the differences in efficiency among foreign banks arise from the asset business model strategy but not during the crisis period. It is notable that although bank-specific characteristics do not mitigate the relationship between the asset business model and efficiency founded from the efficiency comparison of the focused vs. diversified banks, those characteristics help to detect a negative relationship between foreign banks' asset diversification and efficiency during the pre-crisis period. Moreover, the regression analysis shows that there is a lack of a role played by asset diversification on the foreign bank efficiency during the financial crisis. Turning to diversification in the funding dimension, estimated coefficients are positive and statistically significant at the 1% level in all periods, including the period that encompassed the financial crisis. Finally, the coefficients on income diversification are also positive and statistically significant at the 1% level in all periods. In addition, the negative effect of income and funding diversification appears to increase over time. These results suggest that funding and income diversification reduces technical efficiency, confirming the results in Table 3 once the bank-specific characteristics are included.

According to the above results, an interesting novel finding of this work is the apparent robust evidence that diversification in general seems to dampen technical efficiency, and it appears that diversification does not play different roles depending on the strategy dimension considered. More specifically, although assets diversification has a positive effect on foreign banks' efficiency during the consolidation period (in line with the findings of Stiroh, 2004, for US banks and Demirgüç-Kunt and Huizinga, 2010, for a worldwide sample of banks analyzed up to 2008); however, this positive effect is not supported throughout time. On the contrary, our results are

more consistent with the findings for Chinese banks (Berger et al. 2010), according to which focused Chinese banks are associated with higher profit and cost efficiency. There are differences between the Chinese and Luxembourg banking sector, but these two sectors share the problem of cooperation with the directions of an external institution, i.e., the government, for Chinese banks (as mentioned by Berger et al. 2010) and home parent banks' directions for Luxembourg banks, instead of making independent decision.

Furthermore, the regressions in Table 5 provide support for the argument that diversified and focused banks may coexist because diversification enhances efficiency for some bank types and specialization for others. For instance, whereas diversification in the different dimensions and periods decreases efficiency, except for the case of the assets diversification during the consolidation period, this effect might be lessened or expanded for branches compared to subsidiaries. To test not only which organizational form is the most technically efficient but also which business model is optimal for each organizational form, the Branch dummy variable and its interaction with the organizational form by crossing the Branch dummy with the diversification variable (DIV x Branch) is included in the regression analysis. Recall that Table 2 shows that some branches diversified their business model, and others made it more focused over time. The results show that there is a negative and statistically significant effect of branches on inefficiency in all three diversification dimensions and in all periods, except for the financial crisis period. Thus, although the organizational branch form was apparently more efficient than subsidiary organization during the consolidation and pre-crisis period, subsidiary was the organizational form that suffered less deterioration in technical efficiency during the financial crisis. Regarding the business strategy of branches, the results show that from 1995-2000, branches that diversified in assets were more efficient, whereas branches that diversified in funding were less efficient. The opposite is true during the period 2001-2006. This finding is in line with the results in Table 2, which show that during the first sub-period, most of the diversified branches were asset diversified. During the second sub-period, there was a shift toward more funding diversification, and indeed, we find that these branches that diversified in funding were more efficient. However, during the first two sub-periods, few branches diversified in income. Indeed, we do not find any effect for the consolidation period; however, those branches that decided to diversify income during the pre-crisis period were less efficient. The results during the financial crisis provide evidence that although the diversification in funding and income was efficiency destroying (in line with the previous period), if branches diversified in the three dimensions, they better survived the financial crisis. However, Table 2 shows that

during the financial crisis, a large share of branches opted to shift toward a more funding-focused business model, whereas income diversification strategy was adopted for a somewhat higher share of branches.

The estimated coefficient of the *Big* dummy variable suggests that the four largest banks enjoyed a statistically significant efficiency advantage only in the two sub-periods before the financial crisis (1995-2000 for the three diversification dimensions and 2001-2006 only for the funding dimension). When the *Big* bank dummy is crossed with the diversification variable ( $DIV \times Big$ ), these large banks appear to have suffered a relatively larger loss of efficiency from increased diversification in the three dimensions from 1995-2000 and funding diversification from 2001-2006. For the financial crisis, this interaction term is not statistically significant for any diversification dimension. This suggests that contrary to the general wisdom, the combination of size and diversification does not necessarily lead to operational efficiency gains.

The estimated coefficients on the logarithm of total assets (*Size*) suggest that banks with larger size benefited from higher technical efficiency (lower inefficiency) from 2001-2006 in the funding dimension. However, during the financial crisis, the coefficient changed signs (the variance of the estimated coefficient also increased), suggesting that larger banks incurred higher inefficiency. The square of the total assets (*Sizesq*) has a negative effect on efficiency from 2007-2009, suggesting a non-monotonic relationship during the financial crisis. The ratio of equity to total assets (*ETA*) has a positive effect on efficiency in most cases, suggesting that well-capitalized foreign banks tend to run better. The coefficient increased substantially during the financial crisis.

Finally, the dummy variables separating the M&A process into short-run (*merge\_trans*) and long-run (*merge\_compl*) effects gives evidence of the “merger puzzle” concerning operational efficiency. Our results suggest that in the short run, mergers reduce operational efficiency (significantly in most cases), but this inefficiency dissipates quickly, as is evidenced by the statistically insignificant coefficient of the *merge\_compl* dummy in most cases and the statistically significant coefficient with an opposite sign in a few cases.

**Table 5: Truncated Regression Results**

Variable	Consolidation Period (1995-2000)			Pre-crisis (2001-2006)			Financial Crisis (2007-2009)		
	ADIV	FDIV	IDIV	ADIV	FDIV	IDIV	ADIV	FDIV	IDIV
Constant	1.473 <sup>***</sup>	0.645	0.087	1.666 <sup>**</sup>	1.802 <sup>***</sup>	1.431 <sup>*</sup>	-19.793 <sup>**</sup>	-6.370	-1.642
DIV	-0.242 <sup>***</sup>	0.259 <sup>***</sup>	0.736 <sup>***</sup>	0.171 <sup>***</sup>	0.519 <sup>***</sup>	0.451 <sup>***</sup>	0.436	1.739 <sup>***</sup>	3.038 <sup>***</sup>
Branch	-0.229 <sup>***</sup>	-0.414 <sup>***</sup>	-0.154 <sup>***</sup>	-0.355 <sup>***</sup>	-0.097 <sup>***</sup>	-0.052 <sup>**</sup>	1.047 <sup>**</sup>	1.959 <sup>***</sup>	0.293
Big	-3.664 <sup>***</sup>	-2.122 <sup>*</sup>	-0.351 <sup>*</sup>	-0.326	-1.203 <sup>***</sup>	0.299	-0.085	-1.211	0.817
DIV x Branch	-0.152 <sup>***</sup>	0.338 <sup>***</sup>	0.127	0.611 <sup>***</sup>	-0.075 <sup>*</sup>	0.181 <sup>*</sup>	-5.325 <sup>***</sup>	-7.591 <sup>***</sup>	-0.282 <sup>*</sup>
DIV x Big	5.937 <sup>***</sup>	4.245 <sup>***</sup>	1.648 <sup>***</sup>	0.838	2.383 <sup>***</sup>	-0.625	1.522	2.781	-1.753
Size	0.079 <sup>***</sup>	0.150	0.117	-0.012	-0.027 <sup>***</sup>	-0.035	2.456 <sup>**</sup>	1.064 <sup>*</sup>	0.429
Sizesq	-0.004 <sup>***</sup>	-0.006	-0.004	-0.001	0.0009 <sup>*</sup>	0.0003	-0.072 <sup>**</sup>	-0.036 <sup>*</sup>	-0.018 <sup>*</sup>
ETA	-0.624 <sup>***</sup>	-0.838 <sup>***</sup>	-0.452 <sup>***</sup>	-0.594 <sup>***</sup>	-1.212 <sup>***</sup>	-0.353 <sup>***</sup>	-2.762 <sup>***</sup>	-2.865 <sup>***</sup>	-1.921 <sup>***</sup>
merge_trans	0.114 <sup>***</sup>	0.118 <sup>***</sup>	0.069 <sup>***</sup>	0.060 <sup>***</sup>	0.036 <sup>**</sup>	0.030	0.437 <sup>***</sup>	0.356 <sup>*</sup>	0.457
merge_compl	0.058 <sup>***</sup>	-0.019	0.0008	-0.012	-0.009	-0.031	0.166	0.109	-0.243
$\sigma_u^2$	0.033 <sup>***</sup>	0.033 <sup>***</sup>	0.020 <sup>***</sup>	0.021 <sup>***</sup>	0.016 <sup>***</sup>	0.0186 <sup>***</sup>	0.823 <sup>***</sup>	0.627 <sup>***</sup>	0.722 <sup>***</sup>

Note: <sup>\*\*\*</sup>, <sup>\*\*</sup>, <sup>\*</sup> stand for statistically significant at 1%, 5% and 10%, respectively.

Source: Own calculations

#### 5.4. Robustness tests

The conventional wisdom in banking is that diversification enhances bank performance, but there is a lack of consensus for confirming this assertion from the empirical literature. Based on this notion plus the results obtained in this study, which rejects that statement, we extend our regression analysis, attempting to test the robustness of our results. Recently, one new strand of literature appears that aims to control for the endogeneity of a firm's decision to diversify. In particular, this new argument is defended based on the unclear finding obtained from empirical analyses of the extent to which diversification increases or decreases shareholder value in profit-oriented firms or bank performance (Campa and Kedia, 2002; Goddard et al., 2008, among others). Thus, following this new strand of literature, we control for the possible endogeneity problem of the diversification variable as a robustness test of our finding. To address this issue, we have re-estimated our model following the estimation procedure suggested by Simar and Wilson (2007) to be consistent with our regression analysis performed and incorporated the diversification indicators along the three diversification dimensions with a time lag. Table 6 shows that when the endogeneity of a foreign bank's decision to diversify in evaluating the effect of diversification on technical efficiency is controlled for, our previous results remain the same. The results confirm our findings that diversification in general destroys technical efficiency independently of the strategy dimension considered, except, as before, for the case of asset diversification and only for the period of consolidation. Moreover, when endogeneity is controlled for, the argument that diversified and focused banks may coexist is also confirmed. Additionally, the results verified our previous findings that although branches were more efficient than subsidiaries during the two periods before the financial crisis, subsidiaries supported a lower deterioration of technical efficiency during the financial crisis. Moreover, if branches diversified in the three dimensions, they better survived the financial crisis. The cross product  $Div*Branches$  during the consolidation period becomes not statistically significant in the case of the asset dimension. Overall, our previous findings are robust.

**Table 6: Truncated Regression Results with Lag**

Variable	Consolidation Period (1995-2000)			Pre-crisis (2001-2006)			Financial Crisis (2007-2009)		
	ADIV	FDIV	IDIV	ADIV	FDIV	IDIV	ADIV	FDIV	IDIV
Constant	2.679	0.411	-1.252	0.942*	1.018***	1.599***	-22.189*	-5.640***	-3.548
LDIV	-0.269***	0.206***	0.694***	0.156***	0.452***	0.405***	0.609	0.889*	4.054***
Branch	-0.292***	-0.468***	-0.147***	-0.255***	0.018	-0.059*	1.223	1.797***	1.748***
Big	-3.704***	-1.376***	-0.330	-0.433	-1.778***	0.047	-0.076	0.654	-0.348
LDIV x Branch	0.067	0.497***	0.062	0.393*	-0.316***	0.173	-4.865*	-6.878***	-3.465*
LDIV x Big	5.957***	3.023***	1.673	1.023*	3.368***	0.491	1.651	-0.751	4.633
Size	-0.049***	0.173	0.252***	0.059	0.047***	-0.046	2.694**	0.989***	0.498
Sizesq	-0.001***	-0.007*	-0.007***	-0.003	-0.003*	0.0005	-0.078**	-0.034***	-0.019
ETA	-0.510***	-0.725***	-0.174***	-0.595***	-0.957***	-0.380***	-2.002**	-2.005***	0.759
merge_trans	0.098***	0.112*	0.076***	0.069***	0.037**	0.042*	0.473	0.402**	0.268
merge_compl	-0.026***	-0.025	-0.013	-0.005	-0.018	-0.030	0.212	0.078	0.052
$\sigma_u^2$	0.033***	0.034***	0.021***	0.022***	0.018***	0.019***	0.883***	0.618***	0.748***

Note: \*\*\*, \*\*, \* stand for statistically significant at 1%, 5% and 10%, respectively.

Source: Own calculations



Finally, because the efficiency of foreign banks can be affected by specific parent characteristics, as an additional robustness test, we re-estimated our regression with and without lagging the diversification variable by controlling for this possible effect. Indeed, in the empirical analysis of foreign bank efficiency, there exists one important strand in the current literature oriented toward investigating whether the country-level and firm-level characteristics of multinational banks determine differences in foreign bank efficiency in the host nation (Sturm and Williams, 2004, 2008, among others). Among the different parent bank effects, it is often argued that the experience of operating internationally is one important characteristic that enables a multinational bank to succeed in the host nation. Following Tschoegl (1982), we will pay attention to general experiences in place of particular experiences in operating in one particular country. To control for it, we define one proxy variable to indicate the number of countries where the parent bank operates (NCPB). To build this variable, we have elaborated a new database that contains for each foreign bank in Luxembourg the number of countries where its parent bank operates around the world.<sup>13</sup> The findings show that once the NCPB is controlled for (with and without controlling for endogeneity in the diversification decision), the results are consistent with our previous results in all the regressions. Moreover, the results suggest that parent banks that have direct funds and resources to branches established in a large number of countries around the world are less efficient. It is notable that although this effect is statistically significant during the two periods before the financial crisis, it seems that the parent bank effect controlled for in performance does not matter during the financial crisis. These tables are available upon request.

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<sup>13</sup> We would like to thank one of the anonymous referees for incorporating the effect of parent bank on efficiency and particularly to define this type of variable. The database has been built by hand looking bank-by-bank on the Bankscope database.

## 6. Conclusions

In this work, we analyze the business models adopted by foreign banks operating in financial centers both before and during the financial crisis. This analysis is potentially both policy relevant and of independent research interest, given the pressure foreign banks face to maintain market shares, remain competitive and efficiently serve their home parent banks.

To our knowledge, there is no study in the literature that investigates foreign banks' diversification in terms of their asset, funding and income dimensions to analyze the optimal business model.

We focus on a unique data set of foreign banks in Luxembourg over the period from 1995-2009. First, we analyze diversification in the assets, funding and income mix across banks and across time and document the evolution of business models among foreign banks. Then, we estimate technical efficiency separately for focused and diversified banks and test for differences in aggregate efficiency across groups as the first benchmark to test the optimality of foreign banks' business models. Finally, we estimate a truncated regression linking individual technical efficiency scores to bank-specific characteristics and diversification in different dimensions as an essential analysis to accurately identify the optimal business model. The empirical research strategy combines recently developed bootstrap techniques applied to the Li test, weighted DEA and truncated regression.

Our first main result reveals that the most efficient business model for foreign banks in Luxembourg appears to be a focused asset, funding and income strategy. Indeed, the diversified-asset strategy, consistent with the traditional banking theory based on delegated monitoring—which suggests that bank efficiency increases with diversification—is founded only during the consolidation period. Greater funding diversification or income diversification is generally associated with lower technical efficiency, and its effect became more negative during the financial crisis. Our finding show apparent robust evidence that diversification in general destroys technical efficiency and does not play different roles depending on the strategy dimension considered. This finding implies possible limits to how far foreign banks should diversify away from their traditional lending, deposit-taking activities and non-traditional activities.

Our second main result suggests that the organizational forms of banks matter both prior to and during the financial crisis, although it follows different patterns. In fact, branches benefitted from greater efficiency than bank subsidiaries prior to the financial crisis whereas during the

financial crisis, subsidiary banks seemed to be the organizational form that suffered less deterioration in efficiency during the financial crisis. Thus, branches may be preferable to subsidiaries from a technical efficiency point of view; however, bank subsidiaries can also be efficient, and this organizational form is stronger during the financial crisis

The last important result is that, contrary to the general wisdom that branches usually follow focused business models, branches and subsidiaries might adopt both diversified and focused business models, and these models might coexist. During the consolidation period, asset-diversified branches and asset-diversified subsidiaries enjoyed efficiency advantages. Neither branches nor subsidiaries benefitted from greater diversification in funding or income. However, during the financial crisis, diversified branches in the three dimensions suffered enhance efficiency. Overall, although the choice of business model matters for technical efficiency, there is no single business model that fits all foreign banks when we distinguish between branch and subsidiary banks. Thus, neither structure is obviously preferable. As complementary results, our empirical evidence contrasts with the general belief that increasing both diversification and size benefits banks in terms of better efficiency. The results apparently suggest that large foreign banks are also less efficient. Finally, well-capitalized banks appear to be more efficient, and mergers cause short-term efficiency losses, which may be compensated in the long term.

Overall, our empirical evidence suggests that the EU Second Banking Directive may not provide the right incentives for banks operating in the financial center of Luxembourg to develop efficient business models, at least on the income and funding side. In particular, the results suggest that organizational form moderates the effect of diversification on foreign bank efficiency. From a policy point of view, this may contribute to the discussion of how foreign banks should be regulated in Luxembourg and other financial centers. A natural extension for future research would be to study whether foreign bank business models oriented towards focused funding and income are sustainable for the host country.

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## Highlights

- We investigate whether there is an optimal business model for foreign banks along three business dimensions—assets, funding and income.
- Focused business models in all three dimensions enhance efficiency.
- Banks' organizational forms play a role.
- Prior to the financial crisis, branches may be preferable to subsidiaries.
- During the financial crisis, subsidiaries perform better than branches.
- Branches diversified in assets, funding and income exploit efficiency advantages during the financial crisis.

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