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ABSTRACT

Price-Cost Margins and Shares of Fixed Factors*

Reduced form approaches to estimate price-cost markups typically exploit variation in observed input and output. However, these approaches ignore the presence of fixed input factors, which may result in an overestimation of the price-cost margins. We first propose a new methodology to simultaneously estimate price-cost margins and the shares of fixed inputs. We then use Belgian firm level data for manufacturing and service sectors to show that markups are lower when taking into account fixed input factors. We find that the average price-cost margin of manufacturing firms is 0.041, compared to 0.090 when we do not control for fixed costs of production. We also show that price-cost margins increase with the share of fixed costs in turnover. Our findings provide new insights about observed high price-cost margins in service industries. In particular, we show that once fixed costs are taken into account, price-cost margins in service industries are comparable to those in manufacturing.

JEL Classification: L11, L13 and L60
Keywords: fixed input costs, price-cost margins and Solow residual

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1 Introduction

The economic implications of institutional change, competitive pressure and anti-trust policy on market power have been widely conjectured and researched[1]. One prominent concern has been how to estimate market power. When detailed data on product characteristics, supply and demand information, price and input prices for narrowly defined sectors are available, structural models as introduced by Rosse (1970), Just and Chern (1980) and Bresnahan (1981, 1982) have proven to be a useful tool, in particular for merger simulation (see Bresnahan, 1989; Budzinski and Ruhmer, 2010, for a review)[2]. The estimates of price-cost margins obtained from these structural approaches, however, seem rather high, for example, 0.504 for food processing industry (Lopez, 1984), 0.40 for railroads industry (Porter, 1983) and 0.16 for luxury car industry (Verboven, 1996). Boyer (1996), for instance, argues that structural models implicitly assume immediate adjustment of inputs to changes in costs and hence they fail to capture the diversity of oligopoly with respect to the fixity of capital, capital adjustment costs, etc.. With less detailed data on product characteristics, alternative approaches have been adopted making use of the observed variation in output and input factors, following the methodology of Hall (1986, 1988, 1990) and Roeger (1995). The markup estimate of these reduced form approaches is less sensitive to specification bias, but is sensitive to the choice of input factors included in the model specification. Largely overlooked in these reduced form approaches, however, has been the issue of whether fixed costs in production condition how price-cost margins are affected. This is not surprising as fixed costs of production are usually not observed to the econometrician.

Recently, reduced form approaches have commonly been used for estimating markups in the literature, but, like in the structural approaches, the estimates of price-cost margins usually are rather high (between 0.15 and 0.25). As suggested by Roeger and Warzynski (2009), one explanation for these high estimates is that typically fixed costs of production are not taken into account, often because fixed costs are usually not observable in firm level data. For example, using a production function specification in which capital is held quasi-fixed, Klette (1999) obtains a very low markup estimate. Alternatively, de Loecker and Warzynski (2009) propose a new estimation approach, which does not require measuring the cost of capital or assuming constant returns to scale. They start from Hall and apply the control function approach of Olley and Pakes (1996) to control for unobserved productivity. But their approach may be subject to the omitted price variable bias by using deflated sales as a proxy for physical quantity. The treatment of capital cost, as either fixed, variable or both, seems important for estimating markups. Our estimation methodology allows for the flexible

[1]For example, Domowitz, Hubbard, and Peterson (1988) in the context of cyclical fluctuations, Levinsohn (1993) and Harrison (1994) in the context of trade liberalization, Konings, Cayseele, and Warzynski (2005) analyze the effect of privatization, Konings and Vandenbussche (2005) evaluate the effect of trade policy on markups of firms. Kee and Hoekman (2007) study the impact of competition law, import exposure and the number of domestic firms on markups.

[2]The main disadvantage of the structural approach is that the results depend critically on a variety of assumptions concerning specifications.

treatment of capital and allows to solve the endogeneity problems concerning productivity.

To this end, we start from the approaches introduced by Hall (1988) which estimates markups from primal Solow residual and suffers from endogeneity problems and Roeger (1995), which exploits the variation in the primal and dual Solow residual to derive a consistent estimate of the markups. But instead of assuming that all input factors in production are fully flexible we introduce a distinction between variable and fixed capital as well as variable and fixed labor input. This will allow us to simultaneously estimate the fixed costs in the production process and the price-cost margins. The method that we introduce, has the advantage that we can both estimate the markups and the fixed shares of input factors in a consistent manner, without having to worry about potential correlations between the unobserved productivity shocks and the input factors of production. An additional advantage of this approach is that it also relaxes the constant returns to scale assumption which is required in Roeger (1995), instead, the constant returns to scale on the variable factors is required in the model.

We then apply our methodology to micro data of Belgian firms operating in manufacturing sectors and in service sectors for the period 1999-2008. We find that our estimates of price-cost margins are lower when controlling for the existence of fixed capital and labor in manufacturing sectors, and the estimated price-cost margins increase with the share of fixed costs in turnover. The markups in service sectors seem rather high in earlier studies explained by the nature of services exchange and pervasive regulations in services. This has inspired the European Union to implement some policies to strengthen competition in services since the 1990s. Nevertheless, recent empirical studies find it somewhat puzzling that so little progress has been made in reducing the markups in service sectors. Badinger (2007) even finds a small increase in service markups in the EU, despite efforts by the EU Commission (European Commission 2002) to implement the so-called "Service Directive" which aims at reducing administrative entry barriers and increase cross border service flows[3]. Applying our methodology to firms in service sectors allows us to analyze whether the higher markups that are often observed in service sectors (e.g. Siotis, 2003; Christopoulou and Vermeulen, 2008; Martins, Scarpetta, and Pilat, 1996) are potentially driven by the presence of fixed costs. We find that in knowledge-intensive service sectors fixed costs are important and can explain why in earlier studies service sectors had high markups. Our analysis can potentially shed some lights on the importance of technological factors for explaining persistent markup differences across sectors.

The remainder of the paper is organized as follows. The next section summarizes Hall's and Roeger's approaches and then extends it to allow for fixed input factors. In section 3 we describe the firm level data that used and section 4 provides the results and discussions. In section 5, we apply our approach to the service industry. Section 6 gives some concluding remarks and discussions.

[3]The "Services Directive" was adopted in 2006 aiming to further the "Single Market" for services by reducing the barriers to cross-border trade, principally by doing away with the service industry regulations of individual EU Member States.

2 Methodology

2.1 Hall's approach

Consider a production function $Q = F(K, L, M)\Theta$, where K, L and M are capital, labor and material inputs, respectively, Θ is an index of technical progress. Under the assumptions of perfect competition and constant returns to scale, the Solow residual is given by $SRQ^R \equiv \Delta q - \frac{WL}{PQ}\Delta l - \frac{P^M M}{PQ}\Delta m - (1 - \frac{WL}{PQ} - \frac{P^M M}{PQ})\Delta k$ and captures the growth rate of total factor productivity (Solow, 1957), where Δq, Δl, Δm and Δk are the growth rates of output, labor, material and capital inputs, respectively. By relaxing the condition that price equals marginal cost, Hall (1988) shows that the Solow residual can be decomposed into a markup and a productivity factor:

$$SRQ^R = B(\Delta q - \Delta k) + (1 - B)\Delta\theta \tag{1}$$

where B is the price-cost margin defined as $B \equiv \frac{P-MC}{P}$, which is directly related to the markups via $\mu = 1/(1 - B)$.

The problem in estimating equation (1) is that unobserved productivity shocks may be positively correlated with output growth. Thus instrumental variables are required to estimate B. However, it is difficult to find instruments that are correlated with output growth but are neither a consequence nor a cause of technological innovations. Then the estimated markup has an upward bias.

2.2 Roeger's approach

To deal with the potential endogeneity problem, Roeger (1995) obtains a dual price-based Solow residual by solving the dual cost minimization problem, and applies it to cancel out the productivity shocks factor. The dual Solow residual is:

$$\begin{aligned} SRP^R &\equiv \frac{WL}{PQ}\Delta w + \frac{P^M M}{PQ}\Delta p^M + (1 - \frac{WL}{PQ} - \frac{P^M M}{PQ})\Delta r - \Delta p \\ &= -B(\Delta p - \Delta r) + (1 - B)\Delta\theta \end{aligned} \tag{2}$$

where Δp, Δw, Δp^M and Δr are the growth rates of product price, wage, material price and the rental price of capital, respectively.

Subtracting equation (2) from (1), the term capturing productivity shocks is eliminated. And the price-cost margins B can be consistently estimated by equation (3) if factors of production can be adjusted instantaneously (that is, they are costless to adjust) and variables in (3) can be measured without error.

$$SRQ^R - SRP^R = B[(\Delta q + \Delta p) - (\Delta k + \Delta r)] + \epsilon \tag{3}$$

However, the assumption that factors of production can be adjusted instantaneously may not be satisfied and may be more problematic for capital, because it goes against the evidence of considerable adjustment costs in capital. We next introduce fixity of inputs and by taking difference-in-differences we are able to estimate both markups and the shares of fixed input factors consistently.

2.3 Difference-in-difference Approach

2.3.1 Primal and Dual Solow Residuals with Revenue-based Shares

We start from a standard production function with constant returns to scale on the variable factors:

$$Q = F(K - K^f, L - L^f, M)\Theta \tag{4}$$

where output Q is produced with variable capital $K - K^f$, variable labor $L - L^f$ and material M[4]. Θ is the productivity term. $K^f(L^f)$ is the type of capital (labor) which is not adjusted within a period to current demand and cost changes. While $K^v(L^v)$ is the fraction of total capital (labor) which is adjusted to current demand and cost changes without friction. In equation (4), the short-run fixity of capital and labor inputs is allowed for[5]. Data availability precludes an explicit distinction between the two types of capital (labor). Let sv^k and sv^l denote the share of variable capital $K^v/(K^v + K^f)$ and share of variable labor input $L^v/(L^v + L^f)$, respectively, which capture the production technology that firms apply but are unobservable for economists. As will be shown below, the shares can be estimated in the model simultaneously.

Under imperfect competition, the first order condition and Euler's law imply that the output growth is determined by a weighted sum of the input growth and the growth rate of productivity. Input weights are given by the corresponding shares of variable costs in revenue adjusted by markups.

$$\Delta q = \frac{P}{MC}\left(\frac{sv^k RK}{PQ}\Delta k^v + \frac{sv^l WL}{PQ}\Delta l^v + \frac{P^M M}{PQ}\Delta m\right) + \Delta\theta \tag{5}$$

where $\frac{sv^k RK}{PQ}$, $\frac{sv^l WL}{PQ}$ and $\frac{P^M M}{PQ}$ are shares of variable capital cost, variable labor cost and material cost in turnover, respectively. Constant returns to scale implies that the total variable cost is $C^v = MC \cdot Q = sv^k RK + sv^l WL + P^M M$.

As in Hall (1988) the primal Solow residual with revenue-based shares is defined as

$$SRQ^R \equiv \Delta q - \frac{WL}{PQ}\Delta l - \frac{P^M M}{PQ}\Delta m - (1 - \frac{WL}{PQ} - \frac{P^M M}{PQ})\Delta k \tag{6}$$

Substituting equation (5) into equation (6), we get the primal Solow residual with revenue-based shares.

$$\begin{aligned} SRQ^R =& B(\Delta q - \Delta k) + \frac{(1 - sv^l)WL}{PQ}\Delta k + \frac{(sv^l - 1)WL}{PQ}\Delta l + \\ & \frac{sv^k RK}{PQ}(\Delta k^v - \Delta k) + \frac{sv^l WL}{PQ}(\Delta l^v - \Delta l) + (1 - B)\Delta\theta \end{aligned} \tag{7}$$

Following Roeger (1995), we apply the dual price-based Solow residual to eliminate the growth rate of productivity in equation (7). The dual cost minimization problem gives $C^v = \frac{G(W,R,P^M)}{\Theta}Q$ which corresponds to the production function (4). So the marginal cost is $MC = \frac{G(W,R,P^M)}{\Theta}$.

[4] We assume that fixed capital and fixed labor input do not directly enter into production function and they can be treated as overhead costs. All material is variable input.

[5] For instance, because of hiring and firing costs or the presence of trade union, labor cannot be adjusted freely.

Logarithmic differentiation of marginal cost and using Shepard's lemma gives:

$$\Delta p = \frac{P}{MC}\left(\frac{sv^k RK}{PQ}\Delta r + \frac{sv^l WL}{PQ}\Delta w + \frac{P^M M}{PQ}\Delta p^M\right) - \Delta\theta \tag{8}$$

Substituting equation (8) into the dual Solow residual with revenue-based shares defined as equation (9), we obtain equation (10).

$$SRP^R \equiv \frac{WL}{PQ}\Delta w + \frac{P^M M}{PQ}\Delta p^M + (1 - \frac{WL}{PQ} - \frac{P^M M}{PQ})\Delta r - \Delta p \tag{9}$$

$$SRP^R = -B(\Delta p - \Delta r) + \frac{(sv^l - 1)WL}{PQ}\Delta r + \frac{(1 - sv^l)WL}{PQ}\Delta w + (1 - B)\Delta\theta \tag{10}$$

By subtracting (10) from equation (7), the growth rate of productivity is eliminated. The difference of the primal and dual Solow residual with revenue-based shares is,

$$\begin{aligned} SRQ^R - SRP^R =& B[(\Delta q + \Delta p) - (\Delta k + \Delta r)] + \frac{(1 - sv^l)WL}{PQ}(\Delta k + \Delta r) + \\ & \frac{(sv^l - 1)WL}{PQ}(\Delta w + \Delta l) + sv^k\frac{RK}{PQ}(\Delta k^v - \Delta k) + sv^l\frac{WL}{PQ}(\Delta l^v - \Delta l) \end{aligned} \tag{11}$$

The difference of the Solow residual and the price-based dual Solow residual is explained by capital (labor) fixity and imperfect competition[6]. In contrast to equation (3), four extra terms appear in equation (11) which make the prediction of the direction of the estimation bias of Roeger (1995) impossible. The omission of terms $\frac{WL}{PQ}(\Delta k + \Delta r)$ and $\frac{WL}{PQ}(\Delta w + \Delta l)$ leads to a downward bias, while the omission of $\frac{RK}{PQ}(\Delta k^v - \Delta k)$ and $\frac{WL}{PQ}(\Delta l^v - \Delta l)$ leads to an upward bias. In addition, equation (11) cannot be used to estimate B, the average share of fixed capital $sf^k \equiv 1 - sv^k$ and the average share of fixed labor input $sf^l \equiv 1 - sv^l$ either, as the growth rate of variable inputs Δk^v and Δl^v are unobservable in the firm level data. And Δk^v and Δl^v are positively correlated with the growth rate of output, which may lead to an upward bias in the estimate of the price-cost margins using equation (11). In the next section, we try to construct a similar difference of primal and dual Solow residual with cost-weighted shares to eliminate the unobservable terms.

2.3.2 Primal and Dual Solow Residuals with Cost-based Shares

Hall (1990) proposes a cost-weighted TFP measures as a way of avoiding the bias caused by imperfect competition. However, in the presence of fixed inputs, the cost-weighted Solow residual captures not only productivity growth but also the fixity of inputs. In this section, we derive cost-weighted primal and dual Solow residuals allowing for the presence of fixed inputs.

Similarly, the growth rate of output can be written as a cost-weighted average of the growth rate of variable inputs plus the growth rate of productivity.

$$\Delta q = \frac{sv^k RK}{C^v}\Delta k^v + \frac{sv^l WL}{C^v}\Delta l^v + \frac{P^M M}{C^v}\Delta m + \Delta\theta \tag{12}$$

[6] Shapiro (1987) focus on capital fixity to explain why the Solow residual is poorly correlated to the dual Solow residual, while Roeger (1995) stresses imperfect competition in explaining the difference between Solow residual and dual Solow residual.

The primal Solow residual with cost-based shares SRQ^C is defined as follows:

$$SRQ^C \equiv \Delta q - \frac{WL}{C}\Delta l - \frac{P^M M}{C}\Delta m - \frac{RK}{C}\Delta k \tag{13}$$

Substituting equation (12) into equation (13), we have

$$\begin{aligned} SRQ^C =&(1-sv^k)\frac{RK}{C}(\Delta q - \Delta k) + (1-sv^l)\frac{WL}{C}(\Delta q - \Delta l) + \\ & sv^k\frac{RK}{C}(\Delta k^v - \Delta k) + sv^l\frac{WL}{C}(\Delta l^v - \Delta l) + \frac{C^v}{C}\Delta\theta \end{aligned} \tag{14}$$

The dual cost minimization problem implies that the growth rate of price can be written as a cost-weighted average of the growth rate of inputs' prices minus the growth rate of productivity.

$$\Delta p = \frac{sv^k RK}{C^v}\Delta r + \frac{sv^l WL}{C^v}\Delta w + \frac{P^M M}{C^v}\Delta p^M - \Delta\theta \tag{15}$$

The dual Solow residual with cost-based shares is then

$$\begin{aligned} SRP^C &\equiv \frac{RK}{C}\Delta r + \frac{WL}{C}\Delta w + \frac{P^M M}{C}\Delta p^M - \Delta p \\ &= -(1-sv^k)\frac{RK}{C}(\Delta p - \Delta r) - (1-sv^l)\frac{WL}{C}(\Delta p - \Delta w) + \frac{C^v}{C}\theta \end{aligned} \tag{16}$$

By subtracting (16) from equation (14), the growth rate of productivity is eliminated. The difference of the primal and dual Solow residual with cost-based shares is,

$$\begin{aligned} SRQ^C - SRP^C =&(1-sv^k)\frac{RK}{C}[(\Delta q + \Delta p) - (\Delta k + \Delta r)] + (1-sv^l)\frac{WL}{C}[(\Delta q + \Delta p) - (\Delta l + \Delta w)] + \\ & sv^k\frac{RK}{C}(\Delta k^v - \Delta k) + sv^l\frac{WL}{C}(\Delta l^v - \Delta l) \end{aligned} \tag{17}$$

2.3.3 Difference-in-difference Approach

We find that in equation (11) and (17) the unobservable parts are similar except for the denominator. Multiplying both sides of equation (11) by PQ and multiplying both sides of equation (17) by C give:

$$\begin{aligned} (SRQ^R - SRP^R)PQ =&B \cdot PQ[(\Delta q + \Delta p) - (\Delta k + \Delta r)] + (1-sv^l)WL(\Delta k + \Delta r) + \\ & (sv^l - 1)WL(\Delta w + \Delta l) + sv^k RK(\Delta k^v - \Delta k) + sv^l WL(\Delta l^v - \Delta l) \end{aligned} \tag{18}$$

$$\begin{aligned} (SRQ^C - SRP^C)C =&(1-sv^k)RK[(\Delta q + \Delta p) - (\Delta k + \Delta r)] + (1-sv^l)WL[(\Delta q + \Delta p) - (\Delta l + \Delta w)] + \\ & sv^k RK(\Delta k^v - \Delta k) + sv^l WL(\Delta l^v - \Delta l) \end{aligned} \tag{19}$$

By subtracting equation (18) from equation (19), the unobserved parts $sv^k RK(\Delta k^v - \Delta k)$ and $sv^l WL(\Delta l^v - \Delta l)$ can be cancelled out.

$$\begin{aligned} &(SRQ^C - SRP^C)C - (SRQ^R - SRP^R)PQ = \\ &- B \cdot PQ[(\Delta q + \Delta p) - (\Delta k + \Delta r)] + sf^k RK[(\Delta q + \Delta p) - (\Delta k + \Delta r)] + sf^l WL[(\Delta q + \Delta p) - (\Delta k + \Delta r)] \end{aligned} \tag{20}$$

In equation (20), all variables are observable, so equation (20) can easily be estimated with firm level data to obtain the estimates of price-cost margins B, share of fixed capital sf^k and share of fixed labor input sf^l. The parentheses terms on the right side of equation (20) all refer to growth rates of nominal values of output and input factors. Since the left-hand side of equation (20) is the difference of the difference of primal and dual Solow residual with cost-based shares and the difference of primal and dual Solow residual with revenue-based shares, we call it "difference-in-difference" (DID) approach.

3 Data and Variables

3.1 The Data

The data used in this paper are drawn from the Belfirst database collected by Bureau van Dijk. The database includes the full income statements of every Belgian firm that has to report to the tax authorities. We have data of firms active in manufacturing and firms that are active in services and have a panel with observations running from 1999 through 2008. The variables used for the analysis are turnover, number of employees (in full time equivalents), wage bill of full-time equivalents employees, material costs (raw materials, consumables and services) and tangible fixed assets.

Our final sample consists of an unbalanced panel of 9,103 firms operating in manufacturing sectors with a total of 44,253 observations and 61,117 firms operating in service sectors with a total of 239,116 observations (See Appendix A for a detailed description of the dataset and cleaning process). Table 1 provides some summary statistics of the main variables. The median manufacturing firm has 15 employees, 0.404 million Euro tangible fixed assets, earns a revenue of 3.29 million Euro and faces staff cost of 0.58 million Euro per year. Firms in service industries seem to be smaller and have a larger variation. The median service firm has 3 employees, 98 thousand Euro tangible fixed assets, earns a revenue of 0.668 million Euro and faces staff cost of 85 thousand Euro per year.

[Table 1 about here.]

3.2 Capital Cost

The measure of capital cost commonly used in literature is based on Hall and Jorgenson (1967). For capital, we use the book value of the tangible fixed assets. The rental price of capital is based on the standard Hall and Jorgenson (1967) formula: $R = P_I(r - \pi + \delta)$, where P_I denotes the index of investment goods prices, r stands for the nominal interest rate, π is the inflation rate, and δ is the depreciation rate on fixed assets which we assume to be 20% for every sector.

4 Results

4.1 Basic Results

We start by estimating the average price-cost margins for the manufacturing industry as a whole without controlling for fixed inputs using the traditional Roeger approach. The results shown in column (1) and (2) of Table 2 indicate that the average price-cost margin is 0.090, suggesting the average markup is 1.10 for manufacturing firms in Belgium. In column (3) and (4), we apply our new methodology to estimate the average price-cost margins and the average shares of fixed inputs. The fixed effect model gives similar results as OLS. The average price-cost margin is 0.041 which is much lower than the estimate using the traditional Roeger approach. The average share of fixed capital is 28% and the average share of fixed labor input is 7.3%.

[Table 2 about here.]

4.2 Do Profits Cover Fixed Costs?

The estimated price-cost margin using DID approach is much lower than that from Roeger (1995), which gives rise to one concern: is it high enough to cover fixed costs? To address this question, we compare the calculated profit and fixed cost based on the coefficients estimated. The estimated profit is $\hat{\pi} = (P - MC)Q = \hat{B} \times PQ$, and the estimated fixed cost is $\hat{F} = s\hat{f}^k RK + s\hat{f}^l WL$. We define the excess profit margin as $(\hat{\pi} - \hat{F})/PQ$.

Figure 1 shows the kernel probability density estimates of the excess profit margin[7]. The average excess profit margin is 0.0061 in the sample which is consistent with the free entry condition in the market. While around 75% firms make positive excess profits.

[Figure 1 about here.]

4.3 Price-cost Margins, Fixed Costs and Estimation Bias

In this section, we investigate the relation between price-cost margins, fixed costs and estimation bias through estimating equation (20) by sectors. Table 3 shows the estimates of price-cost margins and shares of fixed inputs for each NACE 2-digit manufacturing sector in Belgium. Column (1) reports the price-cost margins estimated by the traditional Roeger approach. Column (2) to (4) show the results estimated by our approach. Here we only focus on the sectors with at least 500 observations in order to obtain statistically reliable results.

[Table 3 about here.]

[7] In order to focus on the shape of distribution, we exclude the smallest 1st percentile and largest 99th percentile observations in the kernel density estimates.

We find that the average price-cost margins vary across sectors. On average, price-cost margins estimated by Roeger (1995) are larger than that estimated by "difference-in-difference" approach for all sectors except three – pulp, paper and paper products; other nonmetallic mineral products; radio, TV, and communication equipment – with significantly higher shares of fixed labor input. The PCM estimated by DID is positively correlated with that by Roeger (1995) with the correlation coefficient of 0.36. The results in column (2) also show that other nonmetallic mineral products, machinery and equipment n.e.c., radio, TV, and communication equipment are among the highest markups sectors.

Regarding the share of fixed capital, the results shown in Table 3 are in line with our expectations, as the share is larger in sectors where we would expect fixed costs to be high. Basic metals (0.86) has the highest share of fixed capital, followed by motor vehicles, trailers, and semi-trailers (0.75), wood, straw, and plaiting materials (0.63), chemicals and chemical products (0.64), and machinery and equipment n.e.c.(0.58). Turning to the share of fixed labor input, 9 out of 18 sectors have significantly positive share of fixed labor input. Radio, TV, and communication equipment has the highest share of fixed labor input (0.34).

As expected, firms with higher fixed costs ($sf^k RK + sf^l WL$) would have higher price-cost margins, i.e., price-cost margins increase with the share of fixed costs in turnover. Figure 2 provides a strong evidence for it. Sectors with higher share of fixed costs in turnover are likely to charge higher markups.

[Figure 2 about here.]

In addition, we are also interested in the relation between the estimation bias and the shares of fixed inputs. Since all estimates vary across sectors, we are able to have rough pictures of them by looking into the estimates by sectors. As discussed in section 2, equation (11) suggests that the bias introduced by ignoring fixed costs is negatively correlated with the share of fixed labor input[8]. However, the relation between the estimation bias and the share of fixed capital is more complex. There should exist an inverted U-shaped relationship between the estimation bias and the share of fixed capital: when the share of fixed capital is 0, $sv^k \frac{RK}{OQ}(\Delta k^v - \Delta k)$ in equation (11) equals to 0, when the share of fixed capital is increased to be 1, $sv^k \frac{RK}{OQ}(\Delta k^v - \Delta k)$ also equals to 0, but if the share of fixed capital falls in the range $(0, 1)$, $sv^k \frac{RK}{OQ}(\Delta k^v - \Delta k)$ is positive which leads to an upward bias. The scatterplot of the bias and the share of fixed capital (share of fixed labor input) is shown in Figure 3. The bias is strongly negatively correlated with the share of fixed labor input, which is in line with our expectation. However, the relation between the bias and the share of fixed capital is weak and not clear.

[Figure 3 about here.]

[8] In equation (11), sf^l is the coefficient of both downward bias terms.

4.4 Different Production Technology: High-tech Manufacturing Sectors

To examine whether different production technology matters in the estimation of markups, manufacturing firms are split into high-technology and low-technology sectors following Eurostat's definition of high-technology, medium high-technology, medium low-technology and low-technology according to technological intensity (see Appendix C for details). Table 4 reports the results for high-tech and low-tech sectors separately. The average price-cost margin for high-tech sectors is 0.047, the average share of fixed capital and the average share of fixed labor input are 43% and 10%, respectively. The results indicate that high-tech manufacturing sectors have higher shares of fixed capital and labor input, and charge higher markups, which are in line with theories.

[Table 4 about here.]

5 An Application: Manufacturing Vs. Service Industries

5.1 A Debate over Service Industries

Since the mid 1990s, the productivity gap between Europe and the United States has increased dramatically: GDP per hour worked in the EU has decreased from 98.3 percent of the U.S. level in 1995 to 90.0 percent in 2006. van Ark, O'Mahony, and Timmer (2008) show that the productivity slowdown in European countries is largely the result of slower productivity growth in service sectors, particularly in trade, finance, and business services[9]. They further argue that the lack of flexibility and competitiveness in labor and product markets in service sectors in the EU is one of the causes of the trend[10]. Desmet and Parente (2010) also suggest that the European service sectors can benefit (productivity gains) from the increase in the competition and spatial concentration in the service sectors. In particular, the network utilities, such as post and telecommunications, air transport, are still highly regulated in Europe. For example, incumbent operators are largely protected from competition in most EU countries through their monopolies or other regulations. So increasing the flexibility in labor market and strengthening the competition in service product markets within and across countries are claimed to be important to improve productivity growth in European service sectors.

Unlike manufacturing, services do not suffer much from international competition because of the nature of services exchange and the restrictiveness of services trade policies, suggesting that there is less competitive pressure in service sector. A number of empirical studies find that service industries have higher markups than manufacturing industry (e.g. Siotis, 2003; Christopoulou and Vermeulen, 2008; Martins, Scarpetta, and Pilat, 1996). Nevertheless, since the 1990s, EU has

[9] That is, productivity levels in manufacturing are relatively similar across countries compared to intermediate services.

[10] The productivity in service sectors is important for the whole economy. First, services account for 70% of GDP and employment in most EU Member States. Second, competition in the Service Sector is a major determinant of the performance of manufacturing firms Francois and Hoekman (2010).

implemented a series of policies to encourage competition between European service producers so as to strengthen competition and foster efficiency in service sectors, for example, the "Single Market" and "Services Directive". However, despite the great efforts made by the EU Commission, Badinger (2007) shows that the markups in most service industries have increased since the early 1990s in EU countries. Hence, if the competition is as low as shown by the estimated markups in service sectors, liberalization and deregulation of services are likely to have a pro-competitive effect. However, this crucially relies on the reliability of the estimation of markups. We therefore apply our new methodology to investigate whether service industries charge high markups after controlling for the fixed factors of production, i.e., the shares of fixed inputs.

5.2 Price-cost margins in Manufacturing and Service Industries

There is large variation in service industries in terms of sales, employment, tangible fixed assets etc.(see Table 1). As shown in Figure 4, the price-cost margins calculated following Collins and Preston (1969) are higher in service sectors, especially the knowledge-intensive services (KIS hereafter), than manufacturing sectors (See Appendix D for the definition of KIS and LKIS). As the fixity of capital input may matter more in KIS, we focus on this sector.

[Figure 4 about here.]

The first two columns in Table 5 show the results using the Roeger (1995) approach, suggesting that the estimated price-cost margin in KIS industries is 0.15, which is almost the double of that in manufacturing industry (0.09). The last two columns in Table 5 report the results using our new approach. The estimated price-cost margin is 0.049, slightly higher than that in manufacturing industry (0.041) but similar as that in high-tech manufacturing sector (0.047). The average share of fixed capital is 0.49, which is much higher than that in manufacturing industry (0.28), but the coefficient of share of fixed labor input is insignificant.

The results in Table 5 imply that the price-cost margins of KIS are overestimated by the traditional approach not taking into account of the fixity of capital, which is high in KIS industries. After controlling for the fixity of inputs, the price-cost margin in KIS industries is only slightly higher than that in manufacturing industry.

[Table 5 about here.]

The KIS sectors have relatively higher markups but also a higher share of fixed capital. We therefore check whether KIS sectors have higher excess profit margins compared to manufacturing sectors. As in Figure 1, we depict the Kernel probability density estimates of the excess profit margin for service sector in Figure 5. The average excess profit margin is -0.0058 in the sample and the left hand tail is longer comparing to the distribution for manufacturing industry. While around 70% of the firms make positive excess profits. Figure 5 suggests that the KIS sectors do not make higher excess profit margins than manufacturing sectors.

[Figure 5 about here.]

6 Conclusions

In this paper, we propose a new methodology to simultaneously estimate the price-cost margins and the shares of fixed inputs extending the work of Hall (1988, 1990) and Roeger (1995). It is superior to traditional approaches in three aspects, first, it allows for the fixity of inputs; second, it relaxes the assumption of constant returns to scale on total factors; third, the shares of fixed inputs can be estimated simultaneously.

Applying the methodology to Belgian firm level data for the period 1999-2008, we find that the average price-cost margin is 0.041 which is much lower than that using traditional approaches, the average share of fixed capital in total capital usage is 0.28 and the average share of fixed labor input in total labor usage is 0.073 for manufacturing firms in Belgium. We also find that firms with a higher share of fixed costs in turnover charge higher markups. Finally, we apply our methodology to firms in services and find that the price-cost margins in service industries are overestimated under the traditional framework because of fixed costs. After controlling for the fixity of inputs, the price-cost margin in knowledge intensive service industries is only slightly higher than that in the manufacturing industry, suggesting production technologies may cause the high markups found in earlier studies, rather than the lack of competition.

A Data Cleaning process

The firm-level data used in this paper are provided by Bureau van Dijk. Firm level data often contains outlier observations that may bias the estimated coefficients. Hence, we carefully clean the original dataset to handle the missing observations and outliers. Several cleaning procedures are applied to the sample:

- We work with unconsolidated accounts only.
- Observations with extreme values (smaller than 1st percentile and larger than 99th percentile) of the variables used in the empirical analysis are dropped, as well as all observations with missing information on some variables and observations that were based on irregular reports or unreasonable data values in the levels of variables (such as negative values of material cost, negative values of staff cost).
- We restrict our data to the manufacturing sector based on NACE Code (15-37) and service sectors based on NACE Rev.1 sectors G to K and sectors M to O.

This leaves us with 33.5 percent of the registered manufacturing firms, accounting on average for about 42.6 percent of aggregated value added in the manufacturing sector, and 18.4 percent of the registered service firms, accounting on average for about 22.7 percent of aggregated value added in the service sectors.

B Definition of Variables

- PQ = Turnover in thousands of Euro
- K = Tangible Fixed Assets
- $P^M M$ = Raw materials, consumables, services and other goods th Euro
- WL = Staff costs of full-time equivalents employees + benefits in addition to wages

C Definition of High-tech and Low-tech manufacturing sectors

[Figure 6 about here.]

D Definition of KIS and LKIS

[Figure 7 about here.]

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Table 1: Summary Statistics for the Sample of Belgian Firms

Industry	Variable	Mean	Median	Std. Dev.
Manufacturing	Turnover	16,202.11	3,287	55,558.64
	Employment	56.18	15	351.64
	Tangible fixed assets	2,331.15	404	8,908.39
	Material Costs	12,665.1	2,145	47,059.43
	Wage bill	2,580.86	580	7,923.93
Service	Turnover	4,620.15	668	21,168.74
	Employment	14.27	3	502.80
	Tangible fixed assets	767.19	98	5,797.15
	Material Costs	3,826.02	441	18,574.19
	Wage bill	552.73	85	2,311.15

Note: Turnover, Tangible fixed asset, material cost and wage bill are expressed in thousands of Euro.

Table 2: Estimation of Price-cost Margins and Shares of Fixed Inputs (Manufacturing)

	Roeger		DID	
	(1) OLS	(2) FE	(3) OLS	(4) FE
$(\Delta p + \Delta q) - (\Delta k + \Delta r)$	0.090***	0.090***		
	(0.0026)	(0.0027)		
$-PQ[(\Delta p + \Delta q) - (\Delta k + \Delta r)]$			0.041***	0.041***
			(0.0031)	(0.0032)
$RK[(\Delta p + \Delta q) - (\Delta k + \Delta r)]$			0.29***	0.28***
			(0.055)	(0.058)
$WL[(\Delta p + \Delta q) - (\Delta k + \Delta r)]$			0.073***	0.073***
			(0.018)	(0.019)
Year dummy	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes
Year dummy × Industry dummy	Yes	Yes	Yes	Yes
Observations	45,235	45,235	44,238	44,238
Nr. of Firms	9,052	9,052	9,103	9,103
R^2	0.16	0.15	0.13	0.12

Note: Robust standard errors adjusted among firms at 4-digit industry and regions at commune level in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 3: Estimates of Price-cost Margins and Shares of Fixed Inputs by Sectors

Code	Description	(1) PCM(Roeger)	(2) PCM	(3) sf^k	(4) sf^l	(5) Obs.
15	Food and Beverages	0.10***	0.018***	0.28**	-0.13***	7,659
		(0.0069)	(0.0050)	(0.11)	(0.044)	
16	Tobacco	0.068**	0.067	-2.26*	0.52	103
		(0.028)	(0.049)	(1.25)	(0.34)	
17	Textiles	0.068***	0.035*	0.12	0.12*	2,211
		(0.014)	(0.012)	(0.23)	(0.068)	
18	Wearing apparel; fur	0.062***	0.030*	-0.37	0.15	894
		(0.016)	(0.016)	(0.27)	(0.14)	
19	Leather, luggage, and footwear	0.12***	0.087***	1.82***	0.21	110
		(0.020)	(0.0060)	(0.24)	(0.12)	
20	Wood, straw, and plaiting materials	0.096***	0.077***	0.63**	0.074	1,631
		(0.013)	(0.028)	(0.17)	(0.13)	
21	Pulp, paper, and paper products	0.058***	0.080**	0.26	0.28**	960
		(0.021)	(0.017)	(0.28)	(0.13)	
22	Publishing, printing, and media	0.11***	0.083***	0.25	0.24***	4,440
		(0.0083)	(0.016)	(0.21)	(0.082)	
23	Coke, refined petroleum products, nuclear fuel	0.043*	-0.0025	-0.040	-0.13	114
		(0.025)	(0.0057)	(0.28)	(0.12)	
24	Chemicals and chemical products	0.086***	0.038***	0.50**	0.0066	2,629
		(0.011)	(0.010)	(0.21)	(0.091)	
25	Rubber and plastic products	0.079***	0.055***	0.39**	0.12	1,799
		(0.015)	(0.012)	(0.18)	(0.077)	
26	Other nonmetallic mineral products	0.083***	0.090***	0.36*	0.22***	2,994
		(0.012)	(0.024)	(0.22)	(0.077)	
27	Basic metals	0.097***	0.057***	0.86***	0.14**	1,310
		(0.014)	(0.012)	(0.31)	(0.077)	
28	Fabricated metal products	0.092***	0.053***	0.21	0.12**	7,114
		(0.0063)	(0.011)	(0.15)	(0.047)	
29	Machinery and equipment n.e.c.	0.095***	0.085**	0.58***	0.21***	3,204
		(0.0081)	(0.010)	(0.23)	(0.052)	
30	Office machinery and computers	0.028	0.057	-0.45	0.29	275
		(0.031)	(0.037)	(1.11)	(0.26)	
31	Electrical machinery and apparatus n.e.c.	0.090***	0.059***	0.039	0.20**	1,089
		(0.016)	(0.019)	(0.47)	(0.091)	
32	Radio, TV, and communication equipment	0.078***	0.090***	-0.22	0.34***	722
		(.027)	(0.022)	(0.54)	(0.10)	
33	Medical, precision, and optical instruments	0.095*	0.078***	0.55*	0.21	1,068
		(0.018)	(0.025)	(0.31)	(0.13)	
34	Motor vehicles, trailers, and semi-trailers	0.056***	-0.0087	0.75***	-0.091	556
		(0.017)	(0.014)	(0.42)	(0.13)	
35	Other transport equipment	0.12***	0.041**	0.24	-0.0056	369
		(0.014)	(0.018)	(0.32)	(0.081)	
36	Furniture, manufacturing n.e.c.	0.069***	0.025**	-0.023	0.010	2,437
		(0.0090)	(0.011)	(0.31)	(0.058)	
37	Recycling	0.10***	0.031*	0.19	-0.20	550
		(0.020)	(0.016)	(0.32)	(0.18)	

Note: Robust standard errors adjusted among firms at 4-digit industry and regions at commune level in parentheses.
* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 4: Different Production Technology: High-tech & Low-tech

	Low-tech		High-tech	
	(1)OLS	(2)FE	(3)OLS	(4)FE
$-PQ[(\Delta p + \Delta q) - (\Delta k + \Delta r)]$	0.039^{***}	0.038^{***}	0.048^{***}	0.047^{***}
	(0.0033)	(0.0036)	(0.0066)	(0.0067)
$RK[(\Delta p + \Delta q) - (\Delta k + \Delta r)]$	0.28^{***}	0.23^{***}	0.36^{*}	0.43^{**}
	(0.058)	(0.064)	(0.13)	(0.13)
$WL[(\Delta p + \Delta q) - (\Delta k + \Delta r)]$	0.048^{**}	0.057^{**}	0.12^{***}	0.10^{***}
	(0.021)	(0.021)	(0.037)	(0.038)
Year dummy	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes
Year dummy × Industry dummy	Yes	Yes	Yes	Yes
Observations	34,491	34,491	9,747	9,747
R^2	0.138	0.133	0.120	0.108

Note: Robust standard errors adjusted among firms at 4-digit industry and regions at commune level in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 5: Price-cost Margins in Knowledge-intensive services (KIS)

	Roeger		DID	
	(1)OLS	(2)FE	(3)OLS	(4)FE
$(\Delta p + \Delta q) - (\Delta k + \Delta r)$	0.15^{***}	0.15^{***}		
	(0.0031)	(0.0033)		
$-PQ[(\Delta p + \Delta q) - (\Delta k + \Delta r)]$			0.050^{***}	0.049^{***}
			(0.0044)	(0.0046)
$RK[(\Delta p + \Delta q) - (\Delta k + \Delta r)]$			0.49^{***}	0.49^{***}
			(0.028)	(0.030)
$WL[(\Delta p + \Delta q) - (\Delta k + \Delta r)]$			-0.00084	-0.0029
			(0.016)	(0.017)
Year dummy	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes
Year dummy × Industry dummy	Yes	Yes	Yes	Yes
Observations	68,002	68,002	64,584	64,584
Nr. of Firms	18,720	18,720	18,715	18,715
R^2	0.22	0.22	0.12	0.12

Note: Robust standard errors adjusted among firms at 4-digit industry and regions at commune level in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

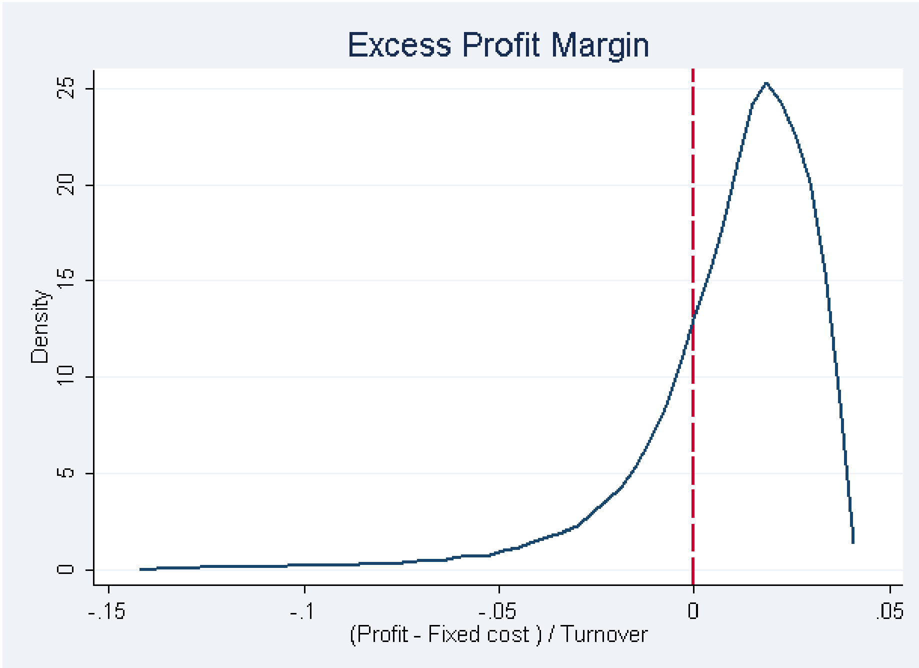

Figure 1: The Kernel Density Estimates of Excess Profit Margin (Manufacturing)

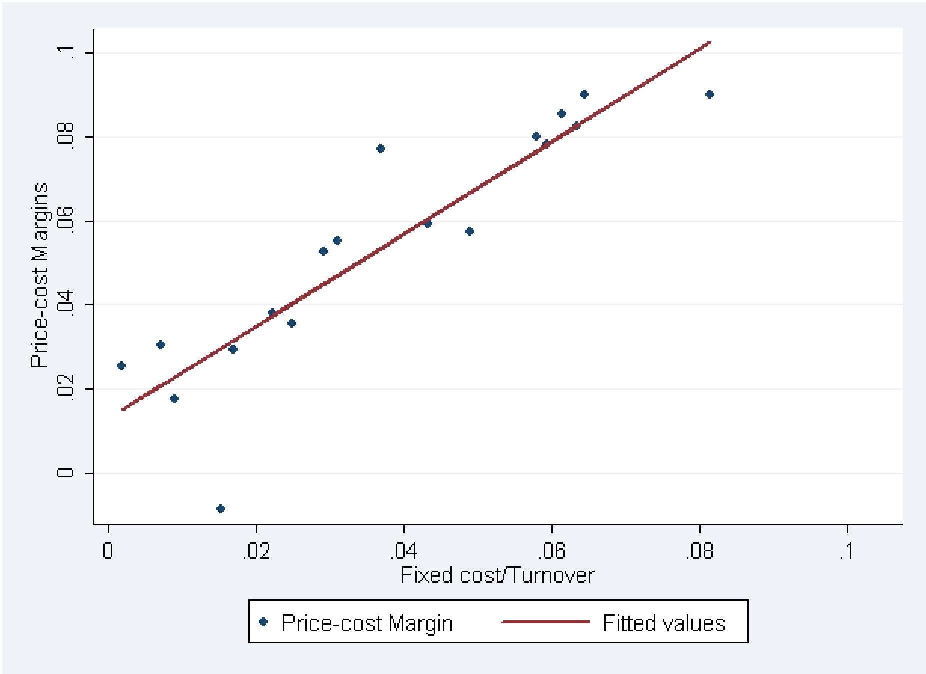

Figure 2: Price-cost Margins and the Share of Fixed Costs in Turnover

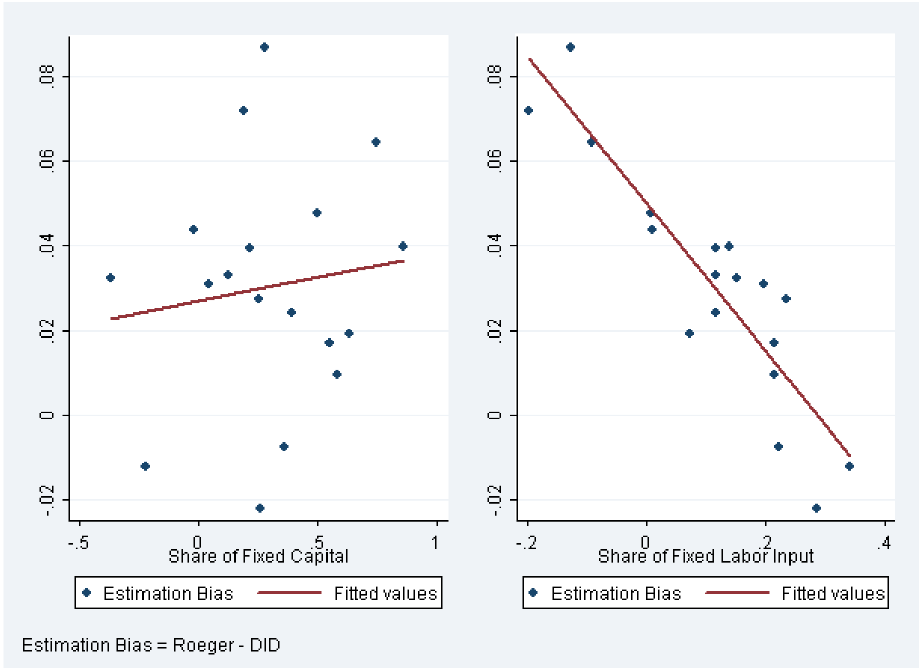

Figure 3: The Estimation Bias and the Shares of Fixed Inputs

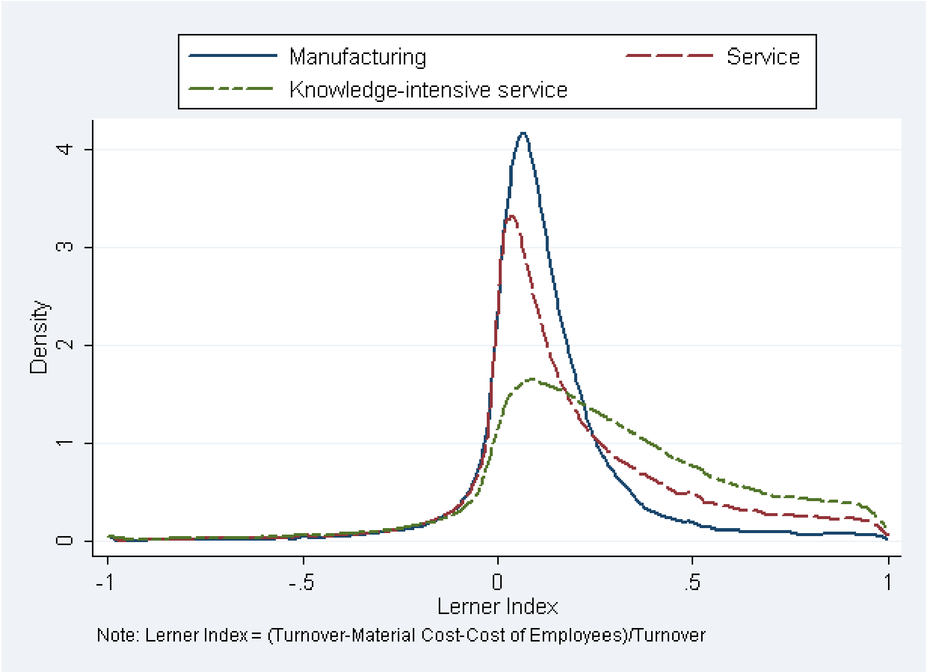

Figure 4: Sectoral Difference in Lerner Index

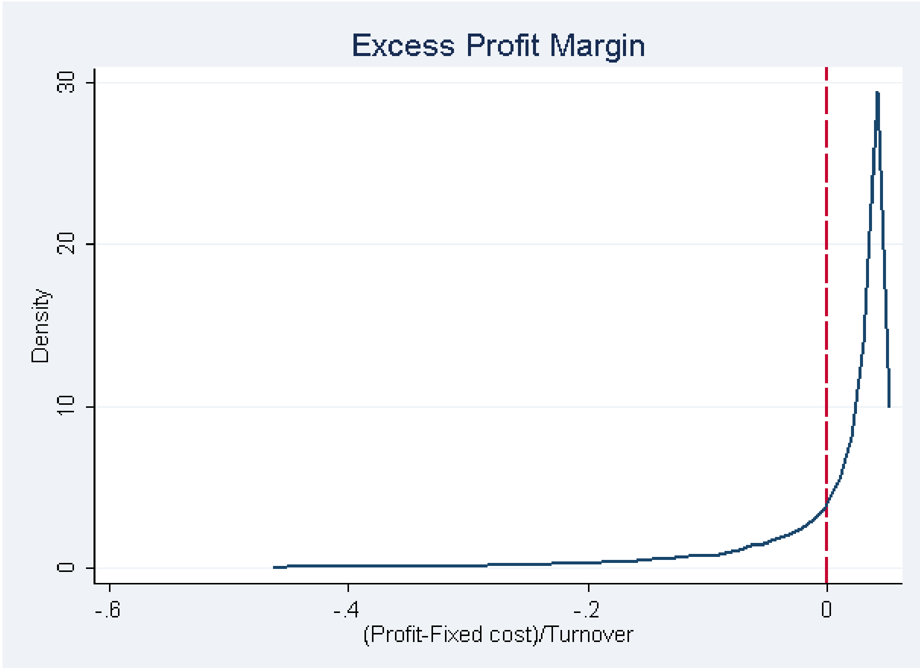

Figure 5: Excess Profit Margin Kernel Density Estimates (KIS)

Manufacturing industries	NACE Rev 1.1 codes
High-technology	**24.4** Manufacture of pharmaceuticals, medicinal chemicals and botanical products; **30** Manufacture of office machinery and computers; **32** Manufacture of radio, television and communication equipment and apparatus; **33** Manufacture of medical, precision and optical instruments, watches and clocks; **35.3** Manufacture of aircraft and spacecraft
Medium-high-technology	**24** Manufacture of chemicals and chemical product, **excluding 24.4** Manufacture of pharmaceuticals, medicinal chemicals and botanical products; **29** Manufacture of machinery and equipment n.e.c.; **31** Manufacture of electrical machinery and apparatus n.e.c.; **34** Manufacture of motor vehicles, trailers and semi-trailers; **35** Manufacture of other transport equipment, **excluding 35.1** Building and repairing of ships and boats **and excluding 35.3** Manufacture of aircraft and spacecraft.
Medium-low-technology	**23** Manufacture of coke, refined petroleum products and nuclear fuel; **25 to 28** Manufacture of rubber and plastic products; basic metals and fabricated metal products; other non-metallic mineral products; **35.1** Building and repairing of ships and boats.
Low-technology	**15 to 22** Manufacture of food products, beverages and tobacco; textiles and textile products; leather and leather products; wood and wood products; pulp, paper and paper products, publishing and printing; **36 to 37** Manufacturing n.e.c.

Figure 6: Breakdown of NACE manufacturing sectors depending on their technological intensity

Knowledge based services	NACE Rev 1.1 codes
Knowledge-intensive services (KIS)	**61** Water transport; **62** Air transport; **64** Post and telecommunications; **65 to 67** Financial intermediation; **70 to 74** Real estate, renting and business activities**;** **80** Education; **85** Health and social work; **92** Recreational, cultural and sporting activities
High-tech KIS	**64** Post and telecommunications; **72** Computer and related activities; **73** Research and development.
Market KIS (excl. financial intermediation and high-tech services)	**61** Water transport; **62** Air transport; **70** Real estate activities; **71** Renting of machinery and equipment without operator and of personal and household goods; **74** Other business activities.
Less Knowledge-intensive Services (LKIS)	**50 to 52** Motor trade; **55** Hotels and restaurants; **60** Land transport; transport via pipelines; **63** Supporting and auxiliary transport activities; activities of travel agencies; **75** Public administration and defence; compulsory social security; **90** Sewage and refuse disposal, sanitation and similar activities; **91** Activities of membership organization n.e.c.; **93** Other service activities; **95 to 97** Activities of households; **99** Extra-territorial organizations and bodies
Market services less KIS	**50 to 52** Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods; **55** Hotels and restaurants; **60** Land transport; transport via pipelines; **63** Supporting and auxiliary transport activities; activities of travel agencies.

Figure 7: Breakdown of NACE service sectors depending on their technological intensity