Centre for Efficiency and Productivity Analysis

Working Paper Series
No. WP02/2011

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Date: March 2011

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ISSN No. 1932 - 4398

Title

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JEL classification: G15, G21; G28, C14

Keywords: Foreign bank efficiency; Home-host country characteristics, Bank regulation, Data Envelopment Analysis, Bootstrap.

Abstract

This paper investigates the effects of home country banking regulations on the performance of foreign banks in Luxembourg's financial center. We control for the main regulatory indicators, such as capital requirements, private monitoring, official disciplinary power and restrictions on bank activities, accounting for the regulatory regime applied to foreign banks. We also control for the level of GDP in the home country and its position in the business cycle. The two-stage bootstrap method proposed by Simar and Wilson (2007) is applied to bank panel data covering 1999-2009. The analysis carries policy implications for bank regulators in both home and host countries and provides insight into the choice between establishing a branch or a subsidiary, when developing cross-border activities through financial centers.

1. Introduction

The internationalization of financial services played a central role in the recent crisis, raising challenges for regulators, firms and investors. Financial centers have contributed in part to the increasing integration between local and global capital markets and the growth of multinational banks. The attraction of financial centers is not just related to favourable fiscal and regulatory frameworks, political stability and adequate telecommunication networks, but also to the concept of "going where the business is": international banks establish a presence in financial centers to interact with other banks (Tschoegl, 2000).

Research on international banking has either focused on the impact of foreign banks on the level of banking competition in the host country (Berger, 2007) or on the impact of banking regulation and supervision framework on performance. However, the literature has mostly neglected financial centers, although these are a natural laboratory to analyze cross-border banking given that they are mainly composed of foreign banks.

Papers focussing on competition are mostly confined to developing countries and their findings have been controversial and inconclusive, in part because they disregard both home and host country characteristics (e.g., Sturm and Williams, 2004). More recently, Sturm and Williams (2008, 2009, 2010) have stressed the importance of national factors in analyzing foreign bank efficiency in Australia. Lensink et al. (2008) also examined the relationship between foreign bank efficiency and the quality of home and host institutions.

Other papers focussed on the impact of regulation on bank performance across countries. However, these usually use financial ratios as a rough indicator of bank performance instead of applying frontier techniques. See Pasiouras et al. (2009), Pasiouras (2008) and Bath et al. (2010) for international evidence.

Only a handful of papers analyse the performance of foreign banks in financial centers: Rime and Stiroh (2003) used data from Switzerland and Kwan (2006) used data from Hong Kong.

The main purpose of this paper is to analyze the performance of foreign banks in financial centers. Given the specific characteristics of financial centers, this analysis requires a modification of the standard research procedure. First, since financial centers are mainly composed of foreign banks, it becomes meaningless to speak of the effects of foreign banks on domestic banks. Second, since financial centers provide a platform where international banks meet through their subsidiaries or branches, the preferred organizational form needs to be investigated. Third, the difference between home and host country characteristics needs to be taken into account to measure performance properly.

The contribution of this paper is twofold. First, we analyze which organizational form (subsidiary vs. branch) perform better when international banks operate in financial centers. Second, we determine which home or host country characteristics drive the efficiency of banks in a financial center, while controlling for other bank-specific features.

We study Luxembourg in particular, which has a long tradition as financial center since it started to develop international syndicated loans, euro-bonds and euro-currency markets in the 1970s (OECD, 2008).

Over time, Luxembourg diversified its financial activities while maintaining a favorable fiscal and regulatory environment to attract foreign banks (IMF, 2009).

From a methodological point of view, we integrate two recently developed approaches: the algorithm based on group-wise Data Envelopment Analysis (DEA) (Simar and Zelenyuk, 2007) and the algorithm based on two-stage DEA (Simar and Wilson, 2007). These allow for more accurate estimates and valid statistical inference on aggregated DEA efficiency scores as well as on regression parameters.

In the first approach, we estimate the efficiency of *groups* of banks, assuming all banks have access to the same nation-specific technology (although the level of efficiency in applying this technology could vary). The second approach identifies the main determinants of individual bank efficiency scores. It consist of two stages: in the first stage the individual efficiency scores are estimated via DEA and in the second stage they are corrected for bias and are regressed on a set of explanatory variables including dummy variables identifying bank groups. A truncated regression with a parametric bootstrap is performed for this second stage.

Summing up, this paper extends the current international banking literature along two dimensions: (i) it analyzes foreign-bank efficiency in a financial center, (ii) it accounts for different home country regulations and supervision frameworks. The rest of the paper is structured as follows. Section 2 provides a brief background of Luxembourg banking sector. Sector 3 and 4 cover the methodology and the data used, Section 5 discusses the empirical results and, Section 6 concludes.

2. Luxembourg banking sector

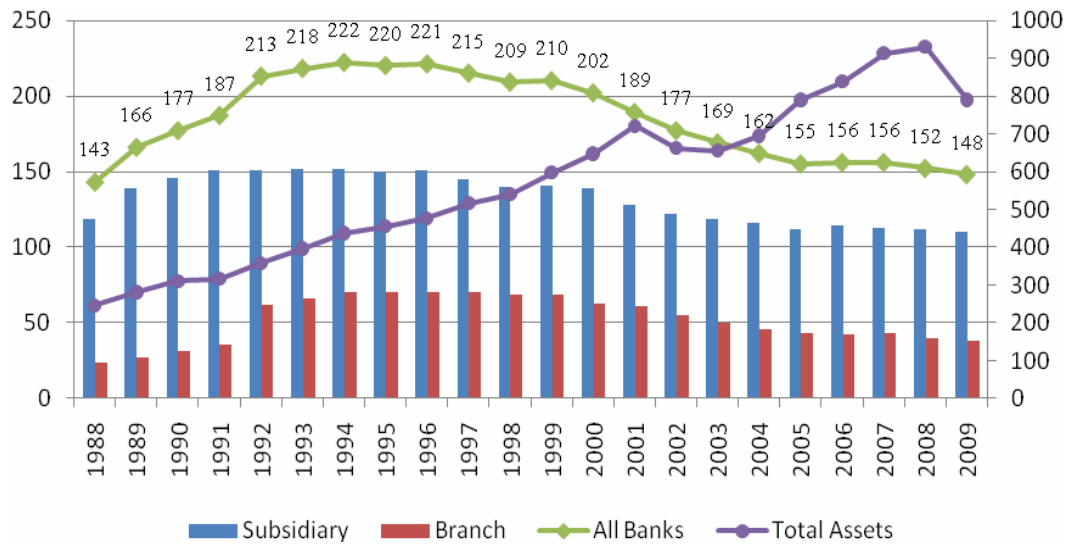
The Luxembourg banking sector is characterized by the strong presence of foreign banks. Initially associated with international syndicated loans in the early 1960s, the financial sector went on to introduce euro-bonds and euro-currency markets (OECD, 2008). More recently, Luxembourg developed as a centre for private banking and currently is the largest European centre for the domiciliation of investment funds (IMF, 2009). Growth was encouraged by tax and regulatory advantages as well as Luxembourg's swift implementation of EU directives (OECD, 2008, 2010).

Supervisory requirements in Luxembourg differ across three types of banks: banks incorporated under Luxembourg law (including foreign-bank subsidiaries), branches of banks incorporated in other EU countries, and branches of banks incorporated in countries outside the EU. A foreign bank's mode of entry may reflect regulatory differences between home and host country. For example, a parent bank may choose to establish a subsidiary that will be supervised under Luxembourg law, or it may prefer to establish a branch to remain subject to its home supervisor. Other aspects also affect the choice between subsidiary and branch : subsidiaries must be at least 50% foreign-owned and the liability of the parent bank is limited to the amount of capital invested. On the other hand, branches are not independently incorporated but are fully owned by their foreign parent bank (Cerruti et al., 2007). Although organizationally less demanding, a branch only allows the parent bank to run a limited set of operations in the foreign country (Pozzolo, 2009), usually focussing on inter-bank activities. A subsidiary instead can operate more freely and provides the

parent bank complete access to the host country in terms of customers served and product/services offered. As an international financial center, Luxembourg has relatively few domestic banks. There are only two wholly state-owned banks: Banque et Caisse d'Epargne de l'Etat and Société Nationale de Crédit et d'Investissement. In addition, there are also two domestic banks with a mix of public and private ownership (Fortuna Banque and Banque Raiffeisen[1]) as well as one domestic bank that is privately owned (Compagnie de Banque Privée). None of them holds a dominant position in any segment of the market (loans or deposits). This low level of domestic competition probably acted as an additional incitement for foreign banks to establish a local presence.

Figure 1 presents the number of banks in Luxembourg, including the breakdown by subsidiaries and branches, as well as the evolution of total assets aggregated across banks. The total number of banks peaked in 1994 at 222, mainly due to rapid growth in the number of branches in the preceding two years. After that, the number of both branches and subsidiaries declined to reach a total of 148 in 2009. Despite, this fall in the number of banks, the aggregate balance sheet grew in all years except during the crises of 2002 and 2009. This indicates that most exits were through mergers, leaving the size of the aggregate balance sheet unaffected, but raising the size of the average bank.

Figure 1: Number of banks and total assets of the sector



Source: BCL

Banks in Luxembourg specialise in different financial activities. Formally, most are universal banks, running both traditional intermediation and financial market activities. However, results in Curi et al., 2010, suggest that over time subsidiaries have mostly specialised away from interbank deposits, while branches have developed a bimodal distribution with some concentrating on interbank deposits while others

[1] Banque Raiffeisen and its local caisses rurales are considered a single credit institution (CSSF, 2007)

specialised away from them. With respect to the traditional banking activities, branches reinforced their specialization, while subsidiaries became more diversified, particularly in interbank deposits. Heterogeneity across banks is high in terms of securities held, both for branches and subsidies. Moreover, subsidiaries became more diversified, and this is true also with regard to the off-balance activities. On the other hand, branches became dedicated business unit of multination banks, allowing the exploitation of international operations at the lowest investment requirement. Clear patterns of convergence appear in interbank lending. In customer loans and deposits, evidence of convergence is more tentative. This could be due to the fact that retail activities account still too little for the majority of subsidiaries insomuch as they could be easily catched up by branches. For interbank deposits, instead, there is evidence of divergence between branches and subsidiaries. This could reflect different structures of liabilities or differences in the level of deposit guarantees. Convergence between branches and subsidiaries is found for securities held whereas a divergence in the off-balance sheet activity. These differences suggest that multinational banks use branches and subsidies for different functions. Convergence appears for those activities requiring less investment and depending more on technology. Divergence appears for activities that require more labor or skills.

3. Literature Overview

In the banking literature, there are three relevant streams of research: the first examines factors determining foreign bank efficiency; the second investigates the impact of banking regulations in the context of international comparisons; the third focuses on financial centers.

Studies on the main determinants of foreign bank efficiency

European banking markets are increasingly integrated through foreign branches and subsidiaries, as well as through cross-border mergers or acquisitions. However, fears that European banking integration is slowing significantly has recently motivated researchers to focus on the main efficiency disadvantages which multinational banks face when operating in a host country. A large academic literature finds that in developed economies foreign banks tend to perform poorly relative to domestic banks, while the reverse is usually true for developing economies (see Berger et al., 2000 and Berger, 2007). For instance, Berger et al. (2000) concluded that in France, Germany and the UK, domestic banks have higher cost and profit efficiency on average. However, Sturm and Williams (2004) found that in Australia foreign banks were more efficient. These papers do not distinguish foreign banks by their nation of the origin, limiting their conclusions.

The sources of these differences in efficiency have been identified by two different theories. Ricardo's theory of comparative advantage suggests that foreign banks must benefit from some core characteristics of their home economies which allows them to overcome the diseconomies of operating in distant markets with foreign economic, cultural, and regulatory environments (Berger et al., 2004). Instead, the new trade theory (Markusen, 1995), suggests that banks with a comparative advantage in management skills are likely to export them to host economies that are relatively similar to their home economy. Thus, under comparative

advantage, foreign direct investment mostly occurs between dissimilar countries while under the new trade theory it occurs between similar countries.

Sturm and Williams (2008) extended their previous work by disentangling the unspecified nationality factors into home nation, parent bank and host nation effects. Applying general-to-specific modeling to control for additional variables, they found that the unspecified nation-specific factors represented by dummy variables have no additional explanatory power in explaining bank efficiency. This evidence rejects the comparative advantage hypothesis supported by Berger et al. (2000). Sturm and Williams (2009) took a step further. After estimating bank efficiency using parametric distance functions, they derived common factors to capture features specific to foreign banks. In Sturm and Williams (2010) they combined general-to-specific modeling and extreme bound analysis to evaluate the sensitivity of performance measures in UK banking. They found support for the comparative advantages hypothesis of Berger et al. (2000) also controlling for the relevance of the new trade theory in explaining foreign bank efficiency.

At the international level, Lensink et al. (2008) examine the relationship between the foreign bank efficiency and the quality of institutions in the home and host country. This paper finds that foreign ownership negatively affects bank efficiency although this effect is less pronounced when governance in the host country is fairly good. Further, foreign bank inefficiency is reduced by higher quality institutions in the home country as well as greater similarity between home and host country.

Studies on the impact of banking regulations on international bank efficiency

Banks are the most highly regulated industry in the economy (Walter, 1985). International comparisons of bank efficiency have sought to account for the influence of different regulatory regimes. Starting with Dietsch and Lozano-Vivas (2000), it has been found that neglecting country-specific regulatory characteristics may bias inefficiency estimates in international comparisons. Initial studies (e.g., Dietsch and Lozano, 2000; Grigorian and Manole, 2002) used simple proxies due to data limitations, but more recently, Pasiouras (2008) analysed a broad range of regulatory and supervision measures over a wide set of countries. Using DEA to estimate bank efficiency in the first stage and Tobit regression to analyse its sources in the second stage, he found evidence that technical efficiency is positively influenced by stricter capital adequacy standards, more powerful supervisory agencies and more effective market discipline mechanisms. Pasiouras et al. (2009) extended the previous work by exploring the impact of regulatory measures on both cost and profit efficiency. This revealed that higher capital requirements improve cost efficiency but reduce profit efficiency, while restrictions on bank activities have the opposite effect, reducing cost efficiency and improving profit efficiency.

Recently, Bath et al. (2010) examined the impact on bank operating efficiency of regulation, supervision and monitoring. Applying DEA and then regressing inefficiency scores on regulatory and other control variables, the authors found that tighter restrictions on bank activities are associated with lower bank efficiency, while more stringent capital regulation is associated with marginally higher bank efficiency. In addition, they found that stronger official supervision is positively associated with higher bank efficiency,

although only in those countries with independent supervisory authorities. Lastly, market-based monitoring of banks (greater financial transparency) is associated with higher bank efficiency. However, these studies do not consider either the organizational form of foreign banks or home and host country effects.

Studies on financial centers

International financial centers are increasingly discussed by academics, regulators and law makers (see Park and Essayyad, 1989). The consensus is that these centers must have some distinct features which benefit international banking in general and the host country in particular. For instance, financial centers improve the international allocation of financial resource by enhancing the integration of local capital markets with global markets; they increase local as well as expatriate employment; they promote the internationalization of the local economy; they encourage the growth of multinational banks by providing a favorable fiscal and regulatory climate. Thus, increasing financial globalization is likely to continue sustaining growth in financial centers. From the point of view of multinational banks, establishing a presence in financial centers is "going where the business is" (Tschoegl, 2000) to meet other banks through subsidiaries and/or branches to develop specific business lines (inter-bank activities or trading in the wholesale financial market). Moreover, financial center is the place where multinational banks establish their subsidiaries and/or branches as oligopolistic reaction to the competitors. Lastly, financial centers provide agglomeration economies which benefit banks' revenues, reduce their costs and encourage innovation.

In the banking literature, two papers focus on bank efficiency in financial centers: Kwan (2006) and Rime et al. (2003). The first investigates cost efficiency of commercial banks in Hong Kong using standard multi-product translog cost function and finds that banks move closer to the frontier over time. On average, large banks were less efficient, but the size effect appears to be related to differences in portfolios. Rime et al. (2003) examine the performance of Swiss banks using the distribution-free approach. They found relatively large cost and profit inefficiencies, with economies of scale for small and mid-size banks.

However, these authors simply apply standard bank efficiency tools to analyze financial centers without considering differences in organizational form, regulatory scheme or business orientation (i.e. more diversified versus more specialized foreign banks).

4. The econometric framework

In this section we briefly outline the methodology we use to assess foreign bank efficiency and to disentangle the effects of home/host regulations and other characteristics. Because the true technology is unknown, we estimate it from the data using Data Envelopment Analysis (DEA) (Farrell 1957; Charnes et al., 1978).[2] To

[2] DEA implicitly assumes that banks have access to the same technology, but the degree of this access, or the level of efficiency in using this technology may differ across banks.

briefly outline the DEA estimator, let $x_k = (x_k^1,...,x_k^H)' \in \Re_+^N$ be a vector of H inputs that each firm k (k = 1, 2,… , n) uses to produce a vector of M outputs, denoted $y_k = (y_k^1,...,y_k^H)' \in \Re_+^M$ Then the DEA estimate of the technology set (assuming constant returns to scale and free disposability of inputs and outputs) can be written

$$\hat{\Psi}_{DEA} = \Big\{(x,y) \in \Re_+^H \times \Re_+^M \;\Big|\; \sum_{k=1}^{n} z_k y_k^m \geq y^m, m = 1,\ldots,M \\ \sum_{k=1}^{n} z_k x_k^h \leq x^h, h = 1,...,H,\; z_k \geq 0, \quad k = 1,\ldots,n\Big\} \tag{1}$$

where $\{z_k \geq 0 : k = 1,...n\}$ are the intensity variables over which the maximization will be made. Under certain regularity conditions on the data generating process (DGP), the expression in (1) provides a consistent estimator of the unknown technology.[3] Note that at this stage we impose constant returns to scale for the DEA estimator to attain greater discriminatory power while measuring all banks to the same (and optimal) level of scale and then, at the second stage, we attempt to disentangle the scale effect on efficiency scores by including a scale variable (and its square) in the regression[4].

The DEA estimator has the advantage that it can easily handle multiple inputs and outputs and makes no parametric assumptions on the form of the production relationship or the distribution of the inefficiency term. DEA can also accommodate cases when some inputs or outputs are zero, which is important in banking, where zero values may reflect strategic decisions by bank management. The main drawback of DEA is that it attributes all deviations from the frontier to the inefficiency term, while some of them could be due to noise (measurement error or imperfect control). Note, however, that the inputs and outputs in our approach are allowed to be random, and moreover, the efficiency level is also allowed to depend on various factors, including a random error, and so, to some extent, we deal with the problem of randomness and noise at the second (regression) stage of our analysis. An important issue here is to correct for the bias of DEA efficiency estimates, which is why we use the recently developed bootstrap techniques in Simar and Wilson (2007), Kneip et al. (2008) and Simar and Zelenyuk (2007).

Once the technology is estimated, various measures can be used to provide inefficiency scores for each bank and we employ the radial distance to the frontier, according to the Debreu (1951)-Farrell (1957) criterion. In particular, we use the output-oriented measure of technical efficiency defined as

$$TE(x,y) = \max_{\theta,z_1,...,z_n} \Big\{\theta \,\Big|\, (x,\theta y) \in \hat{\Psi}_{DEA}\Big\}, \tag{2}$$

[3] See Korostelev et al. (1995) and Park et al. (2010) for proof of consistency and rates of convergence of the DEA estimator under constant returns to scale.

[4] As an alternative to DEA, efficiency can also be measured by stochastic frontier analysis (SFA) (e.g. Park et al. (2008), Simar and Wilson (2010), Simar and Zelenyuk (2010) and references cited therein).

which is a consistent estimator of the true efficiency score from a point (x, y) to the frontier of the true technology set in (1).

Obtaining individual efficiency scores for each bank using (2) is only the first step. We then analyse the aggregate efficiency scores of particular groups in the industry. Intuitively, the aggregation structure we employ is based on economic optimization,[5] which yields the weights reflecting the importance of each bank within and between groups when averaging efficiency scores. In particular, we use the price-independent weighting scheme derived by Färe and Zelenyuk (2003, 2007) and recently extended to a multi-group context by Simar and Zelenyuk (2007). These weights are based on the aggregates of realized shares of each output in the industry. We then use the Simar and Zelenyuk (2007) algorithm, based on the heterogeneous sub-sampling bootstrap, to obtain bias-corrected estimates of aggregate efficiency scores for various groups in the industry, as well as their confidence intervals, which allow us to test for significant differences in aggregate efficiency between groups (see Simar and Zelenyuk (2007) for the technical details).

The next step of our analysis explores the relationship between the (non-weighted) individual bank efficiency scores and the so-called 'environmental variables' that we expect to influence efficiency. When DEA efficiency estimates appear as the dependent variable in such second-stage regressions, Simar and Wilson (2007) proposed a rigorous procedure that addresses important statistical issues ignored by standard regression tools (OLS and Tobit) routinely used in this context. More specifically, we use algorithm 2 of Simar and Wilson (2007), which corrects for (i) the bias of DEA estimates, (ii) serial dependence among DEA estimates (of unknown structure) and (iii) the DEA-related artefact of placing probability mass at 1 for some observations.[6] Formally, the true model we aim to estimate is given by

$$TE_k = Z_k\beta + u_k \,, \quad k = 1,...,n \,, \tag{3}$$

where TE_k is the true (in)efficiency score of bank *k*, while Z_k is the (row) vector of regressors (characteristics of bank *k*) that are believed to influence the (in)efficiency score of bank *k* through the (column) vector of parameters β, which we aim to estimate, while u_k is a random error.

Obviously, the true inefficiency score, TE_k, is unobserved and so we replace it with its DEA estimate from the first stage, corrected for the bias via the bootstrap procedure that accounts for the production model in (1) and the hypothesized structure in (3). Importantly, because $TE_k \geq 1$, we also have $u_k \geq 1 - Z_k\beta$, for all $k = 1,...,n$ and, to account for this boundary issue, we use the truncated regression approach, by assuming $u_k \sim N(0, \sigma_\varepsilon^2)$ such that $u_k \geq 1 - Z_k\beta, k = 1,...,n$, where σ_ε^2 is estimated along with β. To improve

[5] For instance, minimization of costs or maximization of revenues/profits.

[6] The model in Simar and Wilson (2007) requires some regularity conditions, including the 'separability' assumption which could be relaxed in future work.

accuracy of inference, we use the parametric bootstrap (reflecting the structure in (3)) to obtain confidence intervals around each element in β. This procedure is described in more detail in Simar and Wilson (2007).

All the explanatory or environmental variables in Z_k can be grouped into four categories: (i) the macroeconomic variables, (ii) the regulatory variables, which include measures of capital requirements, private monitoring, official disciplinary power, restrictions on banks activities, (iii) the variables that control for bank-specific characteristics, (iv) the variables that control for the subgroups identified at the first step. We also include a time dummy, to pick up the effects of particular years. We discuss these variables in more detail in the next section.

5. Determinants of bank efficiency

This section briefly describes the variables considered as possible determinants of foreign bank efficiency in financial centers. Following Sturm and Williams (2008), we use two different sets of home-host country characteristics (macroeconomic and regulatory variables), also controlling for bank-specific characteristics and individual year effects.

4.1 Country-specific characteristics: economic and regulatory indicators

Economic indicators (home country characteristics)

In international comparisons of bank efficiency, economic conditions are important. We introduce two macroeconomic variables to control for this fact, per capita GDP and business cycle. We control for GDP as nations with higher GDP usually have a more efficient banking sector and therefore are more likely to export efficient practices (Yildirim and Philippatos, 2007; Sturm and Williams, 2010). We use quarterly real GDP, seasonally adjusted (*GDP_CAP*)

We also assume that parent banks could transmit effects of the business cycle in their home economy to their subsidiary and/or branches abroad. Many studies argue there is a close relationship between cyclical movements in output and productivity (e.g. Boisso et al., 2000; Basu and Fernald, 2001; Inklaar, 2007). We use the Hodrick-Prescott output gap measure (*OUTPUT_GAP*) as a proxy of business cycle. This is defined as the percentage deviation of observed GDP from its trend. If this measure is positive, then aggregate demand presumably exceeds aggregate supply, generating inflationary pressure; if this measure is negative, the reverse holds, possibly slowing growth in prices.

These two economic indicators, GDP and business cycle are calculated at the home level, i.e. for each branch and subsidiary we control for the level of per capita GDP and the position in the business cycle of their respective home economy.

Regulatory Indicators (home-host country characteristics)

The regulatory, supervisory and monitoring requirements to which banks are subjected, could have an important impact on bank performance. In the past, data limitations have discouraged international comparisons from addressing this issue. However, three worldwide surveys on bank regulation and supervision have recently appeared (Barth, Caprio and Levine, 2004, 2006, 2008) and are used in this study. Following Pasiouras (2008), we include variables to control for the main regulatory measures, but we distinguish whether it is the regulatory scheme in the home country or the host country that is relevant for each foreign bank in the financial center. The regulatory scheme will be different for subsidiaries and branches. Branches are subject to the supervisor in their home country (that of their parent bank), while subsidiaries are subject to the supervisor in the host country where they operate.

The variables we consider are related to the three pillars of Basel II, namely capital requirements (Pillar 1), official supervisory power (Pillar 2), and market discipline (Pillar 3). The private and the public interest view (Bath et al., 2006) provide conflicting predictions about the effects of regulation and supervision, so empirical studies can help inform policy decisions.

Capital requirement

The variable CAPRQ is an index of capital requirements, with higher values indicating greater capital stringency. Higher capital requirements will raise the cost of doing business at a given level of risk. According to the public interest view, capital requirements are believed to play a crucial role aligning the incentives of bank owners with those of depositors and other creditors, leading to more careful lending and better bank performance (Keeley and Furlong, 1990; Barth et al., 2006). However, this ignores possible costs in the form of higher barriers to entry and greater rent extraction by governments (Barth et al., 2006). Pasiouras (2008) suggests that capital requirements can affect bank efficiency through at least three channels. (i) by reducing aggregate lending; (ii) by substituting loans with alternative forms of assets, and (iii) by influencing the decisions of banks with regard to the mix of deposits and equity, which bear different costs. These arguments, associated with the private interest view, would suggest that more stringent capital requirements are associated with lower bank efficiency.

Private monitoring

The variable (*PRMONT*) measures the degree to which banks are forced to disclose information to the public and whether there are incentives to increase private monitoring. Higher values indicate more informative bank financial statements for auditors and the public. This variable can be considered a general proxy for the third pillar of Basel II. It is related to the *private monitoring hypothesis* which notes that powerful supervision might coexist with corruption or other sources of efficiency loss. However market discipline through private monitoring should always improve bank efficiency (Barth et al., 2007). Nevertheless, Pasiouras (2008) notes that higher disclosure requirements can also have a negative impact on efficiency as they may involve direct and indirect costs, investment in investor relations, coordination among departments, and the release of sensitive information to competitors

Official disciplinary power

The variable *SPOWER* is a measure of supervisory agencies ability to take specific actions against bank management and directors, shareholders, and bank auditors. Higher values of *SPOWER* indicate broader and greater authority for bank supervisors. This indicator is considered as a proxy of the second pillar of Basel II. According to the *official supervision hypothesis* market failure can be avoided by official supervisors directly overseeing, regulating, and disciplining banks. In so far as a powerful supervisor could improve corporate governance within banks, reduce corruption, and generally improve the functioning of financial intermediaries high values of this index should be associated with higher bank efficiency (Beck et al., 2006).

Restrictions on banks activities

The variable *RESTR* captures restrictions on bank activities. It reflects whether securities, insurance, real estate activities, and ownership of non-financial firms are unrestricted, permitted, restricted, or prohibited. Higher values indicate greater restrictions.

Barth et al. (2004) discuss several reasons for restricting bank activities as well as reasons for allowing banks to participate in a broader range of activities. On the one hand, allowing a wide range of financial activities may lead to increased risk exposure, or to the establishment of complex and powerful banks that will be difficult to monitor or discipline and may reduce competition and efficiency. On the other hand, fewer regulatory restrictions may allow economies of scale and scope, increase the franchise value of banks and offer opportunities for income diversification. Barth et al. (2003) also point out that while fewer restrictions could provide greater profit opportunities, banks may fail to meet the challenge of managing a diverse set of financial activities beyond traditional banking, and hence experience lower efficiency.

4.2 Bank-specific characteristics

Bank-specific characteristics: Size and risk measures.

Following the banking literature, we use total assets to measure the size of banks. As in Berger et al. (2010), we use a continuous variable, ln(total assets), that is usually preferred to a size dummy variable. We also include the squared term of ln(total assets) to control for potential nonlinearities in the relationship between size and performance.

As a proxy of risk, we use bank equity defined as the ratio of equity book value to total assets. Empirical evidence suggests that regulators may allow relatively efficient banks to operate with higher leverage, all other things being equal (Hughes and Moon, 1995; Hughes and Mester, 1998). Others, such as Altunbas et al. (2000, 2007) find that financial capital can significantly influence bank cost and profit efficiency measures.

Group-specific characteristics: organizational form, diversification, parent bank nationality

As mentioned in the introduction, in financial centers the organizational form of foreign banks is important given the different regulatory scheme for branches and subsidiaries. While branches are an integral part of the parent bank (they draw on the parent's capital base) and operate in a host country under the authority of the home country supervisor, subsidiaries lend on the basis of their own capitalization and are subject to the host country supervisor. We define a dummy variable equal to 1 if the bank is a branch, and 0 otherwise.

The degree of diversification could affect bank efficiency for two reasons: (i) from the point of view of the single bank, diversification could lead to scope economies and cost advantages (ii) from the point of view of the financial center, diversification may attract a wider set of clients. Following (Berger et al. 2010, Mercieca et al., 2007, Acharya et al., 2002), we use the Henfindahl-Hirschman index (HHI) to measure diversification in terms of bank assets. Total assets are disaggregated into bank loans, customer loans, securities held (including government securities and shares), total fixed assets and other assets. Formally, the HHI is given by the following sum of squares:

$$HHI_i = \left(\frac{LOAN\_B_i}{TA_i}\right)^2 + \left(\frac{LOAN\_C_i}{TA_i}\right)^2 + \left(\frac{SEC_i}{TA_i}\right)^2 + \left(\frac{FIX\_ASS_i}{TA_i}\right)^2 + \left(\frac{Others_i}{TA_i}\right)^2$$

where for each bank i, LOAN_B is loans to other banks, LOAN_C is loans to firms and private households, SEC is securities held, FIX_ASS is total fixed assets, *Others* is other assets and TA is total assets. The index varies between 0 and 1, with higher values identifying banks that are more focused (less diversification). However, banks with a different composition of total assets may record the same level of the HHI[7].

Foreign banks originating or active outside the European Monetary Union may face additional costs related to currency fluctuations. We therefore consider two groups of banks: those belonging to the euro area vs. those which do not. We use two dummy variables, one for each group.

4.3 Period-specific dummy variables

Lastly, we control for some important events in the host country that may affect foreign bank performance. For some specific years, we introduce dummy variables to capture possible economic and structural changes that are common across the sector. A dummy for the year 2001 aims to pick up the end of a period of wage consolidation, one for 2003 picks up the aftermath of the stock market crisis, one for 2006 picks up the boom preceding the financial crisis and one for 2009 picks up the recession after the Lehman Brothers collapse.

[7]It would also be possible to look at the diversification on the financing sources. However, the level of granularity among banks is higher (Stragiotti and Rychtarik, 2009; Curi et al., 2010) and this would lead to smaller sample size of each group, which would create some problems for DEA estimation due to the curse of dimensionality.

5. Data and sources

We work with bank reporting data provided by the Central Bank of Luxembourg (BCL). The sample covers the period 1999:Q1-2009Q4 and consists mostly of commercial banks involved in both customer and inter-bank activities. First, we take annual averages to avoid seasonal effects: for the stock variables (from the balance sheet), we take the average of the four consecutive quarters, while for flow variables (from the profit-and-loss account) we report the year-to-date values. Second, we exclude banks missing balance sheet information. These are mainly branch banks, which face lower reporting requirements because they are regulated and supervised by their home country authorities. Lastly, we remove possible outliers by inspecting the distribution of estimated efficiency scores. The final sample is an unbalanced panel of banks. Note, however, that we do not omit banks with zero values in inputs or outputs as they may represent strategic choices by bank management (Thompson et al., 1993). Data in nominal values are converted to real terms using the GDP deflator with base year 1995. We use unconsolidated statements.

Our choice of bank inputs and outputs is based on the intermediation approach (Sealey and Lindley, 1977) which is common in the bank efficiency literature (Berger and Humprey, 1997). On the input side, we select (i) labor, measured by total labor expenses, (ii) capital, measured by fixed assets, (iii) interbank deposits, and (iv) customer deposits. On the output side, we select interbank loans, customer loans and securities. However, as discussed in Curi et al. 2010, Luxembourg banks increasingly rely on net commission income, so we also include non-interest income as proxy for off-balance sheet activities. Note that interbank activities includes those within the parent banking group as well as with other banks. Customer activities include those with households and with non-financial corporations. Securities include government securities, fixed-income securities, shares, participations and other variable-income securities.

Table 1 presents the summary statistics of input and output variables by subgroup. Subsidiaries appear to be more labor intensive than branches (approximately six times more labour costs on average) and have higher fixed investments. The average subsidiary bank is more involved in customer, securities and non-traditional activities. However, on average subsidiaries and branches are similar in interbank activity (for more discussion of the differences between subsidiaries and branches see Curi et al., 2010). We also distinguish between diversified banks (HHI below 0.6) and focused banks (HHI above 0.6), where 0.6 is the mode of the kernel estimated density of the HHI across banks. The average diversified bank use approximately twice as much inputs as the average focused bank and is (four times) more capital intensive. On the output side, they differ in customer lending and securities. Lastly, the average non-European bank is less involved in interbank, customer and securities activities. Although on average European and non-European banks are similar in non traditional activities.

Table 1: Descriptive statistics of the variables used to estimate bank technical efficiency.

	Subsidiary banks			Branch banks			Ratio
	Obs.	*Mean*	*Std Dev.*	*Obs*	*Mean*	*Std Dev.*	Mean
Labor	1227	12,092,157	22,371,661	299	1,903,994	4,921,832	6.35
Capital	1227	104,761,440	218,142,543	299	990,627	2,140,470	105.75
Interbank Deposits	1227	2,382,471,212	4,980,401,444	299	1,918,695,969	3,929,373,789	1.24
Customer Deposits	1227	1,392,652,295	2,668,355,369	299	497,703,363	847,949,912	2.80
Interbank Loans	1227	1,896,412,480	4,066,248,127	299	1,817,156,227	3,731,337,213	1.04
Costumer Loans	1227	898,894,486	2,126,884,339	299	277,829,571	717,444,293	3.24
Securities	1227	1,105,501,716	2,414,879,031	299	334,382,874	1,016,328,641	3.31
Non Interest Income	1227	26,123,228	41,207,740	299	4,700,637	11,990,650	5.56
		Diversified banks			Focused banks		Ratio
		Mean	*Std Dev.*		*Mean*	*Std Dev.*	Mean
Labor	989	12,440,176	24,341,037	537	5,778,469	9,158,089	2.15
Capital	989	20,291,074	56,947,218	537	4,754,634	10,296,057	4.27
Interbank Deposits	989	2,794,017,940	5,084,553,618	537	1,366,291,487	4,054,465,664	2.04
Customer Deposits	989	1,511,065,466	2,823,096,401	537	676,264,294	1,379,025,610	2.23
Interbank Loans	989	1,986,025,989	3,751,760,504	537	1,687,240,451	4,422,593,366	1.18
Costumer Loans	989	1,108,373,472	2,312,863,084	537	167,287,173	608,900,005	6.63
Securities	989	1,336,670,622	2,575,532,977	537	250,398,213	1,089,227,390	5.34
Non Interest Income	989	25,357,612	42,987,942	537	15,605,238	26,490,398	1.62
	Euro Area banks			Non-Euro Area banks			Ratio
	Obs.	*Mean*	*Std Dev.*	*Obs.*	*Mean*	*Std Dev.*	Mean
Labor	962	11,820,994	24,771,860	564	7,153,502	9,263,953	1.65
Capital	962	20,195,980	57,931,361	564	5,660,599	8,902,653	3.57
Interbank Deposits	962	3,399,658,310	5,732,146,405	564	401,615,208	719,171,008	8.46
Customer Deposits	962	1,617,267,712	2,924,458,175	564	535,081,797	943,133,294	3.02
Interbank Loans	962	2,618,600,885	4,834,424,666	564	622,577,614	983,844,986	4.21
Costumer Loans	962	1,072,764,175	2,368,046,013	564	273,077,020	558,771,781	3.93
Securities	962	1,469,012,527	2,675,166,089	564	76,668,501	244,565,857	19.16
Non Interest Income	962	24,704,854	43,703,745	564	17,185,501	25,959,112	1.44

Table 2 reports descriptive statistics of the environmental variables used in the second stage. Country-specific variables come from two different sources. Data for regulatory and supervisory variables (capital requirement, private monitoring, official disciplinary power, restrictions on banks activities) were obtained from the database developed by Barth et al. (2007). These indicators cover all our home countries for the years 2001, 2003, 2005, except for Norway in 2001 and Turkey in 2005. Macroeconomic indicators (gross domestic product and output gap) were obtained from Eurostat and own calculations.

Table 2: Descriptive statistics of the environmental variables used in the second stage.

Variables	Mean		Median		Std. Dev.	
	Subsidiary	Branch	Subsidiary	Branch	Subsidiary	Branch
CAPRQ	30.64	29.58	26.38	26.38	12.77	11.43
ACTRS	8.24	7.83	8.00	7.00	2.38	2.79
PRMONT	8.77	8.69	9.00	10.00	2.32	2.50
SPOWER	10.82	10.42	10.00	10.00	4.50	4.58
GDP_CAP	25,436	22,551	23,567	23,256	9,206	8,392
OUTPUT_GAP	0.13	0.11	0.19	0.19	1.32	1.43
Variables	Mean		Median		Std. Dev.	
	Diversified	Focused	Diversified	Focused	Diversified	Focused
CAPRQ	30.81	29.73	26.38	26.38	13.08	11.41
ACTRS	8.06	8.34	8.00	8.00	2.38	2.62
PRMONT	8.82	8.63	10.00	9.00	2.32	2.41
SPOWER	10.61	10.99	10.00	11.00	4.40	4.73
GDP_CAP	23,710	24,883	23,366	23,544	7,915	9,124
OUTPUT_GAP	0.13	0.13	0.24	0.13	1.34	1.34
Variables	Mean		Median		Std. Dev.	
	Euro	Non-Euro	Euro	Non-Euro	Euro	Non-Euro
CAPRQ	29.17	32.58	26.38	28.00	10.90	14.66
ACTRS	7.56	9.19	7.00	9.00	2.07	2.74
PRMONT	8.78	8.70	10.00	8.00	2.37	2.33
SPOWER	9.30	13.21	9.00	13.00	3.48	5.00
GDP_CAP	24,883	28,941	23,544	33,782	9,124	13,675
OUTPUT_GAP	0.18	0.05	0.24	-0.01	1.26	1.47

6. Results

We first present results on foreign bank efficiency in Luxembourg. Given the heterogeneity among banks in term of organizational form, level of diversification and parent bank nationality, we report group efficiency with weights derived from economic optimisation. The results from this first stage of analysis provide some insights about which characteristics should be considered

as possible determinants of efficiency among foreign banks in financial centers. We then report results from the second-stage regressions which estimate the effects of home country regulations, as well as country– and group-specific characteristics.

6.1. Group efficiency results

Table 3 presents the first stage results based on the group-wise heterogeneous bootstrap methodology of Simar and Zelenyuk (2007). We control for heterogeneity due to different organizational forms (subsidiary vs. branch), level of asset diversification (diversified vs. focused banks) and exchange rate risk (euro area vs. non-euro area). The results suggest that on average, branch banks are 50% more efficient than subsidiary banks.[8] Furthermore, diversified banks are more efficient than focused banks (about 8% more) and banks belonging to the euro area are more efficient than those of the non-euro area (about 25% more efficient).

To compare group inefficiency scores, we employ relative difference (RD) statistics based on ratios of the means of groups (see Simar and Zelenyuk ,2007, for details). In all cases, the differences in performance between groups are statistically significant, since unity falls outside the confidence intervals of RD statistics (Table 4, column 5 and 6). Thus, we reject the pair-wise null hypothesis that aggregate efficiency is the same across groups based on the 95% bootstrap confidence interval. The weighted group efficiency scores are smaller that the mean and the median efficiency score within each group, suggesting that larger banks are typically more efficient. This would be consistent with the existence of economies of scale within each group. The only exception is for non-euro area banks, possibly because most of them are smaller in the output dimensions.

The results indicate that each of the groups considered may have intrinsic characteristics that should not be neglected when studying candidate determinants of foreign bank efficiency in Luxembourg. In addition, size appears to plays an important role in explaining efficiency.

Column three of Table 3 reports the bias term obtained using bootstrapping techniques. The estimated bias is negative for all weighted group efficiency terms, suggesting that our original efficiency (inefficiency) is overestimated (underestimated). The standard deviation reported in the following column indicates that the estimated bias is statistically different from zero in nearly all cases. The final two columns provide the lower bound (LB) and upper bound (UB) of the 95% confidence interval of the bias-corrected group efficiency scores. These

[8] Recall that we measure efficiency of Banks relative to CRS technology, i.e. relative to the productivity level of optimal scale, which usually yields higher differences in efficiency between banks than otherwise.

indicate that the efficiency measure is statistically significant in all cases. Although, as we pointed out before, these results show that branch banks are around 50% more efficient than subsidiary banks, however both branches and subsidiaries in Luxembourg appear to have room to increase their efficiency. While branch banks might have increased their output 26.4% with an unchanged level of inputs, subsidiary banks might have increased it by around 60%. Comparing diversified and focused banks, the results show that for diversified banks efficiency is 0.427 and for focused banks it is 0.374. Finally, for euro-area banks efficiency is 0.432, while for non-euro area banks efficiency is 0.286. Overall, every group of foreign banks could have increased output while keeping inputs unchanged.

Table 3: Weighted Group Efficiency Estimates.

Statistics	Groups	Raw Agg. Eff.	BC-Agg. Eff.	Est.Bias	Stand. Dev.	LB	UB
Weighted Group Efficiency	Subsidiary	1.834	2.517	-0.684	0.096	2.232	2.611
	Branch	1.268	1.359	-0.091	0.113	1.021	1.478
	Diversif.	1.750	2.342	-0.592	0.104	2.018	2.444
	Focused	1.916	2.666	-0.750	0.108	2.350	2.771
	Euro Area	1.736	2.316	-0.581	0.097	2.037	2.409
	Non-Euro Area	2.327	3.497	-1.170	0.103	3.177	3.599
Mean Group Efficiency	Subsidiary	2.146	3.109	-0.963	0.132	2.709	3.220
	Branch	1.638	2.062	-0.423	0.149	1.632	2.204
	Diversif.	1.912	2.638	-0.725	0.137	2.238	2.750
	Focused	2.297	3.381	-1.084	0.155	2.918	3.512
	Euro Area	2.010	2.829	-0.819	0.133	2.437	2.945
	Non-Euro Area	2.193	3.202	-1.009	0.141	2.782	3.320
Median Group Efficiency	Subsidiary	1.945	2.782	-0.837	0.086	2.525	2.864
	Branch	1.448	1.771	-0.322	0.102	1.474	1.878
	Diversif.	1.822	2.528	-0.706	0.096	2.238	2.615
	Focused	2.010	2.892	-0.882	0.105	2.576	2.991
	Euro Area	1.807	2.501	-0.694	0.090	2.239	2.586
	Non-Euro Area	2.025	2.940	-0.915	0.097	2.646	3.036

Source: Author's calculations. Raw Agg. Eff= group efficiency estimates; BC Agg. Eff= Bias-Corrected efficiency estimates; Est. Bias= Estimated bias, LB=Lower bound and UB= Upper Bound.

Table 4: RD statistics for comparing group efficiency score

Statistics	Groups	Raw Eff.	Bias-Corr. Eff.	Est.bias	Stand. Dev.	LB	UB
Ratio Weighted Group Efficiecy	Subsidiary vs. Branch	1.446	1.913	-0.467	0.047	1.828	2.012
	Diversif. Vs. Focused	0.913	0.832	0.081	0.037	0.759	0.905
	Euro vs. Non-Euro Area	0.746	0.492	0.253	0.038	0.413	0.571
Ratio Mean Group Efficiency	Subsidiary vs. Branch	1.245	1.516	-0.27	0.042	1.436	1.612
	Diversif. Vs. Focused	0.765	0.525	0.24	0.03	0.461	0.583
	Euro vs. Non-Euro Area	0.917	0.828	0.089	0.036	0.758	0.904
Ratio Median Group Efficiency	Subsidiary vs. Branch	1.27	1.555	-0.284	0.042	1.472	1.646
	Diversif. Vs. Focused	0.8	0.591	0.209	0.034	0.517	0.656
	Euro vs. Non-Euro Area	0.897	0.791	0.106	0.044	0.7	0.882

Source: Author's calculations

As far as overall efficiency is concerned, table 5 reports that the entire industry is operating at 56.1% efficiency, meaning the banks could have increased their output two-fold, given the level of inputs.

Table 5: Overall efficiency of the financial sector.

Statistics	Raw Agg. Eff.	BC Agg. Eff.	Est. Bias	Stand. Dev.	LB	UB
Weighted Group Efficiency	1.781	2.405	-0.624	0.097	2.119	2.498
Mean Group Efficiency	2.048	2.906	-0.857	0.134	2.509	3.023
Median Group Efficiency	1.857	2.601	-0.744	0.086	2.346	2.685

Source: Author's calculations. Raw Agg. Eff=Efficiency Estimate; BC Agg. Eff=Bias-Corrected efficiency estimates; Est. Bias=Estimated Bias; LB=Lower bound and UB= Upper Bound.

6.2. Second stage regression results

In the second stage of the analysis, we investigate possible determinants of efficiency by estimating the econometric model described in equation (3) above using the individual bank bias corrected inefficiency score as the dependent variable, and the set of macroeconomic, regulatory and bank- and group-specific characteristics described above as independent variables. The parameters are estimated according to algorithm 2 of Simar and Wilson (2007), with 1000 bootstrap replications for the bias correction and 1000 bootstrap replication for the confidence intervals.

The estimation results are reported in Table 6. As discussed above, for branches the regulatory variables are based on the home country, while for subsidiaries we have used the host-country values. For the macroeconomic variables, instead, only home-country levels are used. Given that the groups considered in the first stage had statistically different results, we identify them in the regression analysis. In particular, we introduce dummies for branch banks and banks belonging to the euro area. To distinguish diversified and focused banks, we prefer to use the continuous variable HHI variable as suggested by Berger et al. (2010) because of its higher explanatory power.

The results obtained in our second stage regression support the hypothesis that more stringent regulation, supervision and monitoring do not boost efficiency of foreign banks in financial centers. Capital stringency appears to have a positive, but insignificant, impact on bank's efficiency. This is not in line with previous findings by Pasiouras et al. (2009) and Barth et al. (2010). Restrictions on bank activities have a negative and statistically significant impact on efficiency (greater restrictions lead to lower technical efficiency). This is consistent with findings in Pasiouras et al. (2009) as well as in Barth et al. (2010). Private monitoring also has a negative statistically significant impact on the technical efficiency, implying that higher disclosure requirements do not seem to enhance foreign bank efficiency in Luxembourg. Lastly, the power of the supervisory agencies also has a negative statistically significant impact on efficiency, while Pasiouras et al. (2009).found a positive effect and Barth et al. (2010) found no significant effect. The differences in the results relative to regulatory measures might be due either to the different sample of countries or differences in the methodology. In particular, previous studies do not accurately identify the relevant regulatory scheme according to organizational form.

Overall, the results are not consistent with the public interest view, as higher regulation does not appear to enhance the efficiency of foreign banks in Luxembourg. Higher capital requirements appear to have no significant effect, while a more powerful supervisory agency may actually be detrimental to bank efficiency. Lastly, stronger disclosure requirements associated with the third pillar of Basel II have a negative and statistically significant impact on bank efficiency. Summing up, the results obtained about the effect of regulation on the efficiency

of foreign banks of the financial center are more consistent with the private interest view than with the public interest view.

Macroeconomic conditions at the home country level do not appear to affect bank efficiency in Luxembourg. Our results provide little evidence to support the limited global advantages hypothesis of Berger et al (2000). GDP_CAP does not appear to have a positive impact on efficiency, but the home country business cycle seems to be positively associated with higher efficiency, although the coefficient is not statistically significant.

The regression results suggest that the organizational form does not play an important role in determining efficiency as the branch dummy has a negative but insignificant coefficient. This suggests that the differences between branches and subsidiaries described earlier disappear when controlling for other characteristics in a multivariate context. The home country of the parent bank appears to be significant, as the coefficient on the euro-area dummy variable suggests a significant impact on efficiency. For diversification, higher values of HHI are associated with lower efficiency levels. This suggests that higher levels of specialization penalise efficiency. However, when this variable is crossed with the branch dummy, an improvement in efficiency appears. This suggests that specialised branches are performing better than specialised subsidiaries. This result is relevant to the debate on which organizational form is better for developing cross-border activities.

In terms of bank-specific characteristics, we do not found that squared term of log(assets) is significantly associated with higher efficiency. This suggests that there are not a non-monotonic relationship between size and performance. The term log(assets) instead carries significant relationship with efficiency. These results suggest that although it seems that there not exist a limit point on size from which larger foreign banks are more efficient, it is true that larger banks are more efficient. The ratio of equity to total assets has a positive impact on efficiency indicating that well capitalized banks tend to be better run. Finally, when controlling for the certain events in the host country over the sample period the results show that banks saw a systemic improvement in efficiency during the boom prior to the financial crisis.

Table 6: Truncated regression results

Variable	Estimates	90%		95%		99%	
		LB	UB	LB	UB	LB	UB
Constant	0.773	-3.119	4.482	-4.212	5.613	-7.912	8,033
Regulatory measures							
CAPRQ	-0.018	-0.036	0.000	-0.038	0.003	-0.046	0.011
ACTRS	0.127**	0.034	0.234	0.015	0.258	-0.025	0.296
PRMONT	0.164**	0.046	0.276	0.029	0.290	-0.024	0.325
SPOWER	0.049***	0.017	0.084	0.009	0.091	0.001	0.105
Macroeconomics measures							
Log (GDP_CAP)	0.674***	0.474	0.855	0.428	0.889	0.344	0.951
OUTPUT_GAP	-0.038	-0.138	0.055	-0.152	0.072	-0.189	0.115
Organizational Structure							
Branch	-0.357	-1.418	0.720	-1.631	0.886	-2.030	1.310
Home parent bank nationality							
Euro Area	-0.347***	-0.549	-0.161	-0.585	-0.124	-0.686	-0.059
Asset Diversification							
HHI	2.734***	2.117	3.346	2.005	3.468	1.797	3.710
HHI x Branch	-2.089**	-3.569	-0.525	-3.799	-0.201	-4.325	0.355
Bank-specific characteristics							
Equity/ assets	-4.268***	-5.601	-2.840	-5.889	-2.579	-6.191	-1.758
Ln (assets)	-0.419*	-0.730	-0.106	-0.819	0.007	-1.067	0.311
Squared ln(assets)	-0.002	-0.010	0.006	-0.013	0.008	-0.020	0.015
Year dummy							
End major consolidation wage	0.184	-0.153	0.540	-0.219	0.604	-0.329	0.721
Stock Market Crisis	0.105	-0.202	0.442	-0.260	0.525	-0.371	0.680
Pre-Global Financial Crisis	-0.603**	-1.014	-0.192	-1.066	-0.105	-1.157	0.043
Global Financial Crisis	0.056	-0.309	0.407	-0.381	0.473	-0.575	0.637
σ_{ε}^{2}	1.950	1.717	2.218	1.655	2.260	1.549	2.308

*, **, *** stand for statistically significant at 90%, 95%, 99%, respectively.

7. Discussion and Conclusions

In this paper we analyze the impact of home country characteristics on foreign bank efficiency, focusing on a financial center. We employ bootstrap techniques both in our first-stage Data Envelopment Analysis and in our second-stage truncated regression. The set of explanatory variables in the second-stage regression includes home-country characteristics of parent banks as well as bank-specific characteristics. As an innovation in the field of international bank efficiency, we distinguish the relevant regulatory scheme according to the bank's organization form (subsidiary or branch). We focus on the Luxembourg financial center as a laboratory composed mostly of foreign banks over the period 1999-2009. DEA results indicate that branch banks, more diversified banks and euro area banks have higher technical efficiency on average.

The results of the second-stage regression seem to support the need to review the current home-host model of bank regulation. More stringent regulation and supervision do not appear to enhance foreign bank efficiency. Even when controlling for other characteristics, well capitalized and more diversified banks tend to be more efficient, supporting the private interest view of the impact of regulation on bank efficiency. Since efficiency is barely affected by home country economic conditions, our results also suggest that multinational banks establish a presence in financial centers mostly to "go where the business is". In terms of the choice of organizational form, branches appear to perform better than subsidiaries if they are specialized, and subsidiaries do better when following diversified business lines.

Acknowledgements

The authors are grateful for comments from participants at the International Workshop on Efficiency and Productivity in honour of Professor Knox Lovell, October 4-5, 2010. Funding from the Fonds National de la Recherche through the PERFILUX project is gratefully acknowledged. Any remaining errors are solely our responsibility. The opinions expressed in this paper are those of the authors and do not necessarily reflect the view of their institutions.

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