Market structure, productivity and scale in European business services

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Henk Kox (CPB Netherlands Bureau for Economic Policy Analysis), The Hague
George van Leeuwen (Statistics Netherlands), Voorburg
Henry van der Wiel (CPB Netherlands Bureau for Economic Policy Analysis)

Statistics Netherlands

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Explanation of symbols

.	= data not available
*	= provisional figure
x	= publication prohibited (confidential figure)
–	= nil or less than half of unit concerned
0 (0,0)	= less than half of unit concerned
–	= (between two figures) inclusive
blank	= not applicable
2005?2006	= 2005 to 2006 inclusive
2005/2006	= average of 2005 up to and including 2006
2005/'06	= crop year, financial year, school year etc. beginning in 2005 and ending in 2006
2003/'04?2005/'06	= crop year, financial year, etc. 2003/'04 to 2005/'06 inclusive

Due to rounding, some totals may not correspond with the sum of the separate figures.

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Abstract

Labour productivity in business-services industry tends to lag behind the rest of the economy. The present chapter investigates whether or not labour productivity in European business services is affected by unexploited economies of scale. Moreover, it analyses whether the incidence of scale sub-optimality is related to characteristics of the market or to national regulation characteristics. The econometric analysis is based on a production function model in combination with a distance-to-the-frontier model. A main result is that we find evidence for the existence of increasing returns to scale in business services firms. Throughout the EU, firms with less than 20 persons have significantly lower average level of labour productivity than the rest of the business-services industry. We find two explanatory factors for the level of scale inefficiency. The first is the level of policy-caused firm-entry costs; higher start-up costs for new firms go along with more scale inefficiency for business-services firms. Secondly, we find evidence that business-services markets tend to be segmented by firm size: firms tend to compete predominantly with firms in their own size segment of the markets. Scale-related inefficiencies may to some extent be compensated by more competition within a firm's own size segment. If a firm operates in a more "crowded" segment this has a significant and positive impact on its labour productivity. We derive some policy implications from our findings.

1. Introduction

During the past 15 years, business-services industry in most OECD countries has been among the industries with the highest growth pace. This held for its production, but even more for its employment growth. Labour productivity in business-services industry tends to lag behind the rest of the economy. This is reason for policy concern, because business-services industry nowadays has become a large part of OECD economies, and it is a major supplier of inputs to other industries. Low productivity in a large economic sector may negatively affect macroeconomic growth in a direct way. One of the findings of a large Dutch research project on the causes of the sluggish productivity growth in business services was that scale sub-optimality may be a source of the poor productivity performance in business services.[1] The then available statistical evidence suggested that the overwhelming majority of firms in this industry operates at a scale where potential scale economies are left unexploited.

The present paper investigates this hypothesis more profoundly by analyzing the scale impacts on productivity in the business services in an internationally comparative context. More specifically, we investigate econometrically the following questions:

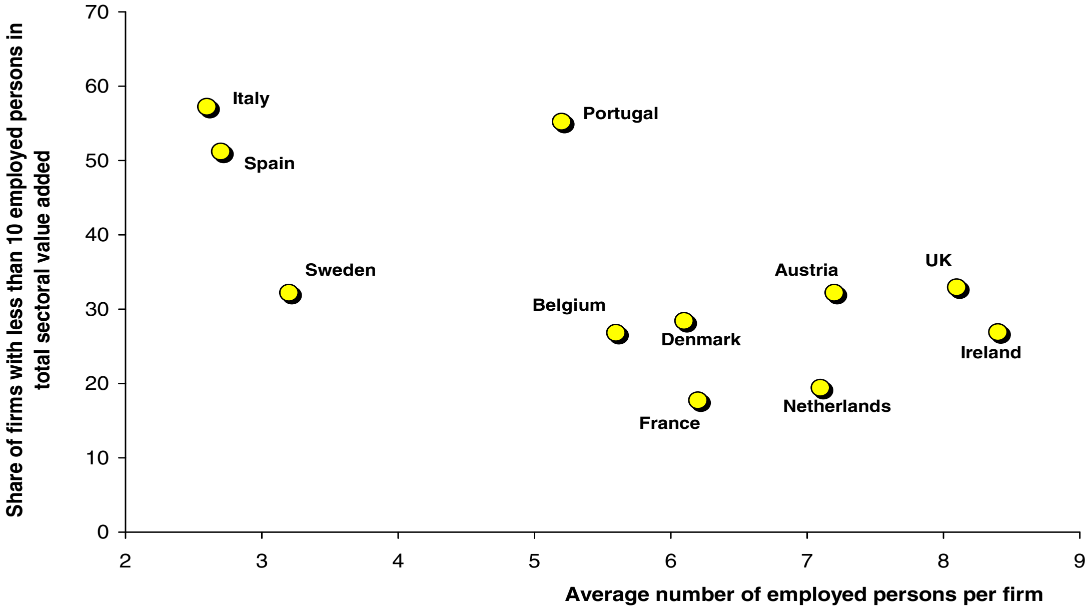
- is productivity in European business services affected by unexploited economies of scale? If this is the case,
- is the incidence of scale sub-optimality related to characteristics of the market or to national regulation characteristics?

The research with regard to these questions will be done mainly based on Eurostat NewCronos data. Section 1 presents some descriptive statistics for the business services for the

[1] Van der Wiel (2001; 1999); Kox (2004, 2002).

11 EU-countries. Section 2 of the paper sketches the analytical framework. After a brief data description in Section 3, Section 4 presents the empirical results with regard to the hypotheses. Section 5 summarizes the overall conclusions.

Figure 1 Average firm size in business services and the share of small firms (<10 employed persons) in total value added, 11 EU-countries, 1999



Note: NACE K72 + K74. Firms with less than 1 employed person are not included. Calculated from Eurostat NewCronos data (Firm demography, Business services by size class). Data for the Netherlands were compiled from Dutch production census data, using the New Cronos classification of size classes.

2. Stylized facts

The business-services industry consists of a wide range of branches such as accountants, market research, economic consultancy, and industrial cleaning. Large differences in features are related to, amongst others, differences in labour intensity, capital intensity, knowledge intensity and product differentiation. The products of the business-services industry are mostly high value added products due to the large knowledge intensity of this industry. Business-services industry compared with other industries employs relatively many high-educated employees and employers. In order to limit the amount of sectoral heterogeneity, we focus on the labour-intensive part of the business-services industry.[2]

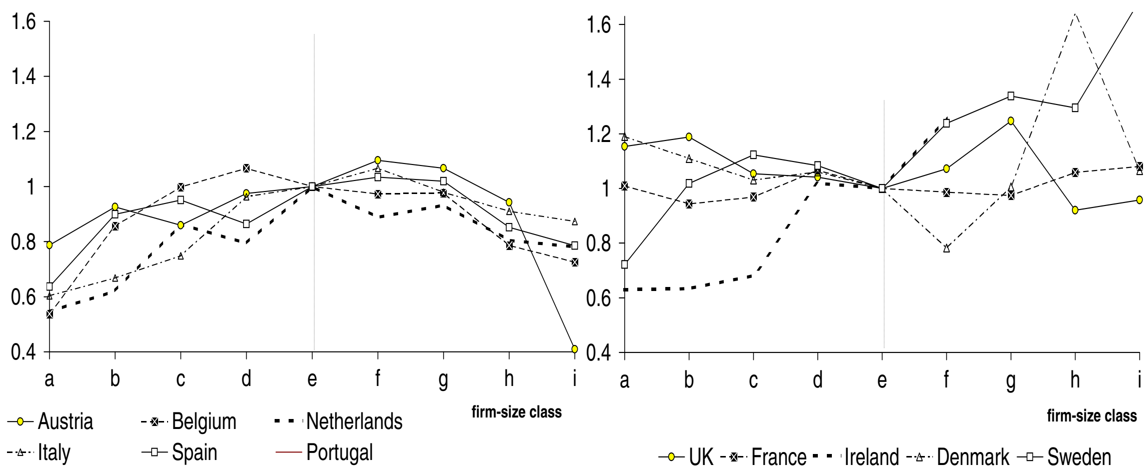
Looking at first glance, there are a number of similarities across the EU-countries with respect to some key statistics. Here, we mention two of them. First, business services in most

[2] We particularly focus on computer-related services (NACE K 72) and Other Business Services (NACE K74). We exclude two capital-intensive branches: real estate (NACE K70) and equipment rental (NACE K71), since the latter two branches use distinctly more fixed capital per employed person than the rest of the business services. We have also left out the data for contract-research establishments (NACE K73), since this sub-sector appeared to include data for university institutes where education is an unobserved side-product.

EU-countries is typically a small-firm business with the average number of employed persons well below ten persons (see figure 1). The figure however also shows that the share of firms with less than ten employed persons ranges between 17 and 57 per cent of total value added. This indicates that there can be large differences between countries in the firm size-distribution.

A second similarity across most EU countries is that average labour productivity level may differ considerably between size classes of firms. Figure 2 depicts the average labour productivity for all business services per size class and per country. In the left panel we see that six out of eleven countries display a clear hump-shape (inverted U) relation between the productivity level and firm size. The right panel shows that in two countries (Ireland, Sweden) there is a monotone productivity increase by size class, and in three countries (UK, France, and Denmark) the relation between labour productivity and scale does not show a clear pattern. Overall, the graphs suggest that scale effects could play a role in the productivity performance of firms. The hump-shape curvature hints at the existence of an optimal firm size. In the rest of the chapter we will further investigate the nature and causes of the different productivity performance by size class.

Figure 2 Relative labour productivity performance by size class in business services, 11 EU countries, 1999



Note: Relative labour productivity by size class (size class with 50-99 employees is benchmark) for all sub-sectors. Labour productivity is measured as value added (in 1000 Euros) per employed person. Legend for firm-size classes, based on employed persons per firm: a) 1-4; b) 5-9; c) 10-19; d) 20-49; e) 50-99; f) 100-249; g) 250-499; h) 500-999; and i) over 1000 employed persons

3. Explanatory models

In this section, we describe the explanatory models that will be tested to locate scale effects in business services, and their main assumptions. Our basic framework is a translog production function. First, we discuss the specification of our basic model. Scale effects are here considered only from a technological perspective. Next, we widen the perspective of the translog function by augmenting it with variables that control for market-specific factors and country-specific policy factors. Finally, we introduce the main characteristics of a distance-to-frontier model. We apply the generalised stochastic frontier approach of Kumbhakar et al. (1991) that simultaneously explains X-inefficiencies and input intensities from market-specific and country-specific characteristics.

a) Basic production function (PF) model

The presence of scale effects means that an output increase (*ΔOUT*) is not only a function of increased inputs (*ΔIN*) but also from the already achieved level of inputs (*IN*):

$$\Delta OUT = f(\Delta IN\ ;\ IN) \tag{1}$$

The effect of the marginal unit of inputs on output growth is variable with the already attained level of inputs. If the long-run average-cost function of a firm in an industry displays a U-shape, then the production elasticity of at least one input must be variable. The occurrence of variable or "local" scale effects can for instance occur when there are discontinuities in the technology options, lower efficiency incentives (bureaucracy), or less facilities for internal labour division. It implies that some firm sizes allow more efficiency than other sizes.

To take into account variable input elasticities, we employ the so-called translog production function in which the expansion of one or more inputs may have a non-linear effect on the output level.[3] The translog specification explicitly checks for variable scale effects and the presence of size-class specific complementarity between inputs. The presence of variable scale effects is detected separately by adding a quadratic term for each input.[4] In a logarithmic specification the basic translog production function for a firm's value added reads:

$$\ln Y = \alpha_y + \beta_1 \ln K + \beta_2 \ln L + \tfrac{1}{2}\beta_{11}(\ln K)^2 + \tfrac{1}{2}\beta_{22}(\ln L)^2 + \beta_{12}(\ln K \times \ln L) \tag{2}$$

in which Y is value added, K is physical capital inputs, and L represents labour inputs. The parameters β_1 and β_2 reflect the linear effects of more input use on value added. The parameters β_{11} and β_{22} reflect the non-linear effects for both basic inputs. Interaction parameter β_{12}

[3] Cf. Christensen et al. (1971); Fuss et al. (1978); Greene (1993); Kim (1992) and Ray (1998).

[4] This is done by introducing a second-order Taylor expansion and parametrising for the quadratic effects of input use. With two inputs, capital (K) and labour (L), the partial derivatives of output with respect to both inputs are evaluated around the sample mean.

represents local level interactions between the individual inputs.[5] The interaction parameter becomes significant if the output elasticity of a particular input depends on the *level* of the other input (input complementarity). As an example for the business-services sector, we may think of the positive labour productivity effects that come within reach after a fixed-capital investment in a local PC network. The constant α_y is a catch-up term for the impact of non-observed variables on output, frequently interpreted as the level of "multi-factor productivity". In the basic specification we add sector and country dummies that account for unobserved sector-specific and country-specific fixed effects.

Measuring economies of scale. With regard to scale effects on production, three meaningful outcomes for the model described by equation (2) can be distinguished. When there are no scale effects (constant returns to scale) we will find that $\beta_1 + \beta_2 = 1$, i.e. the output increase is equal to the increment of combined inputs. There may also be identical scale effects –either diminishing or increasing– for all firm-size classes. That is the case when we find the combination of $\beta_1 + \beta_2 \neq 1$ with $\beta_{11} = \beta_{22} = \beta_{12} = 0$ (no variable scale and input-interaction effects). Finally, if significant non-zero values are found for β_{11} , β_{22} and/or β_{12} it means that differentiated scale effects occur for specific size classes of firms.[6]

b) Augmented PF-model

In the basic translog specification, it is assumed that the shape of the production function and therefore the scale effects are identical everywhere: for all firms in all sub-sectors of business services in all EU-countries. This is a simplification as there may be other factors that play a role in specific sub-sectors and in specific countries. We therefore augment our basic translog PF-model with variables that control for market structure and country-specific policy factors.

We distinguish three market-specific factors that may influence the relation between scale and productivity: market segmentation, market concentration, and the degree of product homogeneity. We subsequently discuss each of these factors.

Market segmentation implies that not all firms in a sub-sector are direct competitors of each other. The existence of market segmentation has potential repercussions for the competitive incentives to remove scale-related inefficiencies. There are some suggestions in the literature that business-services markets may be segmented (at least partly) along firm-size characteristics, and that this is to some extent related to reputation effects.[7] We use a simple procedure to control for the possible impact of firm-size related market segmentation on productivity. Suppose size-related market segmentation is present. In that case, the firm's input choices that

[5] The cross derivatives in (2) are assumed to be symmetric: $\beta_{ij} = \beta_{ji}$ *for* $i \neq j$. Note that by imposing zero restrictions on each of the coefficients β_{ij} $(i,j = 1,2)$ the translog production function reduces to a standard Cobb-Douglas production function.

[6] The type of scale economies that prevail can be measured by adding up the derivative of output with respect to the inputs of capital, respectively labour.

[7] See O' Farrell and Moffat, 1991; CSES 2001; Kox, 2002.

govern productivity performance will be geared more towards competition in its own size segment than towards competition with firms in other size-segments of the market. As the measure of competition we take the average firm's market share; this is the inverse of the inverse the number of firms (*NOF*) in a relevant market. When segmentation by size class is present, the number of competitors in the firm's own size-class (*SEGM*) will have a stronger impact on the firm's productivity performance than the number of competitors in the rest of the sector's size classes (*SR*). For size class s ($s=1,...,S$), sector j ($j=1,..,J$) and country k ($k=1,..,N$) the normalized indicators for intra-segment competition intensity and extra-segment competition intensity are:[8]

$$SEGM_{sjk} = \ln\left(\gamma_{jk}\ NOF_{sjk}\right) \text{ and } SR_{sjk} = \ln\left\{\gamma_{jk}\ (NOF_{jk} - NOF_{sjk})\right\} \quad (3a)$$

$$\text{with } \gamma_{jk} = \frac{\frac{\gamma_k}{J}\sum_j^J NOF_{jk}}{NOF_{jk}} \text{ and } \gamma_k = \frac{\frac{1}{N}\sum_k^N NOF_k}{NOF_k} \quad (3b)$$

The segmentation hypothesis can be tested straightforwardly by adding both variables to the production function model. If α_1 and α_2 are respectively the impact parameters of, respectively, $SEGM_{sjk}$ and SR_{sjk} in the augmented production-function model, the interpretation of the results must be as follows. If *all* firms in the sub-sector compete with each other, regardless of size segment, the parameter α_1 will either be zero or be roughly equal to the parameter α_2. If, however, market segmentation by size class is important, then we will find: $|\alpha_1| > |\alpha_2| > 0$. Given the possibility that one of both parameters could directly pick up scale inefficiencies, we apply the segmentation test in an absolute formulation.[9]

Market concentration is a second market characteristic that we want to control for. High concentration implies that imperfect competition prevails in a market, with less pressure on firms to remove scale-related X-inefficiencies, even if markets are not segmented. Fabiani et al. (2005) and ECB Task Force (2006) find that European non-trade services firms review and change prices less often than in other industries, indicating the presence of mark-up pricing and imperfect competition. With a higher competition intensity, firms have less opportunities for mark-up pricing, and firm size will be more directly related to their cost and labour productivity levels. We want to control for this possibly disturbing effect on our results. We use (the

[8] Since we want to apply the model to cross-section data for different sub-sectors and countries, the normalisation factor γ_{jk} is necessary to remove the impacts on the total number of firms per sub-sector that come from relative country size and relative sector size (within a country). Normalisation makes both indicators comparable across countries and markets.

[9] The test can also be put in a strong form, i.e. $\alpha_1 > \alpha_2 > 0$, but this fails in case of opposite signs. In the case of excessive entry, the average firm's market share could become smaller than minimal efficient scale, thus depressing the size segment's average productivity and producing a negative sign for one of both parameters.

logarithm of) the Hirschmann-Herfindahl index (*HHI*) as a measure of market concentration. It does not measure competition intensity as such, but it may indicate markets with weak incentives for eradicating scale-related inefficiencies.[10] A high degree of market concentration is expected to cause a lower efficiency pressure. Hence, we expect a negative sign for the estimated *HHI* parameter.

Finally, the degree of *product differentiation* is a final market characteristic that we want to take into account. Descriptive data for business-services industry in the EU show that some sub-sectors have a high degree of product differentiation. Product differentiation may affect the input mix and the internal organization of firms. In case of product differentiation, labour-saving and internal division of labour according to the Babbage principle (spreading costs of overhead and management labour over more workers) may get more difficult, thus affecting productivity. Product specialisation in business services could have two opposite effects on productivity. The required higher overall qualification level of employees may benefit labour productivity in some elements of the production process. Conversely, the lack of task standardization, specialization and production routines may negatively affect productivity.[11] A *priori,* it is not obvious which of both productivity effects is dominant. To isolate the potential impact of product differentiation on productivity, we add sub-sector dummies to take account of product differentiation and other unobserved factors that vary by sub-sector.

Apart from market characteristics, the augmented production-function model also accounts for *country-specific differences* in product-market regulation. Regulation of product markets by national governments could possibly explain part of the variation in business services productivity across the EU-countries (see e.g. Paterson et al., 2003). Stricter regulations are found to go along with more mark-up pricing in services (ECB Task Force, 2006); hence, with strict regulations there will be fewer incentives to remove scale-related inefficiencies. Also research by Scarpetta et al. (2002) and Schiantarelli (2005) supports the expectation that the incidence of scale inefficiencies may be a function of the regulation type and the relative regulation intensity in countries. We explicitly control for two types of national policy indicators:[12]

- intensity of product-market regulation, relative to other countries (*PMR*). We expect this variable to correlate negatively with productivity.

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[10] The use of more preferable indicators of competition-intensity like the relative profit measure (cf. Boone 2000) or average price-cost margins is problematic in our case because price and cost data are difficult to obtain for European business services.

[11] If branches with a high degree of product differentiation on average have higher-qualified employees this might also mean that part of their jobs consists of elements for which they are over-qualified. It may thus have a negative impact on cost efficiency.

[12] It turned out that other available indicators such as the national restrictions on foreign direct investment strongly correlate with other explanatory variables.

- entry costs for new firms (*EC*). A high entry hurdle diminishes the competitive pressure that newcomers in the market exert on incumbent firms. We expect a negative effect on average firm productivity.

With the addition of market-specific and country-specific regulation factors to equation (2), we arrive at the augmented translog PF-model. Since we focus on labour productivity, the equation is further reformulated so that labour productivity is indeed the dependent variable:

$$\ln\left(\frac{Y}{L}\right) = \lambda_L + \beta_1 \ln K + (\beta_2 - 1)\ln L + \frac{1}{2}\beta_{11}(\ln K)^2 + \frac{1}{2}\beta_{22}(\ln L)^2 + \beta_{12}(\ln K \times \ln L) + \\ + \alpha_1 SEGM_{sjk} + \alpha_2\, SR_{sjk} + \alpha_3 HHI + \alpha_4 PMR + \alpha_5 EC + \alpha_6 D + \mu$$

All β-parameters refer to technological parameters, whereas the α-parameters refer to the control variables of the augmented model. *SEGM* and *SR* are the indicators for within-segment competition respectively competition with other segments, while *HHI* denotes the market concentration. Both are specific for sub-sector and country. Furthermore, two indicators refer to country-specific policy regulations: product market regulation (*PMR*) and Entry costs (*EC*). Vector *D* contains sub-sector dummies that account for unobserved sector-specific fixed effects. Finally, λ_L is the regression constant, and μ is the error term of the regression. An important element of the (augmented) PF-model is that the error term μ is thought to contain only white noise.[13]

c) Distance-to-the-frontier model

The production function models assume a representative "average" firm with a more or less homogenous input mix. We may get a step closer to reality by allowing for the possibility that firms, size classes or sub-sectors can be heterogeneous in their input mixes. The distance-to-frontier model does two things. It identifies a technological efficiency frontier per sector ("best practice").[14] All individual observations can thus be defined as deviations from the frontier. The model at the same time explains from market-structure variables and regulation characteristics why some or even most firms are not on the efficiency frontier. The individual productivity distance to the frontier firm (X-inefficiency) becomes the independent variable. We use the generalised stochastic frontier (GSF) model, an adapted version of the method developed by Kumbhakar et al. (1991). The GSF takes into account that both X-inefficiencies and input choices depend on market-specific and country-specific characteristics.

[13] The errors are assumed to be i.i.d. normally distributed around mean zero, $\mu \sim N(0, \sigma_\mu^2)$, i.e. they can have positive or negative values.

[14] Technically, the efficiency frontier is the set of all minimum input combinations needed to produce a particular output level. The efficiency frontier is equal to a theoretical production function that identifies all output-maximising (or input-minimising) combinations of inputs and output.

The first part of our GSF-model is again a standard translog productivity equation:

$$\ln\left(\frac{Y}{L}\right) = \lambda_L + \beta_1 \ln K + (\beta_2 - 1)\ln L + \frac{1}{2}\beta_{11}(\ln K)^2 + \frac{1}{2}\beta_{22}(\ln L)^2 + \beta_{12}(\ln K \times \ln L) + \delta B + \varepsilon \tag{5}$$

The vector B collects the sector-, country- and size-class dummies that act as control variables for the technology parameters. The error term ε is important for further analysis in the GSF-model, since it is thought to contain a deterministic component (τ), which representing the part of the X-inefficiencies that can be explained from market and regulation characteristics. Apart from that, a white noise component (ω) is present, so that $\varepsilon = \tau + \omega$.[15] The efficiency frontier is defined as those observations without deterministic X-ineficiencies, so that the distribution of τ is truncated at zero (condition $\tau \geq 0$). The second equation of the GSF- model explains the X-inefficiencies in terms a vector Z that contains the market and regulation variables:

$$\tau = \gamma' Z + \theta \qquad \text{with} \quad \tau \sim N(\gamma' Z, \sigma_\tau^2) \tag{6}$$

Equation (6) says that X-inefficiencies are drawings from a truncated normal distribution with expectation $\hat{\tau} = \gamma' Z$. This specification implies that X-efficiencies are deviations from their mean determined by the vector Z.[16] The market and regulation variables in Z are the same as those used in the augmented PF-model. Both equations of the GSF model (5 and 6) are to be estimated simultaneously. Note that because the last equation explains *in*efficiencies the signs of the explanatory variables must be interpreted in an opposite way (negatively) to find the impact on labour productivity.

The three explanatory models that have been developed in this section are related to each other. They can be considered as stages in diminishing abstraction: the first model (PF) explains possible scale effects only from technological input choices. The second model (augmented PF) allows for the possibility that market characteristics and country-specific regulatory characteristics affect input choices, and hence scale effects. Both models basically assume homogeneity of all firms, i.e. some representative firm. This homogeneity assumption is dropped in the GSF -model, by identifying a production frontier and explaining the individual

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[15] The white noise component in the error term (ω) is again assumed to be i.i.d. normally distributed around mean zero: $\omega \sim N(0, \sigma_\omega^2)$. Moreover, τ and ω are assumed to be independent: $E(\tau, \omega) = 0$.

[16] In a companion paper we show the derivation of the likelihood function for the GSF model (Kox et al. 2006).

firm's deviation to this frontier in terms of market characteristics and country-specific regulatory characteristics. The three models are tested subsequently.

4. Data

In order to test our explanatory models empirically we use national production census data for business-services firms, made available through the Eurostat NewCronos database *Firm demography, Business services by size class* (data retrieval august 2005). The data are for 11 EU member states and cover some 1.9 million individual firms ─ split up by sub-sector and by country ─ with the reference year 1999.[17] The data are aggregated by size class of firms, but since the number of firms by size class is given, we can infer data for the average firm by size class, by sub-sector and country. The aggregation level of the NewCronos data does not allow us to deal with firm-level heterogeneity, but we may calculate scale effects for the average firm in each size class in each sub-sector of the business-services industry.

Firm size is measured by the number of employed persons per firm, a measure that includes the entrepreneur. Nine different size classes are distinguished ranging from small firms with one to four employees to very large firms with more than 1000 employees. The available data allow a cross-section regression for 11 EU-countries: Austria, Belgium, Denmark, France, Ireland, Italy, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom. The total number of observations is about 760, from up to 12 different sub-sectors of NACE 72 (computer-related services) and NACE 74 (Other business services).

Labour input is measured as the number of employed persons. The amount of depreciation is used as an indicator for capital input. For market concentration, we use a modified version of the HHI.[18] For the variable PMR (intensity product-market regulation) we use the OECD's economy-wide indicator for the relative intensity of competition regulation in reference year 1998 (Nicoletti et al. 2000). A high value of the PMR indicates a relatively regulated national economy. Data for variable EC (policy-caused, country-specific costs for setting up a new firm) are derived from a World Bank dataset (Djankov et al. 2002). A high value of the indicator refers to a large amount of entry costs.

5. Empirical results

We subsequently present the estimation results for the explanatory models, starting with the results for the two PF-models. The dependent variable is in all cases the logarithm of the productivity level (value added per employed person).

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[17] Lacking data for the Netherlands have been compiled directly from Dutch production census data, ensuring compatibility by the use of the NewCronos aggregation method.
[18] In order to avoid multi-collinearity with the *SR* variable, we have calculated the *HHI* as the logarithm of summed squares of all size-class shares in a sub-sector's total value added.

Table 1 presents the results of both the basic and the augmented PF-model applied on the pooled dataset for all 11 EU-countries and all available sub-sectors. The results for the basic PF-model suggest that there are increasing returns to scale in the EU-business-services industry.

Table 1 Estimation results for basic and augmented PF-model based on pooled regression in business services (all sub-sectors, 11 EU-countries, reference year 1999)

		Basic PF-model		Augmented PF-model	
Independent variables	Parameter	Estimate [c]	T [a]	Estimate [c]	T [a]
Technology variables					
Fixed capital	β_1	0.51	5.5***	0.35	3.0***
Labour input	β_2	0.63	5.9***	0.60	4.3***
Local scale effects, capital-based	β_{11}	− 0.09	−3.9***	− 0.09	−3.8***
Local scale effects, labour-based	β_{22}	− 0.05	−1.7*	− 0.08	−2.5**
Local scale effects, capital-labour interaction	β_{12}	0.06	2.4***	0.09	3.7***
Size-class dummies					
1-4 employed persons				0.13	1.0
5-9 employed persons				0.02	0.2
10-19 employed persons				0.03	0.4
20-49 employed persons				0.06	1.0
50-99 employed persons				0.01	0.2
250-499 employed persons				0.05	0.8
500-999 employed persons				−0.12	−1.3
>1000 employed persons				−0.09	−1.0
Market-characteristics					
Within-segment competition ($SEGM_{sjk}$)	α_1			−0.06	−3.1***
Competition with non-segment firms (SR_{jk})	α_2			0.08	3.6***
Market concentration, (HHI)	α_3			−0.15	−3.6***
National policy regulation					
Product-market regulation (PMR)	α_4			0.06	1.7*
Entry costs (EC)	α_5			−0.54	−4.6***
Sector dummies [b)]		Yes		Yes	
Country dummies [b)]		Yes		No	
Other regression statistics					
Regression constant	α_y , λ_L	3.15	8.5***	4.49	7.5***
Number of observations		713		713	
Adjusted R^2		0.63		0.61	
Log likelihood		− 176.69		−216.6	

Notes: a) Asterisks denote the confidence interval (two-tailed) of the estimates: *** at 1% level, ** at 5% level, and * at 10% level. b) The size reference group is size class 100-249 employed persons, the reference sector is sub-sector NACE K744, and the reference country is Ireland. c) The use of size-class averages (based on different numbers of firm observations) could create a bias if we used Ordinary Least Squares estimation. To prevent this we apply the Weighted Least Square method, including White Heteroskedasticity-consistent standard errors.

From the magnitude of the technology variables in combination with the levels of capital and labour inputs (not shown) it can be inferred that there are positive scale economies. Since β_{11}, β_{22} and β_{12} are significantly different from zero, we must conclude that these positive scale effects are “local”, i.e. they only occur in some size classes.

We would expect these local effects to pop up in the augmented PF-model where we add dummies for individual size classes as well as variables for market characteristics and country-specific regulation characteristics. However, the estimation outcomes show that none of the size dummies is statistically significant. This suggests that neither small nor very large firms operate on a less-efficient production frontier scale. A small average market share for firms within a size segment (variable *SEGM*) has a significantly negative impact on labour productivity, but overall this effect is dominated by a larger positive productivity impact of competition with firms in other size segments (variable *SR*). Because of the relative size of both effects, the market segmentation hypothesis is rejected in the augmented PF-model: the condition $|\alpha_1| > |\alpha_2|$ is not fulfilled. The estimated coefficients of the market concentration (*HHI*) and policy-caused entry costs (*EC*) have the expected negative sign and are statistically highly significant. The *PMR* variable is significant at the 10 per cent confidence level, but it has not the expected sign. The positive sign suggests that strict regulation in a country strengthens labour productivity performance. This is at odds with most of the literature, and we do not have a good explanation for this result. The indicator for the intensity of product-market regulation in a country could be too broad to be meaningfully used for explaining the differences in productivity level of the business-services industry.

Both of the preceding models illustrate that capital intensity (parameter β_1) matters for the labour productivity level in business services. The coefficient for capital is, however, much smaller in the augmented PF-model. The 'local effect' parameter β_{11} indicates that capital intensity has decreasing returns to scale in some size classes.

Results for the GSF-model

The basic PF-model and its augmented variant pay no attention to the possibility that firms are heterogeneous in their input mix, and that not all of them operate on the efficiency frontier. The results of the GSF-model indicate that it is important to take firm heterogeneity and X-inefficiencies on board. The model simultaneously explains X-inefficiencies and input intensities from market-structure variables and regulation characteristics. Table 2 presents the results for this model.

From the estimated technology parameters and the input levels (not shown) we may conclude that business-services industry is characterised by increasing returns to scale, once we control for the possibility of X-inefficiencies. Particularly, the linear parameters for capital inputs (β_1) and labour inputs (β_2) are substantially larger in the GSF-model than in the augmented PF-model.

The parameters for the non-linear input effect (β_{11}, β_{22} and β_{12}) are significantly different from zero, indicating that there are "local" scale effects, specific for some size classes. The size-class now allows us to identify the locus of these local scale effects. Small firms, up to a size of 20 employed persons, experience considerable productivity disadvantages compared to the reference size class (100-249 employed persons). The findings suggest that firms operate on different production frontiers. Recall that Figure 2 already suggested such a pattern prevails for a considerable part of European business-services industry. The GSF results, however, do not confirm the hump-shape pattern in the size-productivity relation (left panel Figure 2). The size-

Table 2 Estimation results for GSF-model based on pooled regression in business services (all sub-sectors, 11 EU-countries, reference year 1999)

Independent variables	Parameter	Estimate [c]	T [a]
Production frontier equation			
Technology variables			
Fixed capital	β_1	0.42	6.3***
Labour input	β_2	0.67	7.3***
Local scale effects, capital-based	β_{11}	− 0.08	−3.7***
Local scale effects, labour-based	β_{22}	− 0.05	−2.0**
Local scale effects, capital-labour interaction	β_{12}	0.06	2.8***
Size-class dummies			
1-4 employed persons		−0.36	−5.2***
5-9 employed persons		−0.32	−4.5***
10-19 employed persons		−0.21	−3.0***
20-49 employed persons		−0.03	−0.4
50-99 employed persons		−0.01	−0.1
250-499 employed persons		−0.01	−0.1
500-999 employed persons		−0.04	−0.4
>1000 employed persons		0.03	0.3
Sector dummies[b)]		Yes	
Country dummies[b)]		Yes	
X-inefficiencies equation:			
Market-characteristics			
Within-segment competition ($SEGM_{sjk}$)	α_1	−0.31	−1.8*
Competition with non-segment firms (SR_{sjk})	α_2	0.15	0.9
Market concentration (HHI)	α_3	−0.03	−0.2
National policy regulation			
Product-market regulation (OECD)	α_4	0.06	0.3
Entry costs (OECD)	α_5	1.88	1.7*
Size-class dummies [b)]		Yes	
Other regression statistics			
Regression constant	λ_L	3.67	13.0***
Number of observations		713	
Log likelihood		− 112.13	

Notes: a) Asterisks denote the confidence interval (two-tailed) of the estimates: *** at 1% level, ** at 5% level, and * at 10% level. b) The size reference group is size class 100-249 employed persons, the reference sector is sub-sector NACE K744, and the reference country is Ireland. c) Both equations of the GSF model have been estimated simultaneously using the Full-Information Maximum Likelifood estimation procedure (cf Kox et al. 2006).

class dummies for the large size classes turn out not to be significantly different from zero. Possibly because larger firms can, on average, compensate a relatively lower labour productivity by a more efficient use of capital inputs. Scale-related productivity effects only occur up to a threshold firm size. A number of 20 employed persons appears to be the minimum efficient firm size in European business services. Beyond a size of 20 employed persons further firm growth on average yields no more significant productivity advantages, if we control for capital input. The reasons for this minimum firm size can be related to internal labour division (in the spirit of Adam Smith's pin factory), human capital specialisation, spreading fixed capital costs, routine development, and the Babbage principle (possibilities for spreading managerial and other overhead costs). Further research would be necessary to assess which of these factors forms the binding constraint that defines the minimum efficient scale in business services.

While scale-related inefficiencies are primarily found at firm sizes smaller than 20 employed persons, X-inefficiencies related to sub-optimal input choices may also occur at larger firm sizes. The τ-equation of the GSF-model identifies the market characteristics and regulatory environments that tend to be correlated with X-inefficiencies. Size-related market segmentation could be an important characteristic in business-services markets. The market segmentation test $|\alpha_1| > |\alpha_2|$ is satisfied.[19] The estimated parameter is significant at the 10 per cent confidence level; hence the issue warrants further research.

There is a remarkable difference with Table 1. Now that X-inefficiencies are taken into account, the estimated parameter for intra-segment competition (*SEGM*) has a larger value and a different sign. More intra-segment competition has a negative impact on *in*efficiencies, and hence a positive impact on labour productivity. Being in a "crowded" size segment of the market could therefore to some extent compensate any scale-related inefficiencies. Consistent with this is the finding that a high level of policy-caused start-up costs for new firms (*EC*) works out positively on the incidence of X-inefficiencies, and hence negatively on the labour productivity performance. A final result is that, on average, market concentration (*HHI*) and the intensity of competition-related regulation (*PMR*) are not significant factors for explaining the incidence of X-inefficiencies.

6. Conclusions and some policy implications

We find clear indications for the existence of increasing returns to scale in business-services firms. The scale effects are not the same for all size classes. Throughout the EU, firms with less than 20 persons have significantly lower average labour productivity levels than the rest of the business-services industry. The size of 20 employed persons can be regarded as the minimum-efficient scale in European business services. Beyond that size there are no significant impacts of scale on labour productivity performance.

Likely explanatory candidates for the presence of the minimum-efficient scale size in business services are traditional drawbacks of small scale known from the literature, such as

[19] The estimated parameter for α_1 is significant at the 10 per cent confidence level (2-tailed), while α2 is not statistically significant.

having less efficient division of labour, and having less opportunities for spreading fixed managerial costs, overhead costs, fixed human-capital costs, and fixed-capital costs. Further research could establish the reasons for the presence of the minimum-efficient scale size. Apart from scale-related inefficiencies, we find evidence that X-inefficiencies related to input choices may occur in all size classes. Estimation results for the generalised stochastic frontier model (GSF) indicate that X-inefficiencies caused by sub-optimal input choices are affected by market characteristics and the regulatory environment of firms. In particular we find that business-services markets may be segmented by size class of firms. This means that firms from different size classes on average only have weak competition with firms in other size classes. Small firms hardly compete with large firms and vice versa. They possibly serve different market segments, have different clients and also different types of products.

A final result is that more intra-segment competition works out positively on labour productivity of the firms in that size class. Being in a "crowded" size segment of the market could thus to some extent compensate scale-related inefficiencies. For instance, the relatively intense "neck-and-neck" competition among small firms may to some extent both compensate their scale-related inefficiencies, e.g. by reducing their non-scale inefficiencies including suboptimal input choice. Consistent with this is the finding that a high level of policy-caused start-up costs for new firms negatively affects the labour productivity performance. Higher entry barriers may weaken the stimulus for incumbent firms to be efficient.

Our results are based on cross-section analysis for one year, but we think the results warrant a more comprehensive research programme on scale-effects in European business services, using data on more years (panel data) and real micro-level data instead of size-class averages. In fact such research is already long overdue, if we take into account that business services is one of the largest sectors in the European economy with an employment share of about 11 per cent, a value-added share of about 12 per cent in the European Union, and a 54 per cent share in EU employment growth between 1979 and 2001.

Although we cannot discuss policy implications at length, there are several links between the productivity agenda in business services and government policies in EU countries. Government policies have leaned strongly towards promoting market entry by new entrepreneurs, rather than paying attention to existing scale inefficiencies. The idea was that more entry is good for competition is probably right. Entry by new business-services firm constituted was a major factor major in total EU employment growth during the 1990s. This was (partly) the result of government policies. For the future, further thought must be given to such policies before continuing on the same track. When market segmentation is indeed as important as we think it might be, new entrants will mostly compete with each other, i.e. with the other small and 'young' firms.[20] Like with lobsters that try to escape the box in which they are, their mutual competition means that no one gets out. They may remain operating at a relatively inefficient firm size.

Maybe a new balance has to be struck between 'upscaling' in order to remove scale inefficiencies and ensuring a constant influx of new entrepreneurs. The question is whether the markets themselves will solve this issue, or whether the governments have a role to assist the market forces. With segmented markets – both within and between countries– competition may not automatically lead to more scale-efficient production sizes. Many national and EU policy programmes nowadays play at least lip service to lowering administrative burdens for firms. Perhaps especially the firms below 20 employed persons should get a light administrative burden from government regulation. This will make it easier for firms to grow beyond the present small-firm business model. In addition, the opening of markets for intra-EU competition may yield more incentives for 'upscaling' of business-services firms.

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[20] Cf. the "neck-and-neck" competition in Aghion and Griffith (2005).

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