Economies or Diseconomies of Scope in the EU Banking Industry?

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Abstract

This paper documents the presence on average of cost economies of scope and revenues diseconomies of scope in the European banking industry, that is, banks minimize total costs or minimize revenues, given a certain level of outputs, producing a differentiated mix of outputs. Differences emerge among banks of different sizes: both revenue and cost economies of scope tend to increase with bank size. Our results are particularly important in the light of the 2017 EU banking supervisory priorities and of the 2014 structural reform proposal on the EU banking industry, which aims to separate the traditional commercial banking from the investment activity.

Keywords: Economies of Scope; Bank efficiency; Stochastic frontier analysis; EU; Regulation

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1. Introduction

Economies and diseconomies of scope matter for bank management (i.e. do banks need to specialize on traditional lending activities or should they diversify into other activities?), especially in light of the recent debate on the 2014 structural reform proposal on the EU banking sector (European Commission, 2014). Besides, the SSM supervisory priorities set out three focus areas for supervision in 2017; and the first priority area that will guide banking supervision relates to business models and profitability drivers (ECB, 2016). Bankers have long argued production synergies and presumed advantages associated with providing joint products and services, but to date research efforts have been focused on the cost production side (cost economies of scope). However little attention is devoted to the revenue side (revenue economies of scope), that is whether or not bankers can achieve higher revenues by jointly producing investment and commercial outputs, and whether or not consumers pay for (and banks receive higher revenue for) 'one-stop banking'.

Regarding the production side (joint production of commercial and investment banking outputs), in presence of cost economies of scope, diversifying the output mix decrease banks total costs and, therefore, induce an efficiency improvement in the economic system; whereas in presence of cost diseconomies of scope, total costs increase if banks produce a more diversified output mix. Similarly, in presence of revenue economies of scope, diversifying the output mix increase banks total revenues and, therefore, induce an efficiency improvement in the economic system. Regarding the consumption (revenue) side (one-stop banking), in presence of revenue economies of scope, revenues increase through diversification of the output mix; whilst revenue diseconomies of scope imply that revenues decrease if the output mix becomes more diversified. The estimation of economies or diseconomies of scope is particularly relevant from a regulatory point of view, because regulations that prevent banks from producing a diversified output mix might introduce inefficiencies in the economic system, in presence of scope economies. Whilst the literature on the economies of scale is large and growing (Vander Vennet, 2002; Altunbas et al., 2001; Dijkstra, 2013; DeYoung and Jiang, 2013; Davies and Tracey, 2014; Beccalli et al., 2015), to our knowledge no published empirical work investigates economies of scope for European banks in the crisis and post-crisis period.

According to the banking literature (Berget et al., 1987), the four classical main drivers of economies of scope are: the opportunity of spreading fixed costs over different outputs, the possibility of re-employing clients' information, the risk reduction thanks to an increasing diversification, and costumer costs saving (which are transaction, transportation and search costs associated with using banking products from different banks). A regulation that prevents banks to

exploit one of these four channels may give room to inefficiencies. Regulators in the US (under the Dodd Frank Act of 2010) and in the EU (as in recommendations by the Liikanen Report 2012 being implemented into EC law as well as by the Vickers Report 2011 implemented into UK law) have sought to impose limitations on banks by restricting riskier areas of activity. Specifically, the European Commission established a high-level expert group (chaired by Erkki Liikanen) to examine possible reforms to the structure of the EU's banking sector and to determine whether, in addition to ongoing regulatory reforms, structural reforms of EU banks would strengthen financial stability and improve efficiency and consumer protection. Following on, the European proposal for structural reform aimed at minimizing the risky activities of the EU's 30 systemically important banks (European Commission, 2014) bans proprietary trading for banks that are labeled by international regulators as too-big-to-fail in the global economy, or whose activities surpass certain financial thresholds. The EU reform would apply from 2017 in all 28 Member States.

The aim of this paper is to investigate if there are (cost and revenue) economies of scope in the European banking industry, how large they are (it may be the case that economies of scope are present but are economically insignificant), and how they vary across different bank sizes. For a sample of 740 banks from all the 28 EU countries between 2005 and 2015, we estimate the classical measure of economies of scope (WSCOPE) by employing several stochastic frontier analysis with translog cost and production functions. Overall, the results suggest evidence of cost scope economies and revenue scope diseconomies in all European banking industries. Whilst diversification might decrease bank total costs, it might also induce a reduction in revenues. Interestingly, both cost economies of scope and revenue diseconomies of scope tend to increase with asset size. Cost scope economies are lower than revenue scope diseconomies, in absolute value, meaning that the process of diversification might hurt banks productivity. Our empirical findings can contribute to the European banking regulatory debate, providing an overall support for the European proposal for structural reform. Moreover, our findings can contribute to the European banking supervisory debate as for the 2017 supervisory priorities, providing evidence to the SSM useful to build on an assessment of the key risks faced by supervised banks as for the business models and profitability drivers, especially in view of protracted ultra-low/negative interest rates.

Section 1 discusses the relevant literature on economies of scope in banking, whereas section 3 describes the methodology, the sample and the data sources. Section 4 provides the empirical evidence. Section 5 summarizes robustness checks and finally section 6 concludes.

2. Literature review

The post 2008 crisis regulatory trend clearly aims to separate banking from investment

activity to create a banking system mainly composed by specialized banks. Gambacorta and van Rixtel (2013) report that the Volcker rule in the US, the Liikanen Report in the EU, the Vicker commission proposal in the UK and reform proposals in France and Germany, with differences among them, push to draw a line between loan generating activity and securities trading.

On scale economies, a large body of literature has found cost scale economies at all sizes of banks and the largest scale economies at the largest banks, especially over recent years – that is, larger banks are able to provide products at lower average cost than smaller banks (see among the others Berger and Mester 1997; Hughes, Mester, and Moon 2001; Feng and Serletis 2010; Wheelock and Wilson 2012; Hughes and Mester 2013; Dijkstra 2013; Beccalli, Anolli, and Borello 2015). Instead on economies of scope, there is a large body of research, that mainly focuses on the US, providing unclear evidence on whether or not the potential benefits of functional diversification are larger than the costs. The empirical studies on economies of scope for European banks instead are limited and they are all focused on the pre-crisis period (see the recent literature review by Gambacorta and van Rixtel, 2013, where only two studies are reported for Europe)[1].

Altunbas and Molyneux (1996) provide the first empirical investigation on economies of scope in four different European countries in year 1988. They find limited evidence of scope economies, and document differences across countries. Diseconomies of scope appear in Italy for all bank sizes, whilst economies of scope are found in Spain for banks with total assets smaller than $1.5 billion only. Furthermore, economies of scope result for middle size banks in France; in Germany scope economies are found for largest banks whereas smaller banks show scope diseconomies. Subsequent studies expand the time period and take in consideration more European countries. Vennet (2002), using a panel of banks from seventeen EU countries in the period 1995-1996, finds economies of scope in the European banking industry. The SCOPE measure spans between -1.6 and 6.5 for financial conglomerates, 1.1 and 18.1 for universal banks and -1.7 and 17.7 for specialized banks. Moreover, for financial conglomerates and universal banks, economies of scope tend to increase with bank size whereas for specialized banks diseconomies of scope are present for big-size banks and smaller specialized banks enjoy economies of scope. More recently, Dijkstra (2013), using a cross section dataset of European banks, find economies of scope. Another stream of literature investigates the impact of diversification on systematic risk for European banks. Although not specifically on economies of scope, Baele et al. (2007) and Fiordelisi and Marquez-Ibanez (2013) document a positive relationship between bank diversification and systematic risk. Therefore, a trade-off between economic efficiency and financial stability arises: on the one hand

[1] Baele et al. (2007) and Fiordelisi and Marquez-Ibanez (2013) analyze the relationship between diversification and systemic risk, but none of them measure scope economies.

diversified bank seem to be more efficient because they can exploit higher economies of scope, on the other hand huge diversified conglomerates increase systematic risk.

Similarly to Europe, studies on the US banking industry tend to document economies of scope in the pre-crisis period, although several exceptions exist. Mester (1993) find economies of scope in the Savings and Loan industry during the period 1986-1988. Pulley and Humphrey (1993) show that, thanks to the spreading of fixed costs across different outputs, large US banks enjoyed economies of scope during the eighties and the nineties. Clark (1996), using a panel of US banks from 1988 to 1991, find economies for scope for banks with total assets up to 6 billion dollars only. Moreover, for efficient banks, which lie near the efficient production frontier, there is evidences of neither economies nor diseconomies of scope. Mitchell and Onvural (1996), over the period 1986-1990, employing the Fourier Flexible instead of the translog specification, find diseconomies of scope; this suggests that the choice of the functional form might influence the findings. Jagtiani and Khanthavit (1996) document that the changes in capital requirements adopted in December 1990 have an impact on economies of scope. Indeed, before the regulation implementation, US banks enjoyed economies of scope whereas, starting from 1991, banks became, on average, too large to enjoy further economies of scope. Jagtiani and Khanthavit (1996) results are confirmed by Mester (1996), that does not find any evidence of economies of scope in the third Federal Reserve District banks in between 1990 and 1991. Stiroh and Rumble (2006), for US financial holding companies over the period 1997-2002, find that certain diversification gains are more than offset by the costs of increased exposure to volatile activities. The Clearing House (2011), for the 26 largest US banks with more than $50 billion in assets, estimate annual scope benefits of $15-25 billion. In short, these studies suggest that economies of scope are not constant throughout the US industry, but vary with banks sizes. Moreover, regulations can influence scope economies.

Regarding revenue scope economies, the so-called consumption side, literature is much more limited. At our knowledge, the only study on revenues complementarity of one-stop banks between costumers loans and deposits is Berger et al. (1996), in which there are no evidences of neither economies nor diseconomies of scope for revenues as for small and large banks in the US in the period 1978-1990. However, at the best of our knowledge, there is no study in the literature on revenue scope economies between the so-called investing activities and commercial ones.

The joint production of different outputs might affect revenue economies of scope due to the different expertise required in different banking areas. As recently found by Abbassi et al. (2016), during periods of crisis, banks with specific expertise prefer to limit output diversification, and focus their activity where they have a comparative advantage. Indeed, Abbassi et al. (2016) show that banks with higher trading expertise (so-called trading banks) increased investments in

securities and reduced credit supply in conjunction with the financial crisis.

Following on, in this paper we aim to empirically estimate different measures of economies of scope in cost and revenues with regard to European banks before and after the outbreak of the 2008 financial crisis.

3. Sample and methodology

3.1 Sample

Our sample comprises banks operating in the 28 countries of the European Union (EU) over the period 2005-2015. Our final unbalanced panel database consists in 4655 observations from 740 EU banks. Table 1 provides the number of banks within the sample per country and year.

Consolidated statements are taken from Bankscope, deflation indexes from the International Monetary Fund, and environmental variables from the World Bank database.

3.2 Economies of scope measures

In order to estimate scope economies we employ the SCOPE measure. Because the SCOPE measure has the drawback to impose zero on those outputs not produced, in the logarithmic function this is not feasible. Following on, several variations of the SCOPE measures have been proposed in the literature (Berger et al., 1987; Mester, 1993). Specifically, in addition to the EPSUB measure, we employ the within SCOPE measure (WSCOPE hereafter), as in Mester (1993), which substitutes null values with minimum outputs values.

WSCOPE compares a technical efficient multi-product bank with different technical efficient banks, each of them producing one output only and the minimum observed value for the other two outputs. As for total costs, equation 1 represents the WSCOPE:

$$COST\_WSCOPE_{i,t} = \frac{\sum_{j=1}^{J} TC_{j,i,t} - TC_{i,t}}{TC_{i,t}} =$$

$$= \frac{\sum_{j=1}^{J} TC\left(q_1^{min}, \dots, q_{j,i,t} - Jq_j^{min}, \dots, q_J^{min}, P_{i,t}, Z_{i,t}; \hat{\beta}\right) - TC\left(Q_{i,t}, P_{i,t}, Z_{i,t}; \hat{\beta}\right)}{TC\left(Q_{i,t}, P_{i,t}, Z_{i,t}; \hat{\beta}\right)} \quad (1)$$

where TC is the total cost of a technical efficient bank, $q_{j,i,t}$ is the observed minimum value of the j-th output, it can be considered as the minimum feasible amount of output that a bank should produce. Notice that the overall produced output should be equal to the output of the multi product banks, then a correction on output quantity j equal to $Jq_j^{min}$is done. If COST_WSCOPE is greater than zero there are economies of scope because producing the three outputs separately would result in an increase in costs. If COST_WSCOPE is lower than zero there are diseconomies of scope:

producing the three outputs separately would be more efficient. If COST_WSCOPE is equal to zero then there are neither economies nor diseconomies of scope: producing in the two ways would not change costs.

As for total revenues, equation 2 represents the WSCOPE:

$$REVENUE\_WSCOPE_{i,t} = \frac{TR_{i,t} - \sum_{j=1}^{J} TR_{j,i,t}}{TR_{i,t}} =$$
$$= \frac{TR\left(Q_{i,t}, P_{i,t}, Z_{i,t}; \hat{\beta}\right) - \sum_{j=1}^{J} TR\left(q_1^{min}, \dots, q_{j,i,t} - Jq_j^{min}, \dots, q_J^{min}, P_{i,t}, Z_{i,t}; \hat{\beta}\right)}{TR\left(Q_{i,t}, P_{i,t}, Z_{i,t}; \hat{\beta}\right)} \quad (2)$$

where TR are the total revenues of a technical efficient bank. If REVENUE_WSCOPE is statistically significant and positive, revenues from joint production are higher than revenues from mono-production. If it is negative and statistically significant, there are revenue diseconomies of scope. If it is not statistically significant there are not economies nor diseconomies of scope on revenues.

3.3 Econometric specification

To estimate economies of scope we need to define the cost function, the functional form and the variables.

3. 3.1 Regression specification

In this paper we employ Stochastic Frontier Analysis (SFA) to estimate translog cost function. In symbols:

$$\begin{aligned}\frac{\ln(TC)}{\ln(TE)\ln(P_3)} = \alpha_0 &+ \sum_{i=1}^{3} \alpha_i \frac{\ln(Q_i)}{\ln(TE)} \\ &+ \frac{1}{2}\sum_{i=1}^{3}\sum_{j=1}^{3} \alpha_{i,j} \frac{\ln(Q_i)}{\ln(TE)} \frac{\ln(Q_j)}{\ln(TE)} + \sum_{i=1}^{3}\sum_{k=1}^{2} \delta_{i,k} \frac{\ln(Q_i)}{\ln(TE)} \frac{\ln(P_k)}{\ln(P_3)} \\ &+ \sum_{k=1}^{2} \beta_k \frac{\ln(P_k)}{\ln(P_3)} + \frac{1}{2}\sum_{k=1}^{3}\sum_{l=1}^{2} \beta_{k,l} \frac{\ln(P_k)}{\ln(P_3)} \frac{\ln(P_l)}{\ln(P_3)} + GDPGrowth \\ &+ \ln\left(\frac{Reserves\ for\ Impaired\ Loans}{Gross\ loans}\right) + v + u_t\end{aligned} \quad (3)$$

where TC are total costs; Q is a vector of outputs; P is a vector of inputs and control variables; i[2] and t are indexes for bank and time specific observations. Outputs, total costs and total revenues

[2] The subscript i is dropped from equations 3 and 4 for clarity of exposure.

are normalized by total equity (TE). The error term is the sum of two different components: $v_{i,t}$ is an idiosyncratic white noise, $u_{i,t}$ is the technical inefficiency component. Specifically, in this study we employ the technical inefficiency specification proposed by Battese and Coelli (1992)[3]. SFA models can be estimated through iterative log-likelihood procedure.

Moreover, we employ Stochastic Frontier Analysis (SFA) to estimate translog revenue function. In symbols:

$$\begin{aligned}\frac{\ln(TR)}{\ln(TE)\ln(P_3)} = \alpha_0 &+ \sum_{i=1}^{3}\alpha_i\frac{\ln(Q_i)}{\ln(TE)} \\ &+ \frac{1}{2}\sum_{i=1}^{3}\sum_{j=1}^{3}\alpha_{i,j}\frac{\ln(Q_i)}{\ln(TE)}\frac{\ln(Q_j)}{\ln(TE)} + \sum_{i=1}^{3}\sum_{k=1}^{2}\delta_{i,k}\frac{\ln(Q_i)}{\ln(TE)}\frac{\ln(P_k)}{\ln(P_3)} \\ &+ \sum_{k=1}^{2}\beta_k\frac{\ln(P_k)}{\ln(P_3)} + \frac{1}{2}\sum_{k=1}^{3}\sum_{l=1}^{2}\beta_{k,l}\frac{\ln(P_k)}{\ln(P_3)}\frac{\ln(P_l)}{\ln(P_3)} + GDPGrowth \\ &+ \ln\left(\frac{Reserves\ for\ Impaired\ Loans}{Gross\ loans}\right) + v + u_t\end{aligned} \qquad (4)$$

where TR are total revenues.

Symmetry requires $\alpha_{i,j} = \alpha_{j,i}$ and $\beta_{l,k} = \beta_{k,l}$; linear homogeneity requires $\sum_{k=1}^{3}\beta_k = 1$, $\sum_{l=1}^{3}\beta_{k,l} = 1$, $\sum_{k=1}^{3}\delta_k = 0$.

3.3.2 Variables

In order to perform cost function estimates we collected data about banks total costs (TC), banks' outputs (Q), banks' inputs (P) and a set of control variables (Z). Total cost will be the dependent variables in all regressions. Banks outputs are gross loans (Q1), total securities (Q2) and off-balance sheet items (Q3), calculated as the difference between banks' total business volume and total assets. Banks inputs prices are price of labour (P1), price of loanable funds (P2) and price of capital (P3). Price of labour is calculated as the ratio between personnel expenses on total assets, price of loanable funds is expressed as the ratio between total interest expenses on total deposits and price of capital is the ratio between other operating expenses and fixed assets. Bank specific control variable is the natural logarithm of ratio between loan loss reserve and gross loans (Z) as a proxy of bank loans quality (Mester, 1996). We use the GDP growth to control for the general macroeconomic environment. Total costs, total revenues and outputs are deflated with the IMF

[3] According to Battese and Coelli (1992), the inefficiency term is $u_{i,t} = \exp[-\eta(t - T_i)]u_i$ where u_i is a positive half-normal distributed; η is the decay parameter; T_i is the last observed time period for the i-th.

deflation index (using 2004 as base year).

In order to perform the empirical regression we dropped observations with non-reported values for Q, P, Z, TC, TR or TE; moreover, in order to perform the empirical regression, we dropped observations with non-positive values of Q, P[4]. Therefore, our unbalanced panel database consists in 4655 observations from 740 banks.

Table 2 reports correlations among total cost, total revenues, outputs, inputs and control variables; pairwise correlations indicate statistical significant positive links across all outputs and between outputs, total costs and total revenues. Table 3 (Panel A) reports the descriptive statistics for the variables (including total assets). We divide the sample in deciles, in order to show how economies of scope change for banks of different sizes. Table 3 (Panel B) specifies the minimum level of assets of each of the ten size deciles.

4. Results

We estimate COST_WSCOPE and REVENUE_WSCOPE for each observation. When we aggregate the scope economies measure at the country, year or size level we average bank-year specific results.

Table 4 reports the coefficients of revenue and cost functions. The three output interaction terms are statistically significant and negative for both the cost and the revenue function: this means that producing together output 1 (loans), 2 (total securities) and 3 (off balance sheet items) might decrease total costs and total revenues, meaning cost economies of scope and revenues diseconomies of scope. However, the sign of cross coefficients is not sufficient to determine neither economies nor diseconomies of scope when outputs and input prices are not separable, as it is here. Notice that the control variables are not statistically significant, which implies that bank total costs and revenues are not determined by variables other than inputs and outputs. However, the variation of statistical significance of control variables is high across specifications, in general the impact of control variables on total costs appears to be negative. Table 4 (Panel B) shows that the parameter μ of the time invariant half-normal distribution is negative and statistically not significant[5], whereas the parameter η is statistically significant, meaning that inefficiency does vary over time (assuming

[4] Some researchers prefer to substitute the value 1 for null outputs, therefore introducing a small bias without dropping observations. We prefer to drop such observations in order to avoid any biases, which could be amplified if the functional form does not well interpolate out-of-the-sample values, as it is for the translog function. Berger et al. (2000) estimate cost functions for subsets of firms winch have one or more outputs equal to zero; unfortunately, in our case, the number of banks with null outputs is too small for performing a separate empirical regression on those observations.

[5] Recalling that for the half-normal distribution the expected value is $E[X] = \mu + \sigma\sqrt{\frac{2}{\pi}}$.

the time function as in Battese and Coelli 1992). Wald test is reported in panel C: the null hypothesis that all coefficients are jointly statistically not significant can be rejected.

Table 5 (panel A) reports the mean values of COST_WSCOPE for each size decile (defined according to bank total assets), from the smallest (decile 1) to the giant (decile 10) and for the overall sample over the period 2005-2015. For all European banks during the period under observation, the mean COST_WSCOPE measure is equal to 1.027 and it is statistically significant at the 1 percent level. This evidence indicates that, on average, cost economies of scope exist in the European banking industry. These results are in line with previous papers that analyze the EU industry and rely on the translog function (Altunbas and Molyneux, 1996; Cavalli and Rossi, 2001; Vennet, 2002; Goisis et al., 2009; Dijkstra, 2013). As for the evolution of economies of scope over time, they increase over time, suggesting that the effect of the outbreak of the financial crisis increased cost economies of scope for European banks. As for the levels of economies of scope for different size deciles, the mean values of COST_WSCOPE increase with bank size (from a statistically significant value of cost scope diseconomies equal to -0.031 for bank in the smallest size decile to 4.161 for giant banks). This evidence means that the larger the size the larger the benefit in terms of cost economies of scope.

Table 6 reports the mean values of COST_WSCOPE for each country. Cost economies of scope are documented for all EU countries on average. Cost scope economies are present in each year, notably all the countries most affected by the financial crisis (PIIGS) have high values of cost economies of scope, close or higher than 1. Cost economies of scope are spread out in European banking markets – this result differs from the one in Altunbas and Molyneux (1996) that document differences across the French, German, Italian and Spanish banking markets (i.e. diseconomies of scope for Italian banks and economies of scope for Spanish banks in year 1988). This difference could be the result of the EU's single market program as advocated by Altunbas and Molyneux (1996) - bank diversification became an important factor in generating cost savings resulting from the EU's single market program.

Table 7 report average revenue diseconomies of scope in the EU banking industry. Indeed, the mean value of REVENUE_WSCOPE over the period is equal to -1.66 ad it is statistically significant at 1% confidence level. Revenues from joint production might be lower than revenues from mono-production. Interestingly, we do not find confirmation of the expectation that banks would move from traditional lending activities to more diversified activities (i.e. more capital market oriented activities). We also document that revenue diseconomies of scope tend to increase over time (from a value of revenues scope diseconomies equal to -1.346 in 2005 to -2.456 in 2015, both values statistically significant) and with bank size (from a value of revenues scope

diseconomies equal to -0.032 for bank in the smallest size decile to 7.072 for giant banks, both values statistically significant). Finally, it is worth notice that revenues diseconomies of scope are higher than cost economies of scope in absolute value, therefore suggesting that the EU structural reform will not create inefficiencies because banks that will be forced to separate their activities might able to increase revenues more than costs. These results suggest, according to Abbassi et al. (2016), that during and after financial crisis for banks it is profitable to reduce output diversification and to concentrate activities in areas where they have comparative advantages because of better expertise.

Table 8 reports the mean values of REVENUE_WSCOPE for each country. Again, revenue economies of scope are documented for all EU countries with no exception. Interesting, PIIGS countries have high revenue diseconomies of scope, close or lower than -1.5. Moreover, the two countries with higher cost economies of scope (Netherlands and United Kingdom) have also the highest revenue diseconomies of scope.

The evidence of economies of scope for systemically important banks supports the arguments of some industry studies (Institute of International Finance, 2010; The Clearing House, 2011) that find substantial to very substantial benefits related to both size and diversification. Their argument is that larger banks and their scope for achieving greater diversification across business lines and geographies may realize significant synergies, promoting safer, more stable and ultimately more valuable banks. Our evidence on cost economies of scope is in line with this view. Nevertheless our evidence on revenues diseconomies of scope enriches the picture. Although the bank structural reforms would imply higher costs, not only for banks and their shareholders, but for the economy as a whole, not necessarily the same is true on the revenue side.

5. Robustness tests

We employ a set of robustness tests in order to validate our results. One first critique may be that the results in this paper are dependent on the chosen functional form for our cost and revenue functions. In order to encompass this problem we employ a second functional form, meaning the Fourier Flexible function, which, as opposed to the translog function, does not impose a U-shaped function ex-ante. Thanks to trigonometric terms, the impact of outliers can be reduced. Indeed, trigonometric terms are particularly powerful in interpolating observations away from the sample mean. Fourier Flexible function is explained in appendix A.

A second critique may be that our results depend on the measure of economies of scope that we have chosen (WSCOPE). In order to address this argument, we calculate a second measure, that

is the expansion path subadditivity (EPSUB) measure, which is explained in appendix B.

A third point is that the econometric specification we use (SFA) is not appropriate and allocative efficiency should be modeled instead of technical inefficiency. To show that our results are still valid, we estimate a system of equations with seemingly unrelated regression (SUR) methodology. Technicalities of this econometric methodology are reported in appendix C.

Lastly, it may be that the aggregation methodology we use impacts on results. Therefore, in order to get threat of this criticism, we aggregate bank year scope measures with the median instead of mean value, results are reported in appendix D.

Results from all this set of robustness tests (as reported in Tables A1-A2, B1-B2, C1-C2, D1-D2) confirm our results from the main analysis.

6. Conclusions

Despite the importance of scope economies in light of the policy debate on the 2014 structural reform proposal on the EU banking industry, no recent studies appear to have provided cross-country comparisons for European banks. In order to contribute to the policy debate, this paper empirically investigates economies of scope for 740 banks located in the 28 EU countries over the period 2005-2015. By using different measures of economies of scope (WSCOPE and EPSUB) and several regression specifications in terms of cost function (SFA and SUR models) and functional forms (translog and Fourier flexible), we document the presence of widespread cost economies of scope and revenue diseconomies of scope in all European banking industries. On average, to separate the three main banks outputs (loans, securities and off-balance sheet) might introduce economic cost inefficiencies and revenue efficiencies in the financial system. The highest values of cost economies of scope and revenue diseconomies of scope are reported for the countries mostly affected by the 2008 financial crisis and after the outbreak of the financial crisis (years 2009 and 2010).

To date, research efforts focused on the production side - cost economies of scope – and these effects have been found to be positive. Accordingly our evidence documents that cost economies of scope exist in the European banking industry. Instead, little has been made on the revenue side, although the presumed advantages associated with the joint production of various bank products and services are believed to be large. In this paper we attempt to answer also the question of whether or not consumers pay for (and banks receive higher revenue for) 'one-stop banking'. Our evidence of significant revenue diseconomies of scope would imply both that consumers value one-stop banking but competition prevents banks from exploiting that demand to their advantage, or that banks do not have market power in the pricing of their outputs and that consumers do not

necessarily value the joint consumption of banking outputs.

The findings of this paper support the view of the European proposal for structural reform aimed at minimizing the proprietary activities only for the EU's 30 systemically important banks (and not for all banks independently of their size) – our evidence implies that such a reform would impose impairment charges costs and contemporaneously impose an increase in revenues for systematically important banks and their shareholders. The effect that this reform will have on cost transmitted to clients and to the economy as a whole has to be further investigated. Finally, our findings contribute to the European banking supervisory debate and more precisely to the 2017 supervisory priorities as for business models and profitability drivers.

Appendix A – Alternative production function: Fourier Flexible

The Fourier Flexible function, proposed by Gallant (1980), is an augmented translog function with trigonometric terms (trigonometric transformations applied to outputs only). In symbols:

$$\begin{aligned}\frac{\ln(TC)}{\ln(TE)\ln(P_3)} = \alpha_0 &+ \sum_{i=1}^{3}\alpha_i\frac{\ln(Q_i)}{\ln(TE)} \\ &+ \frac{1}{2}\sum_{i=1}^{3}\sum_{j=1}^{3}\alpha_{i,j}\frac{\ln(Q_i)}{\ln(TE)}\frac{\ln(Q_j)}{\ln(TE)} + \sum_{i=1}^{3}\sum_{k=1}^{2}\delta_{i,k}\frac{\ln(Q_i)}{\ln(TE)}\frac{\ln(P_k)}{\ln(P_3)} \\ &+ \sum_{k=1}^{2}\beta_k\frac{\ln(P_k)}{\ln(P_3)} + \frac{1}{2}\sum_{k=1}^{3}\sum_{l=1}^{2}\beta_{k,l}\frac{\ln(P_k)}{\ln(P_3)}\frac{\ln(P_l)}{\ln(P_3)} \\ &+ \sum_{i=1}^{3}[\kappa_i\cos(z_i) + \rho_i\sin(z_i)] \\ &+ \sum_{i=1}^{3}\sum_{j=1}^{3}[\kappa_{i,j}\cos(z_i+z_j) + \rho_{i,j}\sin(z_i+z_j)] + GDPGrowth \\ &+ \ln\left(\frac{Reserves\ for\ Impaired\ Loans}{Gross\ loans}\right) + v + u_t\end{aligned} \qquad (A.1)$$

Zs (where $z = m(\ln(Q) + \varepsilon)$, with $\varepsilon = a - ln(Q^{min})$ are restricted to span in the interval [0.2π ; 1.8π]. The share formula is represented by equation A.2.

Symmetry requires $\alpha_{i,j} = \alpha_{j,i}$ and$\beta_{l,k} = \beta_{k,l}$; linear homogeneity requires $\sum_{k=1}^{3}\beta_k = 1$, $\sum_{l=1}^{3}\beta_{k,l} = 1$, $\sum_{k=1}^{3}\delta_k = 0$.

Results of COST_WSCOPE are reported in table A.1 and table A.2 summarizes results of REVENUE_WSCOPE when Fourier Flexible is the functional form.

Appendix B - Alternative economies of scope measure: Expansion Path Subadditivity (EPSUB)

This measure, proposed by Berger et al. (1987), compares the costs of joint production of a bigger multi product bank with the ones of two smaller and specialized banks. In symbols:

$$EPSUB_{i,t} = \frac{TC_{i,t}(Q_A) + TC_{i,t}(Q_D) - TC_{i,t}(Q_B)}{TC_{i,t}(Q_B)} \qquad (B.1)$$

where Q_B is the output of the bigger multi product bank; Q_A and Q_D are the outputs vectors of the two smaller specialized banks and $Q_B = Q_A + Q_D$. In order to construct the output vectors of banks A and D, the original banks should be divided in different groups, ranked by their size. Then, the average output of each group should be computed. The output vector A is equal to the average output one size lower group. The output vector of bank D is the difference between the output vector of bank B and bank A. For same banks computation produces negative values for output vector of bank D. In this case, observations are simply dropped because we assume that a bank which is on the lower boundary of its group is too small to be divided in two smaller banks. When EPSUB is greater than zero there are economies of scope. When EPSUB is smaller than zero there are diseconomies of scope and the bigger bank is not competitive: it could be leaded away from the market by the two banks A and D. When EPSUB is equal to zero there are neither economies nor diseconomies of scope. In table B.1 there are results of COST_EPSUB, in table B.2 there are results of REVENUE_EPSUB.

Appendix C – Alternative Econometric Specification: Seemingly Unrelated Regressions for allocative efficiency

SUR, firstly introduced by Zellner (1962), allows to estimate a system of equations, which allows to evaluate allocative inefficiencies, which are deviations from the optimal inputs level. However, this model does not allow to calculate technical inefficiencies. Obviously only two out of the three share input equations can be estimated, in order to avoid multicollinearity problem.

For the system of equation is specified as follows:

$$\begin{aligned}\frac{\ln(TC)}{\ln(TE)\ln(P_3)} = \alpha_0 &+ \sum_{i=1}^{3}\alpha_i\frac{\ln(Q_i)}{\ln(TE)} \\ &+ \frac{1}{2}\sum_{i=1}^{3}\sum_{j=1}^{3}\alpha_{i,j}\frac{\ln(Q_i)}{\ln(TE)}\frac{\ln(Q_j)}{\ln(TE)} + \sum_{i=1}^{3}\sum_{k=1}^{2}\delta_{i,k}\frac{\ln(Q_i)}{\ln(TE)}\frac{\ln(P_k)}{\ln(P_3)} \\ &+ \sum_{k=1}^{2}\beta_k\frac{\ln(P_k)}{\ln(P_3)} + \frac{1}{2}\sum_{k=1}^{3}\sum_{l=1}^{2}\beta_{k,l}\frac{\ln(P_k)}{\ln(P_3)}\frac{\ln(P_l)}{\ln(P_3)} + GDPGrowth \\ &+ \ln\left(\frac{Reserves\ for\ Impaired\ Loans}{Gross\ loans}\right) + v \end{aligned} \qquad (C.1)$$

$$S_1 = \frac{\partial TC}{\partial P_1} + \omega$$

$$S_2 = \frac{\partial TC}{\partial P_2} + \omega$$

Were the associated share equations are:

$$S_s = \beta_s + \sum_{i=1}^{3} \delta_{i,s} \frac{\ln(Q_i)}{\ln(TE)} + \sum_{l=1}^{2} \beta_{s,l} \frac{\ln(P_l)}{\ln(P_3)} \qquad (C.2)$$

Symmetry requires $\alpha_{i,j} = \alpha_{j,i}$ and $\beta_{l,k} = \beta_{k,l}$; linear homogeneity requires $\sum_{k=1}^{3} \beta_k = 1$, $\sum_{l=1}^{3} \beta_{k,l} = 1$, $\sum_{k=1}^{3} \delta_k = 0$.

Generalized least-squares (GLS) algorithm is used in SUR estimation. Tables C.1 and C.2 report results of COST_WSCOPE and REVENUE_WSCOPE when coefficients of the translog function are estimated with SUR.

Appendix D – Alternative aggregation method: median value of bank year WSCOPE

We aggregate the individual bank year observations of COST_WSCOPE and REVENUE_WSCOPE with medial value to get country year estimates. Tables D.1 and D.2 report results when median value is used instead of the average.

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Table 1: Number of banks in the sample (per year/country)

This table provides the total number of bank-year observations per county (28) and year (2005-2015).

Country / Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Austria	8	5	7	12	12	13	15	15	18	17	15	137
Belgium	3	3	4	5	4	6	5	8	10	9	8	65
Bulgaria	4	4	3	3	3	4	4	4	4	3	3	39
Croatia	-	1	1	3	4	4	4	4	4	4	3	32
Cyprus	3	3	3	3	2	2	4	2	4	3	2	31
Czech Republic	5	5	5	4	4	5	5	5	5	6	5	54
Denmark	5	8	11	13	13	13	17	18	18	19	15	150
Estonia	2	2	2	2	1	1	2	2	2	2	2	20
Finland	3	4	4	6	6	6	7	8	9	10	10	73
France	42	48	56	71	72	85	87	98	95	91	82	827
Germany	42	45	51	56	62	73	79	101	106	91	54	760
Greece	8	6	7	7	10	9	4	2	5	5	5	68
Hungary	2	2	5	5	6	7	7	7	7	7	6	61
Ireland	10	12	12	11	10	9	8	8	6	7	6	99
Italy	30	32	43	49	52	54	65	69	66	63	48	571
Latvia	2	2	2	2	2	3	3	3	4	4	3	30
Lithuania	2	2	2	2	2	1	1	2	2	2	2	20
Luxembourg	4	4	6	7	6	7	6	9	11	12	8	80
Malta	3	3	3	3	2	1	3	3	3	3	3	30
Netherlands	7	8	9	8	8	4	5	12	14	14	12	101
Poland	4	8	12	14	16	16	15	15	15	16	15	146
Portugal	6	6	6	6	7	8	13	13	12	12	11	100
Romania	3	3	3	4	4	4	4	5	6	6	3	45
Slovak Republic	4	4	4	3	2	3	3	3	3	3	2	34
Slovenia	4	4	3	3	4	4	5	5	4	6	5	47
Spain	35	38	39	48	46	41	47	37	37	34	30	432
Sweden	5	6	7	7	9	10	13	15	15	15	13	115
United Kingdom	40	46	48	46	44	42	43	42	46	46	45	488
Total	286	314	358	403	413	435	474	515	531	510	416	4,655

Table 2: Correlations

Table 2 reports correlations among total costs, total revenues, outputs, input prices and control variables. ***p<0.01, **p<0.05, *p<0.1.

	TC	TR	Q1	Q2	Q3	P1	P2	P3	ln (z)	GDP(%) Growth
TC	1									
TR	0.992***	1								
Q1	0.895***	0.920***	1							
Q2	0.819***	0.812***	0.730***	1						
Q3	0.597***	0.607***	0.592***	0.625***	1					
P1	-0.098***	-0.097***	-0.120***	-0.086***	-0.078***	1				
P2	0.070***	0.059***	0.033*	-0.001	0.005	-0.031*	1			
P3	-0.022	-0.023	-0.025	-0.011	-0.007	0.018	0.027	1		
ln (z)	-0.046**	-0.038**	-0.037*	-0.031*	-0.037*	0.125***	-0.157***	-0.016	1	
GDP(%) Growth	-0.001	-0.003	-0.015	-0.001	0.006	0.011	-0.002	0.001	-0.137***	1

Table 3: Summary statistics

Panel A reports information about number of observations, mean values, standard deviations, minimum and maximum values of total equity, total costs, total revenues, outputs, input prices and control variables. Panel B reports the minimum level of total assets for each size decile.

Panel A

Variable	Observations	Mean	Std. Dev.	Min	Max
TE (th EUR)	4655	3197006	8395923	3180.091	78700000
TC (th EUR)	4655	2078542	5935031	792.703	89100000
TR (th EUR)	4655	2560795	7178821	869.777	90500000
Q1 (th EUR)	4655	31800000	80600000	430.970	696000000
Q2 (th EUR)	4655	24300000	101000000	79.869	1490000000
Q3 (th EUR)	4655	13100000	55000000	100.000	2240000000
P1	4655	0.011	0.014	0.000	0.437
P2	4655	0.034	0.056	0.000	1.743
P3	4655	5.335	41.022	0.024	1609.000
ln (z)	4655	0.804	1.237	-4.605	4.479
GDP(%) Growth	4655	1.018	2.760	-14.814	11.902

Panel B

	1	2	3	4	5
Min TA (th EUR)	24284	614976	1531224	3183055	5560990
	6	**7**	**8**	**9**	**10**
	8588266	13849313	23013900	40294746	146800000

Table 4: Regressions results

Table 4 reports results of the translog functions. Panel A reports coefficients, standard errors and t statistic in parentesis; all regressions include a proxy of bank quality ratio (Z) and GDP growth. Panel B reports μ and η coefficients for estimating technical inefficiency. Panel C reports Wald Chi^2. In all regression 2004 is the base year and the United Kingdom is the base country. ***p<0.01, **p<0.05, *p<0.1.

Dep Var	lnTC	lnTR
Panel A		
N Obs	4655	4655
lnQ1	0.497***	0.538***
	(21.49)	(22.01)
lnQ2	0.206***	0.163***
	(15.41)	(11.16)
lnQ3	0.0842***	0.0765***
	(6.13)	(5.17)
lnP1	0.569***	0.615***
	(32.34)	(32.65)
lnP2	0.302***	0.297***
	(20.66)	(18.95)
(lnQ1)^2	0.147***	0.130***
	(26.58)	(21.47)
(lnQ2)^2	0.058***	0.055***
	(22.98)	(20.32)
(lnQ3)^2	0.011***	0.011***
	(4.23)	(4.29)
lnQ1lnQ2	-0.037***	-0.027***
	(-11.18)	(-6.22)
lnQ1lnQ3	-0.037***	-0.041***
	(-12.29)	(-12.55)
lnQ2lnQ3	-0.009***	-0.007***
	(-4.86)	(-3.64)
(lnP1)^2	0.033***	0.042***
	(7.42)	(8.86)
(lnP2)^2	0.034***	0.033***
	(8.58)	(7.5)
lnP1lnP2	-0.032***	-0.033***
	(-8.90)	(-8.46)
lnQ1lnP1	0.008	0.024***
	(1.72)	(4.86)
lnQ1lnP2	0.025***	0.007
	(5.81)	(1.54)
lnQ2lnP1	-0.015***	-0.011***
	(-5.43)	(-3.85)
lnQ2lnP2	0.008**	0.005
	(3.18)	(1.68)
lnQ3lnP1	-0.019***	-0.024***
	(-7.36)	(-8.79)
lnQ3lnP2	0.019***	0.022***
	(7.57)	(8.1)
ln (z)	0.006	0.001
	(1.63)	(0.19)
GDP Growth	-0.0003	0.002
	(-0.25)	(1.79)
cons	1.471***	1.825***
	(26.16)	(30.06)
Panel B		
μ	-51.23	-10.64
	(-0.50)	(-0.57)
η	0.046***	0.031***
	(16.84)	(11.01)
Panel C		
Wald chi^2	73304.40***	66807.54***

Table 5: COST_WSCOPE estimates

Table 5 reports COST_WSCOPE mean values. Results are shown for each size decile and across years. P-values have been calculated through t-test for statistical significance of mean values. ***p<0.01, **p<0.05, *p<0.1.

Size \ Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
1	-0.027	-0.028	-0.099***	-0.119***	-0.062*	-0.039	-0.030	-0.008	-0.001	-0.002	0.063*	-0.031***
2	0.029	-0.042	-0.083*	-0.077**	0.026	0.081*	0.040	0.037	0.077**	0.155***	0.226***	0.044***
3	0.148***	0.155***	0.082	0.104**	0.114**	0.293***	0.265***	0.280***	0.316***	0.458***	0.547***	0.263***
4	0.371***	0.316***	0.262***	0.206***	0.369***	0.435***	0.459***	0.455***	0.500***	0.577***	0.606***	0.429***
5	0.454***	0.534***	0.418***	0.425***	0.622***	0.709***	0.634***	0.633***	0.672***	0.698***	0.764***	0.616***
6	0.624***	0.342***	0.383***	0.493***	0.520***	0.686***	0.657***	0.749***	0.845***	0.956***	1.274***	0.718***
7	1.117***	0.871***	0.624***	0.639***	0.891***	1.002***	1.119***	0.910***	1.184***	1.313***	1.228***	0.985***
8	0.834***	1.002***	0.811***	0.783***	1.078***	1.232***	1.077***	1.039***	1.218***	1.328***	1.611***	1.128***
9	1.521***	2.059***	1.390***	1.447***	1.782***	2.173***	2.032***	1.814***	1.960***	2.036***	2.323***	1.900***
10	3.362***	3.180***	2.904***	2.497***	3.513***	4.499***	4.377***	4.215***	4.712***	5.237***	6.117***	4.161***
Total	0.801***	0.827***	0.711***	0.667***	0.902***	1.093***	1.024***	0.983***	1.109***	1.266***	1.669***	1.027***

Table 6: COST_WSCOPE estimates by country

Table 6 reports COST_WSCOPE mean values. Results are shown for each EU country and across years. P-values have been calculated through t-test for statistical significance of mean values. ***p<0.01, **p<0.05, *p<0.1.

Country \ Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Austria	0.642	0.469	0.454	0.365	0.409**	0.421*	0.674**	0.702**	0.736**	0.833***	0.956***	0.641***
Belgium	1.053	0.852	0.308	-0.147*	0.354	0.727	0.613	0.918	1.088**	1.391**	1.650**	0.908***
Bulgaria	0.034	0.035	0.244	0.313	0.256	0.140	0.205	0.199	0.318	0.501**	0.692	0.250***
Croatia	-	-0.100	-0.023	0.377	0.380*	0.437	0.472	0.416	0.430	0.470	0.781***	0.430***
Cyprus	0.704**	0.741**	0.939***	1.014**	0.824	0.980	1.366**	0.882	1.005*	1.013**	1.293	0.989***
Czech Republic	0.592**	0.548	0.542	0.714**	0.838***	0.736**	0.722*	0.772*	0.936*	1.240**	1.656**	0.855***
Denmark	0.718**	0.737**	0.613**	0.541***	0.760***	1.011***	0.713***	0.710***	0.764***	0.811***	1.274***	0.796***
Estonia	0.955	0.978	1.006	0.778	0.896	1.279	0.821*	1.013**	1.370***	1.677*	1.910*	1.160***
Finland	1.054	4.953	0.803	0.406	0.886*	1.385**	1.168**	1.161***	1.344**	1.311***	1.331**	1.346***
France	0.681***	0.620***	0.725***	0.757***	1.084***	1.210***	1.267***	1.332***	1.474***	1.541***	1.769***	1.207***
Germany	0.216	0.234*	0.184	0.061	0.238**	0.314**	0.338***	0.328***	0.521***	0.668***	0.962***	0.392***
Greece	0.973*	0.575	0.828**	0.873**	1.441***	1.975***	2.232*	1.585	2.011***	2.231***	1.980***	1.449***
Hungary	0.312	0.375	0.408**	0.338	0.291	0.522**	0.429**	0.278*	0.245	0.404	0.428	0.370***
Ireland	0.668**	0.960***	0.774**	1.017***	0.988**	1.398**	0.992**	1.138**	1.464**	1.291**	1.559*	1.064***
Italy	0.727***	0.371***	0.860***	0.850***	1.255***	1.417***	1.171***	1.016***	1.050***	1.222***	1.739***	1.103***
Latvia	0.312	0.350	0.264	0.209**	0.239	0.134	0.157	0.176	0.249	0.207	0.458	0.245***
Lithuania	0.620*	0.593*	0.551*	0.439**	0.352	0.417	0.504	0.563*	0.744*	0.876***	0.915**	0.611***
Luxembourg	0.163	0.138	-0.138	0.003	0.262	0.149	-0.039	0.315	0.521**	0.529**	0.790**	0.306***
Malta	0.021	-0.001	-0.030	0.008	0.178	0.599	0.178	0.175	0.167	0.172	0.236	0.124**
Netherlands	0.764*	1.149*	1.380*	1.796**	2.126**	1.892	2.075	1.918**	1.926***	1.895***	2.235***	1.778***
Poland	0.290**	0.412***	0.449***	0.506***	0.469***	0.579***	0.618***	0.525***	0.841***	0.973***	1.186***	0.663***
Portugal	1.479**	1.296**	1.187**	1.088**	1.317***	1.416***	0.897***	0.776***	0.842***	0.870***	1.054***	1.047***
Romania	0.047	0.355	0.505**	0.305*	-0.063	0.041	0.069	0.081	0.189	0.296	0.701	0.212***
Slovak Republic	0.187	0.108	0.172	0.051	0.236	0.537	0.439	0.452	0.690	1.067**	1.538	0.445***
Slovenia	0.260	0.313*	0.268*	0.252*	0.322*	0.424**	0.464**	0.443**	0.356*	0.426**	0.576**	0.388***
Spain	1.324***	1.307***	1.124***	1.069***	1.150***	1.599***	1.530***	1.502***	1.671***	1.854***	2.593***	1.481***
Sweden	1.446**	1.154**	0.767	0.702	0.952*	1.193**	0.663*	0.686**	0.887**	1.022**	1.498**	0.973***
United Kingdom	1.470***	1.572***	1.042***	0.872***	1.340***	2.040***	2.072***	2.197***	2.210***	2.741***	3.136***	1.877***
Total	0.801***	0.827***	0.711***	0.667***	0.902***	1.093***	1.024***	0.983***	1.109***	1.266***	1.669***	1.027***

Table 7: REVENUE_WSCOPE estimates

Table 7 reports REVENUE_WSCOPE mean values. Results are shown for each size decile and across years. P-values have been calculated through t-test for statistical significance of mean values. ***p<0.01, **p<0.05, *p<0.1.

Size \ Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
1	-0.067**	-0.059	0.008	0.024	-0.008	-0.021	-0.029	-0.041	-0.045*	-0.035	-0.090***	-0.032***
2	-0.160**	-0.094**	-0.039	-0.061	-0.164***	-0.210***	-0.160***	-0.165***	-0.192***	-0.252***	-0.328***	-0.167***
3	-0.313***	-0.372***	-0.277***	-0.304***	-0.281***	-0.467***	-0.448***	-0.456***	-0.471***	-0.663***	-0.751***	-0.447***
4	-0.653***	-0.527***	-0.548***	-0.461***	-0.628***	-0.734***	-0.716***	-0.700***	-0.713***	-0.748***	-0.728***	-0.659***
5	-0.776***	-0.878***	-0.734***	-0.764***	-0.968***	-1.074***	-0.989***	-0.954***	-1.024***	-1.024***	-1.090***	-0.954***
6	-1.016***	-0.738***	-0.833***	-0.887***	-0.899***	-1.086***	-1.065***	-1.132***	-1.188***	-1.299***	-1.687***	-1.106***
7	-1.644***	-1.362***	-1.053***	-1.044***	-1.328***	-1.498***	-1.633***	-1.369***	-1.736***	-1.930***	-1.637***	-1.468***
8	-1.382***	-1.218***	-1.420***	-1.341***	-1.669***	-1.771***	-1.610***	-1.587***	-1.755***	-1.875***	-2.241***	-1.673***
9	-2.295***	-4.328**	-2.323***	-2.347***	-2.831***	-3.131***	-2.920***	-2.717***	-2.932***	-3.057***	-3.331***	-2.933***
10	-5.849***	-5.799***	-5.833***	-4.588***	-6.069***	-7.581***	-7.439***	-7.088***	-7.676***	-8.539***	-9.777***	-7.072***
Total	-1.346***	-1.523***	-1.382***	-1.221***	-1.510***	-1.725***	-1.639***	-1.577***	-1.713***	-1.926***	-2.456***	-1.660***

Table 8: REVENUE_WSCOPE estimates by country

Table 8 reports REVENUE_WSCOPE mean values. Results are shown for each EU country and across years. P-values have been calculated through t-test for statistical significance of mean values. ***p<0.01, **p<0.05, *p<0.1.

Country \ Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Austria	-1.143	-0.940	-0.942	-0.774**	-0.785**	-0.795**	-1.182**	-1.236**	-1.216***	-1.319***	-1.499***	-1.113***
Belgium	-1.818	-1.776	-1.611	-0.011	-0.798	-1.232	-1.106	-1.702*	-1.761*	-2.197*	-2.608**	-1.619***
Bulgaria	-0.235	-0.251	-0.543	-0.640*	-0.588*	-0.438	-0.508	-0.500	-0.640*	-0.851**	-1.040*	-0.546***
Croatia	-	0.013	-0.074	-0.762	-0.797*	-0.858*	-0.902*	-0.861*	-0.866*	-0.911*	-1.309***	-0.845***
Cyprus	-1.119**	-1.181**	-1.549***	-1.632***	-1.428	-1.578	-1.800**	-1.416	-1.513*	-1.556*	-2.032	-1.525***
Czech Republic	-0.989***	-0.899*	-0.904*	-1.194***	-1.306***	-1.104**	-1.102*	-1.185*	-1.287**	-1.604**	-1.999**	-1.240***
Denmark	-1.012*	-1.148**	-1.034**	-0.904***	-1.157***	-1.361***	-1.017***	-1.000***	-1.017***	-1.067***	-1.531***	-1.113***
Estonia	-1.342	-1.347	-1.448	-1.206	-1.331	-1.790	-1.192**	-1.464**	-1.816**	-2.153*	-2.376*	-1.590***
Finland	-1.769	-15.783	-1.893*	-1.101*	-1.645	-1.971**	-1.650***	-1.655***	-1.758***	-1.567***	-1.617***	-2.422***
France	-1.349***	-1.309***	-1.538***	-1.453***	-1.910***	-2.019***	-2.164***	-2.206***	-2.374***	-2.546***	-2.913***	-2.076***
Germany	-0.457**	-0.513**	-0.495***	-0.285**	-0.491***	-0.579***	-0.632***	-0.586***	-0.835***	-1.051***	-1.454***	-0.695***
Greece	-1.386**	-0.899*	-1.332**	-1.352**	-2.068***	-2.548***	-2.542*	-2.101	-2.888***	-3.162***	-2.918***	-2.031***
Hungary	-0.572	-0.683	-0.769**	-0.642**	-0.651**	-0.899**	-0.773**	-0.621**	-0.555*	-0.728**	-0.733*	-0.703***
Ireland	-1.004**	-1.509***	-1.341***	-1.283***	-1.383**	-1.590**	-1.472**	-1.643**	-2.042**	-1.838**	-2.217**	-1.513***
Italy	-1.104***	-0.681***	-1.630***	-1.525***	-2.012***	-2.229***	-1.770***	-1.593***	-1.617***	-1.794***	-2.399***	-1.725***
Latvia	-0.503	-0.582	-0.535	-0.461	-0.467	-0.325	-0.337	-0.352	-0.397	-0.295	-0.591	-0.423***
Lithuania	-0.918**	-0.879*	-0.851*	-0.759***	-0.606*	-0.665	-0.767	-0.891**	-1.070**	-1.226**	-1.268**	-0.918***
Luxembourg	-0.488*	-0.530*	-0.222	-0.463	-0.976	-0.458*	-0.131	-0.687*	-0.880**	-0.877***	-1.116**	-0.678***
Malta	-0.202	-0.190	-0.157	-0.199	-0.367	-0.870	-0.388	-0.387	-0.386	-0.374	-0.395	-0.321***
Netherlands	-1.193*	-1.828*	-2.618**	-2.593**	-2.874**	-2.652	-3.117	-2.928***	-2.861***	-2.903***	-3.478***	-2.713***
Poland	-0.620***	-0.650***	-0.805***	-0.896***	-0.833***	-0.961***	-1.004***	-0.955***	-1.415***	-1.555***	-1.727***	-1.096***
Portugal	-2.181**	-2.088**	-1.946**	-1.734**	-2.062***	-2.124***	-1.313***	-1.198***	-1.298***	-1.352***	-1.555***	-1.607***
Romania	-0.238	-0.611*	-0.829**	-0.591**	-0.164	-0.268	-0.291	-0.284	-0.405*	-0.507**	-0.947*	-0.445***
Slovak Republic	-0.387*	-0.354**	-0.446**	-0.336	-0.610	-0.870*	-0.768	-0.784	-1.011	-1.414**	-1.924*	-0.746***
Slovenia	-0.545*	-0.610**	-0.528**	-0.521**	-0.555**	-0.663**	-0.735**	-0.709**	-0.582**	-0.692**	-0.853**	-0.651***
Spain	-2.113***	-2.165***	-1.989***	-1.840***	-1.819***	-2.356***	-2.328***	-2.252***	-2.462***	-2.713***	-3.656***	-2.287***
Sweden	-2.173**	-1.789**	-1.369*	-1.254*	-1.493*	-1.820**	-1.138*	-1.113**	-1.363**	-1.505**	-2.124**	-1.511***
United Kingdom	-2.451***	-2.501***	-1.996***	-1.636***	-2.282***	-3.290***	-3.303***	-3.377***	-3.320***	-4.008***	-4.477***	-2.961***
Total	-1.346***	-1.523***	-1.382***	-1.221***	-1.510***	-1.725***	-1.639***	-1.577***	-1.713***	-1.926***	-2.456***	-1.660***

Table A.1: COST_WSCOPE with FOURIER FLEXIBLE

Table A.1 reports COST_WSCOPE mean values when the cost function is the Fourier Flexible. Results are shown for each size decile and across years. P-values have been calculated through t-test for statistical significance of mean values. ***p<0.01, **p<0.05, *p<0.1.

Size \ Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
1	0.037	0.038	-0.041	-0.060**	-0.012	0.023	0.021	0.046	0.046	0.049	0.121**	0.025**
2	0.160**	0.060	0.022	0.002	0.158**	0.211***	0.163***	0.184***	0.229***	0.309***	0.424***	0.176***
3	0.305***	0.323***	0.231***	0.250***	0.264***	0.535***	0.478***	0.492***	0.538***	0.678***	0.783***	0.460***
4	0.611***	0.551***	0.477***	0.379***	0.555***	0.661***	0.709***	0.685***	0.719***	0.838***	0.853***	0.656***
5	0.707***	0.774***	0.646***	0.657***	0.917***	1.002***	0.941***	0.873***	0.959***	0.989***	1.017***	0.884***
6	0.892***	0.509***	0.559***	0.708***	0.737***	0.950***	0.925***	1.047***	1.153***	1.253***	1.686***	0.989***
7	1.551***	1.152***	0.831***	0.855***	1.197***	1.346***	1.558***	1.218***	1.522***	1.503***	1.472***	1.282***
8	1.123***	1.095***	1.059***	1.015***	1.389***	1.539***	1.321***	1.289***	1.493***	1.588***	1.892***	1.388***
9	2.029***	1.992***	1.694***	1.785***	2.158***	2.716***	2.490***	2.198***	2.358***	2.433***	2.737***	2.280***
10	4.026***	3.740***	3.250***	2.914***	4.007***	5.091***	4.890***	4.705***	5.212***	5.634***	6.433***	4.631***
Total	1.094***	1.018***	0.919***	0.881***	1.157***	1.395***	1.303***	1.240***	1.377***	1.520***	1.950***	1.283***

Table A.2: REVENUE_WSCOPE with FOURIER FLEXIBLE

Table A.2 reports REVENUE_WSCOPE mean values when the cost function is the Fourier Flexible. Results are shown for each size decile and across years. P-values have been calculated through t-test for statistical significance of mean values. ***p<0.01, **p<0.05, *p<0.1.

Size \ Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
1	-0.412***	-0.399***	-0.308***	-0.263***	-0.314***	-0.385***	-0.331***	-0.371***	-0.374***	-0.371***	-0.421***	-0.357***
2	-0.774***	-0.590***	-0.512***	-0.490***	-0.775***	-0.851***	-0.753***	-0.824***	-0.878***	-0.987***	-1.238***	-0.790***
3	-1.091***	-1.199***	-1.025***	-1.059***	-1.032***	-1.529***	-1.415***	-1.430***	-1.483***	-1.839***	-2.073***	-1.404***
4	-1.930***	-1.620***	-1.557***	-1.318***	-1.677***	-1.987***	-2.044***	-1.989***	-2.031***	-2.206***	-2.127***	-1.888***
5	-2.131***	-2.297***	-2.007***	-2.034***	-2.595***	-2.766***	-2.654***	-2.491***	-2.700***	-2.700***	-2.738***	-2.510***
6	-2.530***	-1.738***	-1.901***	-2.209***	-2.260***	-2.701***	-2.588***	-2.795***	-3.004***	-3.225***	-4.436***	-2.754***
7	-4.223***	-3.169***	-2.472***	-2.450***	-3.242***	-3.640***	-4.157***	-3.341***	-4.070***	-4.024***	-3.754***	-3.480***
8	-3.242***	-2.783***	-3.122***	-3.039***	-3.902***	-4.199***	-3.625***	-3.516***	-3.907***	-4.192***	-4.966***	-3.782***
9	-5.648***	-5.750***	-4.692***	-4.921***	-5.912***	-7.280***	-6.684***	-6.018***	-6.400***	-6.567***	-7.218***	-6.197***
10	-10.395***	-9.731***	-8.280***	-7.142***	-9.636***	-11.983***	-11.565***	-10.906***	-12.164***	-12.743***	-14.996***	-11.021***
Total	-3.109***	-2.916***	-2.696***	-2.561***	-3.184***	-3.711***	-3.473***	-3.284***	-3.589***	-3.861***	-4.905***	-3.433***

Table B.1: COST_EPSUB estimates

Table B.1 reports COST_EPSUB mean values. Results are shown for each size decile and across years. P-values have been calculated through t-test for statistical significance of mean values. ***p<0.01, **p<0.05, *p<0.1.

Size \ Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
1-2	0.097***	0.090***	0.067***	0.075***	0.116***	0.093***	0.110***	0.111***	0.129***	0.146***	0.171***	0.111***
2-3	0.125***	0.114***	0.089***	0.093***	0.110***	0.134***	0.118***	0.118***	0.148***	0.153***	0.175***	0.127***
3-4	0.107***	0.084***	0.079***	0.093***	0.112	0.127***	0.113***	0.122***	0.122***	0.139***	0.171***	0.117***
4-5	0.059***	0.104*	0.095***	0.067***	0.118***	0.137***	0.095***	0.096***	0.097***	0.112***	0.138***	0.106***
5-6	0.092***	0.066**	0.062***	0.075***	0.063***	0.078***	0.111***	0.096***	0.111***	0.123***	0.154***	0.096***
6-7	0.107***	0.101***	0.081***	0.042**	0.072***	0.112***	0.059***	0.096***	0.121***	0.144***	0.137***	0.097***
7-8	0.059	0.089***	0.132	0.064***	0.060***	0.075***	0.068***	0.089***	0.090***	0.131***	0.136***	0.092***
8-9	0.063***	0.036**	0.029*	0.027***	0.054***	0.066***	0.066***	0.075***	0.080***	0.089***	0.101***	0.066***
9-10	0.058***	0.045***	0.032***	0.029***	0.053***	0.069***	0.065***	0.064***	0.075***	0.077***	0.087***	0.061***
Total	0.086***	0.074***	0.065***	0.055***	0.076***	0.090***	0.086***	0.091***	0.103***	0.115***	0.126***	0.090***

Table B.2: REVENUE_EPSUB estimates

Table B.2 reports REVENUE_EPSUB mean values. Results are shown for each size decile and across years. P-values have been calculated through t-test for statistical significance of mean values. ***p<0.01, **p<0.05, *p<0.1.

Size \ Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
1-2	-0.106***	-0.103***	-0.084***	-0.091***	-0.116***	-0.103***	-0.115***	-0.116***	-0.128***	-0.146***	-0.159***	-0.116***
2-3	-0.137***	-0.131***	-0.109***	-0.112***	-0.120***	-0.138***	-0.128***	-0.126***	-0.148***	-0.154***	-0.172***	-0.135***
3-4	-0.121***	-0.105***	-0.102***	-0.114***	-0.131***	-0.138***	-0.122***	-0.135***	-0.130***	-0.143***	-0.165***	-0.128***
4-5	-0.077**	-0.119***	-0.120***	-0.098***	-0.135***	-0.143***	-0.107***	-0.112***	-0.117***	-0.124***	-0.146***	-0.121***
5-6	-0.099***	-0.091***	-0.091***	-0.097***	-0.084***	-0.090***	-0.128***	-0.116***	-0.131***	-0.136***	-0.167***	-0.114***
6-7	-0.121***	-0.120***	-0.105***	-0.072***	-0.096***	-0.125***	-0.086***	-0.110***	-0.136***	-0.150***	-0.149***	-0.115***
7-8	-0.075	-0.106***	-0.118***	-0.083***	-0.076***	-0.083***	-0.079***	-0.101***	-0.094***	-0.140***	-0.141***	-0.101***
8-9	-0.087***	-0.061***	-0.060***	-0.057***	-0.078***	-0.083***	-0.085***	-0.091***	-0.095***	-0.101***	-0.110***	-0.085***
9-10	-0.073***	-0.063***	-0.051***	-0.049***	-0.066***	-0.078***	-0.077***	-0.075***	-0.084***	-0.084***	-0.093***	-0.073***
Total	-0.100***	-0.093***	-0.085***	-0.077***	-0.092***	-0.101***	-0.099***	-0.103***	-0.112***	-0.123***	-0.131***	-0.103***

Table C.1: COST_WSCOPE with SUR

Table C.1 reports COST_WSCOPE mean values when the cost function is estimated with SUR. Results are shown for each size decile and across years. P-values have been calculated through t-test for statistical significance of mean values. ***p<0.01, **p<0.05, *p<0.1.

Size \ Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
1	0.300***	0.258***	0.181***	0.140***	0.302***	0.242***	0.310***	0.356***	0.375***	0.408***	0.452***	0.308***
2	0.360***	0.399***	0.259***	0.281***	0.404***	0.432***	0.458***	0.428***	0.577***	0.709***	0.665***	0.458***
3	0.825***	0.736***	0.507***	0.452***	0.834***	0.873***	0.795***	0.897***	1.090***	1.179***	1.532***	0.901***
4	0.897***	1.059***	0.944***	0.991***	1.111***	1.159***	1.249***	1.382***	1.733***	1.940***	2.262***	1.406***
5	1.617***	1.698***	1.388***	1.191***	1.452***	1.565***	1.617***	1.950***	1.906***	2.314***	2.827***	1.827***
6	2.159***	2.225***	1.928***	1.466***	1.914***	2.174***	2.456***	2.786***	3.067***	3.411***	3.484***	2.537***
7	2.223***	2.335***	2.600***	2.352***	2.312***	2.838***	2.745***	3.145***	3.795***	5.136***	5.477***	3.180***
8	3.823***	5.906**	2.797***	3.039***	4.140***	4.808***	4.762***	5.331***	6.666***	6.805***	7.350***	5.213***
9	5.082***	5.576***	5.998***	4.382***	6.248***	8.226***	8.091***	9.643***	10.075***	11.516***	13.734***	8.513***
10	42.052***	42.877***	51.609***	46.859***	59.800***	82.688***	86.903***	83.702***	87.238***	106.673***	110.053***	76.026***
Total	5.591***	6.238***	7.443***	6.484***	7.993***	9.819***	10.368***	10.688***	11.267***	14.013***	17.052***	10.105***

Table C.2: REVENUE_WSCOPE with SUR

Table C.2 reports REVENUE_WSCOPE mean values when the cost function is estimated with SUR. Results are shown for each size decile and across years. P-values have been calculated through t-test for statistical significance of mean values. ***p<0.01, **p<0.05, *p<0.1.

Size \ Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
1	-0.078*	-0.072*	-0.019	-0.004	-0.071	-0.047	-0.106***	-0.126***	-0.135***	-0.146***	-0.194***	-0.094***
2	-0.036	-0.049	-0.003	-0.013	-0.071*	-0.108***	-0.099**	-0.066**	-0.135***	-0.207***	-0.182***	-0.091***
3	-0.185***	-0.156***	-0.104***	-0.124***	-0.210***	-0.209***	-0.192***	-0.226***	-0.261***	-0.359***	-0.521***	-0.236***
4	-0.269***	-0.294***	-0.248***	-0.242***	-0.321***	-0.348***	-0.359***	-0.400***	-0.510***	-0.563***	-0.622***	-0.399***
5	-0.393***	-0.484***	-0.409***	-0.399***	-0.446***	-0.463***	-0.451***	-0.583***	-0.540***	-0.614***	-0.728***	-0.515***
6	-0.500***	-0.448***	-0.455***	-0.380***	-0.475***	-0.562***	-0.621***	-0.692***	-0.791***	-0.877***	-0.928***	-0.638***
7	-0.547***	-0.605***	-0.629***	-0.609***	-0.612***	-0.752***	-0.740***	-0.773***	-0.946***	-1.220***	-1.272***	-0.793***
8	-0.738***	-1.108**	-0.652***	-0.667***	-0.833***	-0.940***	-0.958***	-1.019***	-1.271***	-1.347***	-1.468***	-1.034***
9	-0.970***	-1.130***	-1.094***	-1.013***	-1.274***	-1.537***	-1.540***	-1.689***	-1.668***	-1.778***	-2.087***	-1.495***
10	-2.728***	-2.700***	-2.865***	-2.625***	-3.418***	-4.246***	-4.204***	-4.236***	-4.485***	-5.071***	-5.462***	-3.946***
Total	-0.607***	-0.685***	-0.686***	-0.634***	-0.785***	-0.901***	-0.896***	-0.956***	-1.043***	-1.211***	-1.517***	-0.929***

Table D.1: COST_WSCOPE aggregated with median

Table D.1 reports COST_WSCOPE median values. Results are shown for each size decile and across years. P-values have been calculated through t-test for statistical significance of mean values. ***p<0.01, **p<0.05, *p<0.1.

Size \ Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
1	-0.062*	-0.076**	-0.104***	-0.138***	-0.107**	-0.093**	-0.054*	-0.070	-0.068	-0.066	0.063*	-0.071***
2	-0.034	-0.040	-0.078**	-0.121**	-0.032	0.031	-0.040	-0.011	0.067*	0.111***	0.231***	-0.017
3	0.079***	0.104***	0.024	0.065*	0.094*	0.149***	0.199***	0.211***	0.258***	0.378***	0.453***	0.202***
4	0.407***	0.365***	0.308***	0.299***	0.366***	0.477***	0.503***	0.423***	0.452***	0.475***	0.569***	0.406***
5	0.560***	0.517***	0.474***	0.450***	0.540***	0.677***	0.695***	0.594***	0.625***	0.656***	0.723***	0.599***
6	0.660***	0.414***	0.414***	0.551***	0.550***	0.713***	0.723***	0.729***	0.790***	0.904***	1.079***	0.710***
7	1.076***	0.894***	0.758***	0.723***	0.843***	0.940***	0.977***	0.822***	1.050***	1.067***	1.149***	0.936***
8	0.959***	0.904***	0.904***	0.830***	1.022***	1.140***	1.087***	1.053***	1.120***	1.238***	1.498***	1.061***
9	1.260***	1.498***	1.347***	1.332***	1.701***	2.232***	2.059***	2.071***	1.997***	2.065***	2.392***	1.823***
10	3.023***	2.702***	2.500***	2.296***	3.106***	3.907***	3.575***	3.613***	3.976***	4.214***	5.050***	3.591***
Total	0.412***	0.390***	0.407***	0.405***	0.532***	0.645***	0.578***	0.548***	0.631***	0.727***	0.974***	0.577***

Table D.2: REVENUE_WSCOPE aggregated with median

Table D.2 reports REVENUE_WSCOPE median values. Results are shown for each size decile and across years. P-values have been calculated through t-test for statistical significance of mean values. ***p<0.01, **p<0.05, *p<0.1.

Size \ Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
1	-0.064*	-0.014	0.032	0.034	0.044	0.030	-0.039	-0.005	0.007	0.005	-0.112***	-0.005**
2	-0.107**	-0.073**	-0.040	-0.009	-0.086***	-0.172***	-0.092***	-0.144***	-0.196***	-0.223***	-0.346***	-0.116***
3	-0.316***	-0.343***	-0.228***	-0.247***	-0.300***	-0.330***	-0.416***	-0.427***	-0.425***	-0.625***	-0.680***	-0.382***
4	-0.735***	-0.668***	-0.673***	-0.565***	-0.598***	-0.785***	-0.770***	-0.719***	-0.680***	-0.709***	-0.582***	-0.679***
5	-0.803***	-0.878***	-0.798***	-0.769***	-0.937***	-1.133***	-1.055***	-0.958***	-0.969***	-1.002***	-1.113***	-0.958***
6	-1.167***	-0.871***	-0.989***	-0.909***	-0.941***	-1.173***	-1.185***	-1.234***	-1.241***	-1.357***	-1.631***	-1.171***
7	-1.620***	-1.417***	-1.270***	-1.126***	-1.336***	-1.515***	-1.587***	-1.288***	-1.675***	-1.688***	-1.689***	-1.464***
8	-1.599***	-1.385***	-1.527***	-1.365***	-1.721***	-1.692***	-1.624***	-1.594***	-1.622***	-1.772***	-2.102***	-1.638***
9	-2.090***	-2.692***	-2.201***	-2.259***	-2.730***	-3.386***	-3.087***	-3.017***	-2.911***	-3.157***	-3.504***	-2.842***
10	-5.518***	-4.828***	-5.029***	-3.797***	-4.717***	-6.185***	-5.845***	-5.738***	-6.451***	-6.582***	-7.960***	-5.665***
Total	-0.720***	-0.717***	-0.783***	-0.768***	-0.900***	-1.029***	-0.923***	-0.869***	-0.963***	-1.047***	-1.427***	-0.922***