

Rethinking productivity measures in case of exporters

Anže Burger* Jože P. Damijan[†] Črt Kostevc[‡] Sašo Polanec[§]

Abstract

This paper extends recent work by Martin (2005) on estimation of total factor productivity by allowing heterogeneity of markets in terms of competitive pressure. We show that conventional methods yield biased measures of TFP when firms charge market specific prices. Using matched accounting-foreign trade data for Slovenian manufacturing firms, we show that firms charge higher markups in domestic market, which may be accounted by home-bias. These results imply that TFP of exporting firms is lower if heterogeneity of markups is not accounted for. Moreover, this evidence also provides an explanation why empirical studies failed to find any evidence on the learning-by-exporting hypothesis.

JEL classification: C14, D24, L11, L25

Keywords: Productivity measurement, Imperfect competition, Exporting

*Faculty of Social Sciences, University of Ljubljana. E-mail: anze.burger@fdv.uni-lj.si.

[†]Faculty of Economics, University of Ljubljana. E-mail: joze.damijan@ef.uni-lj.si.

[‡]Faculty of Economics, University of Ljubljana. E-mail: crt.kostevc@ef.uni-lj.si.

[§]Faculty of Management, University of Primorska. E-mail: polanec@iue.it.

1 Introduction

The debate on accurate measurement of total factor productivity (TFP) has been a mainstay in applied econometrics ever since Marschak and Andrews (1944) published their seminal paper. The ensuing literature raised important issues, ranging from endogeneity of factor inputs and sample selection to measurement and misspecification, many of which are yet to be unequivocally resolved. This paper continues this tradition and deals with the issue of measurement of TFP when firms face different degrees of competition in different markets. We develop an estimation method for TFP when firms supply domestic and foreign markets. Working along the lines of recent contributions in productivity estimation for multi-product firms, we show that application of conventional techniques may give biased estimates of productivity measures.¹ Given observed lower markups in foreign markets, the bias of measured productivity is negative for exporting firms.

The key results of this paper are derived in a framework suggested by Klette and Griliches (1996). They argued that productivity in differentiated goods markets cannot be estimated independently of markups and scale economies when deflated firm revenue is used as a proxy for output. In differentiated goods industries use of deflated sales as an output proxy will lead to a downward bias of the estimates of economies of scale. The application of their approach to estimates of productivity was left to Melitz (2001), who shows that the true productivity differences will also be understated when firms can affect prices. In addition, he notes that, assuming exporting markups are lower than those attainable in the domestic market, the bias would be accentuated in the case of exporting firms. Based on the propositions in Melitz (2001) and Martin (2005), we provide a basic model of production that enables us to evaluate the direction and the size of the productivity bias as well as provide an estimation approach that could serve to control for the set bias. This paper also provides an application of proposed method based on a sample of Slovenian manufacturing firms. The results not only confirm the conjecture that firms can charge higher markups in domestic markets, but also rankings of markups across foreign markets. We find that markups in domestic market are the highest, followed by markups in historically important, but less developed, markets on the ground of ex-Yugoslavia and markups in EU. These systematic variations in markups across different markets justify the calculation of total factor productivity that takes into account this source of heterogeneity. Hence productivity of exporting firms is in fact larger than the productivity of domestic firms and may also explain why researchers so rarely confirm the hypothesis of learning by exporting for new exporting firms.

The remainder of the paper is organized as follows. We start with description of the monopolistically competitive model with multiple markets and derive the key relations between productivity, markups and foreign markets exposure. In the third section we discuss the determinants of the size of bias. The fourth section discusses the data on Slovenian manufacturing firms and descriptive statistics, while the fifth section discusses measurement issues and estimates of markups for Slovenian manufacturing firms. Concluding remarks are made in the last section.

¹At the same time overestimating the actual productivity of non-exporters.

2 Model

Theoretical framework for productivity estimation of exporting firms is developed along the lines of work by Klette and Griliches (1996), Klette (1999), Melitz (2001) and Martin (2005). Firms are assumed to be monopolistic competitors who produce according to increasing returns to scale production function. Our extension introduces multiple markets in which firms face different degrees of competition modeled as differences in elasticity of substitution. These differences in elasticity of substitution imply variation of markups across markets. Given observed higher markups in domestic markets, we show that standard productivity measurement may give downward bias for exporting firms. Let us now turn to exposition of the modeling framework.

Throughout the paper, we assume that the total number in each industry is large and that firms take factor prices as given. While we do not model explicitly the transport costs, their introduction is straightforward and does not change the substantive nature of our results.²

The representative consumer in country is assumed to pursue the following constant elasticity of substitution utility function

$$U^m = \left(\sum_{i=1}^{N_m} (\Lambda_i Q_{it})^{(\sigma^m-1)/\sigma^m} \right)^{\sigma^m/(\sigma^m-1)}, \quad (1)$$

where Q_{it} denotes consumption of firm i 's variety in period t , Λ_i is the representative consumer's valuation of firm i 's product quality and σ^m is elasticity of substitution in market m . This type of utility function gives the conditional demand functions for domestic (h) and foreign markets (f). Allowing for differences in elasticities of substitution in different markets, the demand functions and price to marginal cost markups also differ. For simplicity, producers are assumed to supply the same quality level in domestic and foreign markets.

The standard consumer utility maximization problem subject to the budget constraint gives the demand functions that firms face in domestic and foreign markets

$$\begin{aligned} Q_{it}^h &= \Lambda_{it}^{\sigma^h-1} \left(P_{it}^h / \tilde{P}_t^h \right)^{-\sigma^h} \left(R_t^h / \tilde{P}_t^h \right), \\ Q_{it}^f &= \Lambda_i^{\sigma^f-1} \left(P_{it}^f / \tilde{P}_t^f \right)^{-\sigma^f} \left(R_t^f / \tilde{P}_t^f \right). \end{aligned} \quad (2)$$

where the quality adjusted price indices \tilde{P}_t^h and \tilde{P}_t^f are defined as

$$\begin{aligned} \tilde{P}_t^h &= \left(\sum_{i=1}^{N_h} (P_{it}^h / \Lambda_i)^{1-\sigma^h} \right)^{1/(1-\sigma^h)}, \\ \tilde{P}_t^f &= \left(\sum_{i=1}^{N_f} (P_{it}^f / \Lambda_i)^{1-\sigma^f} \right)^{1/(1-\sigma^f)}. \end{aligned} \quad (3)$$

In profit maximization, the firm producing variety i transforms inputs into output according to the following general production function

²The costs of transportation to different markets may have direct impact on estimation of markups. For example, firms that export to more distant markets may exhibit lower profitability due to higher transport costs. However, since we do not have information on transport costs, we neglect this aspect in this paper.

$$Q_{it} = A_{it} [f(\mathbf{X}_{it})]^\gamma. \quad (4)$$

Here $f(\cdot)$ is a standard linearly homogenous function, A_{it} is a Hicks neutral productivity index (TFP) and \mathbf{X}_{it} is a vector of factor inputs. If γ is above (below) one, the production function exhibits increasing (decreasing) returns to scale. The profit maximization of firm i under the above demand function (2) gives the following first order conditions

$$\begin{aligned} P_{it}^h \gamma \frac{Q_{it}}{f(\mathbf{X}_{it})} f_X(\mathbf{X}_{it}) &= \mu_t^h W_{Xt}, \\ P_{it}^f \gamma \frac{Q_{it}}{f(\mathbf{X}_{it})} f_X(\mathbf{X}_{it}) &= \mu_t^f W_{xt}, \end{aligned} \quad (5)$$

where μ_t^h and μ_t^f denote markups in domestic and foreign markets respectively and W_{Xt} denotes price of production factor X . The markups are determined by elasticity of demand in respective markets

$$\mu_t^h = \frac{1}{1 - 1/\sigma_t^h} \quad \mu_t^f = \frac{1}{1 - 1/\sigma_t^f}. \quad (6)$$

and imply the standard relationship between prices that monopolistic firms charge in different markets

$$\frac{P_{it}^h}{\mu_t^h} = \frac{P_{it}^f}{\mu_t^f} \quad (7)$$

For the production function (4), we define output elasticity to factor X as

$$\alpha_X = \gamma \frac{f_X(\mathbf{X}_{it}) X_{it}}{f(\mathbf{X}_{it})},$$

which combined with the first order conditions in (5) gives the relationship between cost and revenue shares

$$\alpha_X = \mu_t^h \frac{W_{Xt} X_{it}}{P_{it}^h Q_{it}} = \mu_t^f \frac{W_{Xt} X_{it}}{P_{it}^f Q_{it}} = \mu_t^h s_{Xit}^h = \mu_t^f s_{Xit}^f. \quad (8)$$

Here s_{Xit}^m denotes the share of factor X in revenue generated in both markets evaluated at either foreign or domestic price. Since prices that firms charge in different markets are typically not observed, the denominators in (8) can not be determined. Instead, the data contain information on total revenues generated on domestic and foreign markets is observed. Using these as proxies for the denominators in (8), we get

$$\mu_{it}^h \frac{W_{xt} X_{it}}{P_{it}^h Q_{it}^h + P_{it}^f Q_{it}^f} = \mu_{it}^h \frac{W_{xt} X_{it}}{P_{it}^h Q_{it} \left[(1 - ex_{it}) + \left(\mu_{it}^f / \mu_{it}^h \right) ex_{it} \right]} = \frac{\mu_{it}^h}{(1 - ex_{it}) + \left(\mu_{it}^f / \mu_{it}^h \right) ex_{it}} s_{Xit}^h. \quad (9)$$

Here ex denotes the share of exports in total output, Q_{it}^f / Q_{it} .³ This expression gives biased factor elasticities α_X . Anticipating our empirical results on lower markups in

³More often than not in empirical applications this ratio cannot be measured and has to be approximated by revenue shares. This issue is discussed further below.

foreign markets, the expected direction of this bias is positive. Hence the estimates of domestic markups are too low for exporting firms.

In order to eliminate sector specific factors, such as expenditure and price index from estimation, we transform the production function in (4) as deviations from the median plant

$$q_{it} = a_{it} + \sum_X \alpha_X x_{it} \quad (10)$$

where

$$\alpha_x = \gamma f_x(\bar{\mathbf{X}}_{it}) \frac{\bar{X}_{it}}{f(\bar{\mathbf{X}}_{it})} \quad (11)$$

and $f_X(\cdot)$ denotes the partial derivative of $f(\cdot)$ with respect to factor X , $\bar{\mathbf{X}}_{it}$ is some point in the convex hull spanned by \mathbf{X}_{it} and $\mathbf{X}_{Median,t}$ and all lower case letters denote log deviations from the median plant in terms of revenue; e.g. $q_{it} = \ln Q_{it} - \ln Q_{Median,t}$. The assumption of linear homogeneity implies that factor elasticities sum to γ . Using (10), we get

$$q_{it} = a_{it} + \mu_t^h v_{it} + \gamma k_{it} + \mu_{it}^h \varsigma_{it} \quad (12)$$

where v_{it} is an index of all variable factors weighted by respective revenue shares

$$v_{it} = \sum_{x \neq k} \bar{s}_{Xit}^h (x_{it} - k_{it}) \quad (13)$$

and ς_{it} is an iid error introduced by the fact that the first order conditions might not hold exactly. Following the mean value theorem, \bar{s}_{Xit}^h is the factor share prevailing at some point in the convex hull spanned by \mathbf{X}_{it} and $\mathbf{X}_{Median,t}$. If we subscribe to the common practice in productivity analysis⁴ and approximate the implied factor share by the average factor share at plant i and the share at the median plant, we can write \bar{s}_{Xit}^h as

$$\bar{s}_{Xit}^h \approx \frac{s_{Xit}^h + s_{X,Median,t}^h}{2} \quad (14)$$

Using the definition of firm revenue (in logged deviations from the median) for the two markets $r_{it} = q_{it} + p_{it}$ and the demand functions (2) to eliminate the plant level prices

$$r_{it}^h = \frac{1}{\mu_t^h} q_{it}^h + \frac{1}{\mu_t^h} \lambda_{it} \quad (15)$$

$$r_{it}^f = \frac{1}{\mu_t^f} q_{it}^f + \frac{1}{\mu_t^f} \lambda_{it} \quad (16)$$

one could then obtain total revenues.

Using equations 15 and 16, we can write the relationship between the log deviation of total revenues from median firm as

$$r_{it} = r_{it}^h + \ln \left(\frac{1 + (\mu_t^f / \mu_t^h) ex_{it} / (1 - ex_{it})}{1 + (\mu_{Med,t}^f / \mu_{Med,t}^h) ex_{Med,t} / (1 - ex_{Med,t})} \right). \quad (17)$$

⁴for example Baily et al. (1992) and Martin (2005). A similar solution is implied in Criscuolo and Leaver (2005).

Replacing domestic revenues by 12 and 15 and assuming time invariant markups yields⁵

$$r_{it} = 1/\mu^h (a_{it} + \mu^h v_{it} + \mu^h \varsigma_{it} + \gamma k_{it}) + (1/\mu^h) \lambda_{it} + \quad (18)$$

$$+ \ln \left[\left(\frac{1 - ex_{it}}{1 - ex_{Med,t}} \right)^{\frac{1}{\mu^h}} \left(\frac{\mu^h + \mu^f ex_{it}/(1 - ex_{it})}{\mu^h + \mu^f ex_{Med,t}/(1 - ex_{Med,t})} \right) \right]$$

Following Martin (2005), we define the measured TFP (MTFP) as

$$MTFP_{it} = r_{it} - v_{it} = \left(\frac{\gamma}{\mu^h} - 1 \right) k_{it} + \frac{1}{\mu^h} (a_{it} + \lambda_{it}) + \varsigma_{it} + \quad (19)$$

$$+ \ln \left[\left(\frac{1 - ex_{it}}{1 - ex_{Med,t}} \right)^{\frac{1}{\mu^h}} \left(\frac{\mu^h + \mu^f ex_{it}/(1 - ex_{it})}{\mu^h + \mu^f ex_{Med,t}/(1 - ex_{Med,t})} \right) \right]$$

which can, by introducing a new variable ω_{it} ,

$$\omega_{it} = \frac{1}{\mu^h} (a_{it} + \lambda_{it}) \quad (20)$$

be rewritten as

$$MTFP_{it} = \left(\frac{\gamma}{\mu^h} - 1 \right) k_{it} + \omega_{it} + \varsigma_{it} + \ln \left[\left(\frac{1 - ex_{it}}{1 - ex_{Med,t}} \right)^{\frac{1}{\mu^h}} \left(\frac{\mu^h + \mu^f ex_{it}/(1 - ex_{it})}{\mu^h + \mu^f ex_{Med,t}/(1 - ex_{Med,t})} \right) \right] \quad (21)$$

This expression shows the relationship between actual productivity and the standard measure of productivity. The first term on the right-hand side shows that measured TFP is biased if returns to scale differ from markups. If the parameter for returns to scale exceeds the markup, the bias for firms larger than the median firm in terms of physical capital is positive and vice versa. This bias has already been established in Martin (2005). The novelty of this paper is the bias in measures of productivity that stem from the difference in markups across different markets. In the light of the evidence given below, the markups in domestic market exceed those in foreign markets. This is reflected in the last term in the right-hand side of equation (21). If the median firm is a non-exporter, then for all exporting firms this term would be negative and thus the measured TFP would be downward biased. If on the other hand the median firm is an exporter, then for firms with share of exports below that of the median firm the measured TFP would be upward biased and for firms with share of exports above that of the median firm the measured TFP would be downward biased.

⁵Note also that the logged quantity of goods sold in the domestic (in terms of deviation from the median) can be expressed as

$$q_{it}^h = \ln \left(\frac{1 - ex_{it}}{1 - ex_{Med,t}} \right) + q_{it}$$

3 Data

The accuracy of TFP estimates generally depends on the quality of the data. This is also important for the proposed method of estimation as there is substantial variation of markups across foreign markets. Typically the standard balance sheet data contain only information on aggregate domestic and foreign sales, which is not sufficient to eliminate the bias in measured TFP. For this reason, we use matched accounting-foreign trade data for 6,987 Slovenian manufacturing (NACE-2 digit sectors 15-37) operating during the period 1994-2002.⁶

Table 1 summarizes basic descriptive statistics for our sample of active firms.⁷ Among 5,034 active firms in 2002 as many as 3,026 were engaged in exports. In line with evidence for other countries, typical features of exporters and non-exporters are very different. In 2002, average employment of exporters was 66 workers, while average non-exporting firm employed only 6 workers. In the same year, the average sales of exporters was almost sixteen times higher than that of non-exporters. More importantly, we also find that exporters have 35 percent productivity advantage and 42 percent higher capital intensity. These features are not typical only for the latest available period of our data, but are very similar for early transition as well. We show this in Table 1, where we summarize the basic statistics for 1994. Nevertheless, it is important to note that dynamics of our sample is typical of any transition country. After deregulation of entry in 1988, the number of active firms increased substantially. Only during the period between 1994 and 2002, there was a 50 percent increase in total number of firms.⁸ Since size distributions of entering firms differ substantially from those of surviving firms, average size of firms declined by 35 percent. At the same time, there was an intensive process of productivity growth with average real annual growth rates around 8 percent (Polanec, 2006).

Table 1: Some descriptive statistics for 1994 and 2002

Variable \ Year	1994		2002	
	All	Exporters	All	Exporters
Sample				
Number of firms	3358	1987	5034	3026
Average # of employees	64,9	105,0	42,3	66,3
Average sales	411	672	753	1205
Average labor productivity	2067	2197	4737	5280
Average capital intensity	3599	3804	8374	9484

Notes: i) Average sales, labor productivity and capital intensity are given in thousand SIT and calculated in current prices

Source: Bank of Slovenia and authors' own calculations.

Exporters and non-exporters do not differ only in terms of size and productivity, but also in terms of markups. As was shown in theoretical exposition of proposed method for TFP measurement, these differences may lead to bias in measured productivity. In

⁶The data were kindly provided by the Bank of Slovenia.

⁷An active firm must satisfy the following three conditions: (i) employ at least one worker, (ii) engage a positive amount of physical capital and (iii) produce positive value added.

⁸The dynamics of firm size distribution is explored in Polanec (2006).

particular, if markups in foreign markets are lower than markups in domestic market, we should expect that productivity of exporters downward biased.

A simple comparison of markups across two sets of firms is subject to many caveats. Since exporters are larger firms with higher capital intensity and labor productivity, not controlling for these differences may yield biased estimates of markups. Nevertheless, in Table 2 we report the average markups for two sets of firms. In calculation we follow Roeger (1995) and approximate markups with the following ratio

$$markup_{it} = \frac{R_{it} - C_{it}}{R_{it}},$$

where C_{it} denotes the total costs in firm i in period t . Table 2 contains three measures of mean values: median, unweighted and weighted average. Unweighted average is denoted by average and weighted average by the shares in aggregate sales is denoted by aggregate. Not surprisingly, these measures give conflicting results. While weighted average of markups is consistently lower for exporters, the opposite is true for unweighted markups. Moreover, comparison of markups for median firms shows time varying pattern of rankings. That is, until 1999 the median non-exporter had higher markup. The standard deviations of markups reported in fifth and ninth columns confirm greater dispersion of markups for small firms. Given low information value to comparison of markups for exporters and non-exporters, we do not report mean markups for firms supplying different foreign markets.

Table 2: Markups of exporting and non-exporting firms, 1994-2002

Year \ Sample	Non-exporters				Exporters			
Measure	Median	Average	Aggregate	SD	Median	Average	Aggregate	SD
1994	0.0169	-0.0043	-0.0057	0.1834	0.0037	-0.0172	-0.0185	0.1304
1995	0.0122	-0.0228	-0.0093	0.1937	0.0013	-0.0273	-0.0306	0.1391
1996	0.0151	-0.0334	0.0118	0.2330	0.0098	-0.0188	-0.0133	0.1575
1997	0.0201	-0.0110	0.0188	0.1862	0.0184	-0.0012	0.0076	0.1371
1998	0.0182	-0.0183	0.0082	0.1974	0.0161	-0.0037	0.0011	0.1354
1999	0.0205	-0.0187	0.0155	0.2136	0.0187	-0.0016	0.0134	0.1404
2000	0.0178	-0.0259	0.0221	0.2029	0.0179	-0.0016	0.0126	0.1409
2001	0.0178	-0.0209	0.0181	0.2032	0.0211	-0.0005	0.0110	0.1425
2002	0.0141	-0.0185	0.0187	0.2052	0.0224	0.0011	0.0140	0.1473
Average	0.0167	-0.0195	0.0119	0.2031	0.0151	-0.0069	0.0121	0.1419

Notes: Average markups are calculated as unweighted averages of firm-level markups. Aggregate markups are calculated as weighted average (weights are shares in aggregate sales) of firm-level markups. SD denotes standard deviation of markups.

Source: Bank of Slovenia and authors' own calculations.

4 Estimation procedure and results

4.1 Measurement of variables

In equation 21, we have shown that standard approach to measurement of TFP may give biased estimates. As already derived by Martin (2005), bias in traditional TFP decompo-

sitions may arise if we fail to account for economies of scale and wedge between marginal costs and prices (markups). Our work is a natural extension of Martin’s framework by introducing distinction between domestic and foreign markets. In such framework, the bias in standard measure of TFP has additional term that depends on the difference in markups across markets and shares of foreign market sales. Although, this extension seems innocuous, it has important consequences for the measured productivity dynamics after firms become exporters and could account for persistent lack of empirical evidence on the learning-by-exporting hypothesis due to underestimated productivity of exporters.

The quality of estimates obtained from our estimation procedure depends on measurement of relevant variables. The procedure relies on two variables that are not directly observable: i) share of exported output (ex) and ii) factor share in revenues evaluated at either domestic (s_X^h) or foreign prices (s_X^f). Hence, in order to estimate TFP, we need to rely on proxy variables. The most obvious choice of proxy for the share of exported output is the share of exports in total sales, denoted \widetilde{ex} . In addition to physical quantities, this ratio also reflects prices charged in different markets, which introduces a new source of bias in estimation of TFP evident from the following relationship

$$\widetilde{ex}_{it} = \frac{R_{it}^f}{R_{it}^f + R_{it}^h} = \frac{Q_{it}^f P_{it}^f}{Q_{it}^f P_{it}^f + Q_{it}^h P_{it}^h} = \frac{Q_{it}^f}{Q_{it}^f + Q_{it}^h} \frac{(Q_{it}^f + Q_{it}^h) P_{it}^f}{Q_{it}^f P_{it}^f + Q_{it}^h P_{it}^h} = ex_{it} \frac{Q_{it}^f + Q_{it}^h}{Q_{it}^f + Q_{it}^h \frac{\mu_{it}^h}{\mu_{it}^f}} \quad (22)$$

This expression suggests that for firms with higher markups and thus higher prices charged in domestic markets, the estimated export share is downward biased and vice versa.

The proxy for the factor share in revenues evaluated at domestic or foreign prices can be proxied by the factor share in total sales evaluated at prices set in different markets (see equation 9). The extent of bias depends on the export share and the ratio of relative markups

$$\widetilde{s}_{Xit} = \frac{\mu_{it}^h}{(1 - ex_{it}) + \left(\mu_{it}^f / \mu_{it}^h\right) ex_{it}} s_{Xit}^h \quad (23)$$

For firms with higher domestic markups, the factor share in total revenues is upward biased and vice versa. If, alternatively, we base the approximation of factor shares on revenue evaluated at exporting prices instead of domestic as is suggested in (9), one would obtain upward biased estimates of foreign markups

$$\widetilde{s}_{Xit} = \frac{\mu_{it}^f}{(\mu_{it}^h / \mu_{it}^f) (1 - ex_{it}) + ex_{it}} s_{Xit}^f \quad (24)$$

Again, the estimate of the factor share in revenues evaluated in foreign market prices is downward biased if domestic markups exceed foreign markups.

Let us now summarize the effects of these biases on estimates of TFP. For firms with high (above median) domestic markups and prices (relative to those in exporting markets), the estimated export and (domestic price) factor shares are underestimated, while the measured TFP is overestimated. On the contrary, for firms that charge lower prices in foreign markets, the revenue based export share and domestic price factor share are upward biased and thus measured TFP is underestimated. Given more likely scenario of higher domestic markups, we should expect that our measure of TFP is overestimated.

4.2 Results

Any estimation of production function parameters has to deal with endogeneity issues. First, as noted by Marschak and Andrews (1944) factor demands may reflect unobserved productivity shocks known to the firm, but unknown to econometrician (e.g. managerial ability, land quality, quality of materials). Second, in plant level data endogeneity can also be introduced through the correlation between firm exit (exit decision) and the unobserved productivity variables. The so called survival or selection bias occurs when likelihood of exit depends on firm size or capital-to-labor ratio.

In addition to controlling for simultaneity and selection biases, we adapt our estimation procedure in order to account for endogeneity of the decision to export. Following Van Biesebroeck (2005) and De Loecker (2005) we modify the Olley and Pakes (1996) estimation algorithm to include exporting, inward and outward foreign direct investment status as additional state variables. Alternatively, we could follow Rizov and Walsh (2005) in adding an additional selection rule (parallel to the selection into the sample) with selection into exporting. The difference between the two approaches is that Van Biesebroeck's approach assumes validity of learning-by-exporting,⁹ while the Rizov and Walsh approach builds only on the self-selection premise. In particular, the former considers exporting to be a state variable (along with firm capital stock and productivity level) with its law of motion determined by other contemporaneous state variables and lagged exporting status,¹⁰ whereas the latter proposes that selection into exporting serves to split the sample (into exporters and non-exporters) based on their productivity.¹¹ The advantage of Van Biesebroeck's approach is endogeneity of exporting decision and direct inclusion of this status in production function. Rizov and Walsh's approach, on the other hand, benefits primarily from the fact that, by estimating productivity separately on exporting and non-exporting firm samples, the estimation retains considerable flexibility of the production function coefficients.¹²

In line with the theoretical disposition we base our estimation on evaluating market revenue net of variable costs

$$r_{it}^h - vi_{it} = \frac{\gamma}{\mu^h} k_{it} + \frac{1}{\mu^h} \ln\left(\frac{1 - ex_{it}}{1 - ex_{Med,t}}\right) + \varepsilon_{it} \quad (25)$$

$$r_{it}^f - vi_{it} = \frac{\gamma}{\mu^f} k_{it} + \frac{1}{\mu^f} \ln\left(\frac{ex_{it}}{ex_{Med,t}}\right) + u_{it} \quad (26)$$

where ε_{it} and u_{it} are the respective the error terms. As is the case with estimations of production functions we do not observe firm-specific productivity and have to control for its effects on the regressors and regressant.

We opt for augmented version of the Olley-Pakes estimation approach akin in spirit to the proposition of Van Biesebroeck (2005).¹³ While Olley and Pakes (1996) allow for endogeneity of capital and age, we account for the endogeneity of capital (k_{it}) and export

⁹Van Biesebroeck's version of the Olley-Pakes algorithm does not include controls for the self-selection into exports based on productivity although the issue is implied (2005, pp. 385).

¹⁰In essence, exporting status serves as an additional determinant of investment and exit decisions in the second stage of the Olley-Pakes algorithm.

¹¹In further steps of the estimation, Rizov and Walsh (2005) validate their approach by estimating the factor coefficients (and subsequently productivity) on two separate subamples of exporters and non-exporters.

¹²Coefficient estimates on the inputs are allowed to differ between exporting and non-exporting firms.

¹³A detailed description of the estimation procedure is given in the Appendix B.

share variables ($\ln(ex_{it}/ex_{Med,t})$). In order to control for the unobserved productivity we employ the firm-investment function, but adapt it to include exporting status as an added state variable. This addition serves to account for the fact that exporters are likely to adopt different investment strategies than non-exporters and the response of investment to productivity shocks may differ as a consequence. In contrast to Olley and Pakes (1996) and in line with Martin (2005), we can forego the first stage of the estimation algorithm as we do not need to estimate the coefficients on the variable factors. The second stage of estimation closely follows the Olley-Pakes algorithm as we control for sample selection bias¹⁴ and, finally, in the third stage using nonlinear least squares account for the endogeneity of capital and export share variables. In addition, we propose to control for the measurement biases introduced due to data limitations by using markup estimates to correct factor-cost shares (as shown in equation 9) and export shares (as detailed in equation 22). We take advantage of the concavity of the system of equations and use iterative process where markup estimates of the preceding stage are employed in the following stage in order to deal with measurement issues discussed in previous subsection.

We now turn to the estimates of markups using the OLS estimation procedure corrected with markup correction in iterative process. In Table 3 are summarized year-by-year estimates of domestic and foreign markups for four steps of iteration procedure, although the results in the last step are relevant. The rest of the output is suppressed for brevity. Only in 1999, the estimates confirm conjecture of higher markups in domestic market.

Table 3: Results of the first four stages of the iteration algorithm, 1996-2002

<i>year</i>		<i>1.step</i>	<i>2.step</i>	<i>3.step</i>	<i>4.step</i>	<i>N</i>
1996	<i>domestic</i>	0.078954	0.066727	0.065436	0.065161	821
	<i>foreign</i>	0.012857	0.012219	0.012979	0.013125	821
1997	<i>domestic</i>	0.039427	0.031948	0.031316	0.031091	1537
	<i>foreign</i>	0.011904	0.007245	0.007553	0.007669	1537
1998	<i>domestic</i>	0.024106	0.018764	0.017861	0.017558	1597
	<i>foreign</i>	0.010220	0.008870	0.009294	0.009437	1597
1999	<i>domestic</i>	0.016742	0.006226	0.003709	0.002880	1876
	<i>foreign</i>	0.013316	0.014019	0.015193	0.015579	1876
2000	<i>domestic</i>	0.040308	0.002631	0.002391	0.002306	1988
	<i>foreign</i>	0.001945	-0.001857	-0.000775	-0.000395	1988
2001	<i>domestic</i>	0.075052	0.071457	0.071458	0.071458	819
	<i>foreign</i>	0.005822	0.002458	0.002458	0.002458	819
2002	<i>domestic</i>	0.046596	0.029831	0.027074	0.025994	1525
	<i>foreign</i>	0.013011	0.006879	0.008177	0.008688	1525

Notes: All estimates statistically significant at the 1% level.

¹⁴In modeling firm survival we also accounted for the possible differences in attrition between domestic and exporting firms by including exporting status as one of the determinants of firm survival.

For example, in 1996 markup in domestic market is 6,5 percent, while markup in foreign market is only 1,3 percent. In later periods markups were typically lower and the difference between domestic and foreign markets is relatively small. Higher markups may be either a result of home-bias (lower elasticity of demand for domestic firms) or significant trade cost (primarily transport cost). However, we believe that the majority of the above margin differences can in fact be attributed to the pricing policies in the two markets, since all transport costs (intra and inter-country) are assigned equally to domestic and foreign sales. Namely, since our data does not allow us to separate transport costs between markets, the observed differences in markups reflect primarily the home bias in pricing strategies or the different market competition levels. The estimates of markups in foreign markets given in Table 3 are weighted averages of market specific markups.

Table 4: Markups in different markets, 1996-2002

year		1.step	2.step	3.step	4.step	N
1996	domestic	0.072233	0.072465	0.072345	0.072320	821
	EU15 markets	0.003333	0.004775	0.004848	0.004861	626
	ex-Yugoslav markets	0.022984	0.026314	0.026470	0.026481	602
	CEEC markets	0.058505	0.066995	0.067609	0.067665	289
1997	domestic	0.040200	0.033484	0.031443	0.030717	1537
	EU15 markets	0.018253	0.020015	0.020991	0.021366	1103
	ex-Yugoslav markets	0.018135	0.022978	0.023166	0.023114	1066
	CEEC markets	-0.005515	0.002915	0.003598	0.003690	457
1998	domestic	0.026389	0.024081	0.022639	0.022072	1597
	EU15 markets	0.017798	0.021336	0.022229	0.022523	1164
	ex-Yugoslav markets	0.026468	0.027411	0.027180	0.027105	1114
	CEEC markets	-0.007584	0.006859	0.007711	0.007808	479
1999	domestic	0.014947	0.012652	0.011735	0.011584	1876
	EU15 markets	0.013599	0.015080	0.014811	0.014884	1378
	ex-Yugoslav markets	0.014719	0.014866	0.014672	0.014669	1244
	CEEC markets	0.016332	0.030244	0.031105	0.031208	549
2000	domestic	0.040638	0.042321	0.042147	0.041453	1988
	EU15 markets	0.003575	0.005730	0.008139	0.008471	1499
	ex-Yugoslav markets	0.013288	0.015798	0.016262	0.016113	1357
	CEEC markets	0.010016	0.016322	0.017078	0.017075	650
2001	domestic	0.076754	0.083340	0.086950	0.088535	819
	EU15 markets	0.011012	0.004175	0.001781	0.000965	595
	ex-Yugoslav markets	0.023497	0.033994	0.035049	0.035267	524
	CEEC markets	0.056369	0.072272	0.074127	0.074462	213
2002	domestic	0.045336	0.042458	0.041343	0.040897	1525
	EU15 markets	0.011490	0.012631	0.013135	0.013330	1058
	ex-Yugoslav markets	0.009668	0.013222	0.013521	0.013552	1040
	CEEC markets	0.018085	0.024605	0.025044	0.025174	435

All estimates statistically significant at the 1% level.

Since exporting markets of Slovenian firms are heterogeneous in terms of competitive pressure, we also expect heterogeneous markups. In particular, EU15 markets are highly competitive, which implies that markups should be the lowest. On the other hand, exYugoslav markets and CEEC markets are less competitive and should charge higher markups than in EU markets, but lower than markets in domestic market. Table 4 contains markups for these four groups of firms. Indeed, markups in domestic market are again the highest, while EU markets allow Slovenian firms to apply lowest markups over marginal costs. Surprisingly, CEEC markets offer higher markups than ex-Yugoslav markets despite historical relations between Slovenian firms and other markets.

5 Robustness of the results

In order to test the robustness of the above results we turn to the tried and tested method of estimating price-cost markups, the Roeger (1995) approach. There are many alternative ways of estimating markups, but the choice between them inevitably involves some trade offs. Given the limitations of our data set, which consists of company accounts data and does not afford us the luxury of unit prices and output data, we cannot estimate demand elasticities in a structural approach. Instead, we rely on a method first proposed by Roeger (1995), which builds on Hall's (1988) work, taking advantage of both the primal and dual Solow residual to eliminate the unobserved productivity and consistently estimate markups without instrumentalization. Additionally, similar to our approach both input and output variables can enter the regression in their nominal values, which eliminates the need for finding appropriate deflators. The downside of using Roeger's approach is that it, in contrast to Hall, assumes constant returns to scale in the production function, which may result on either upward or downward bias in the estimate of markup levels if returns to scale are decreasing or increasing, respectively¹⁵. Despite these reservation we present estimates of markups using Roeger's approach (Table 5) in order to establish a benchmark to evaluate our results in terms of absolute and relative size of markups.

Table 5: Markups according to export share using Roeger's method, 1995-2002

year	1995	1996	1997	1998	1999	2000	2001	2002
non-exportes	0.0521	0.0513	0.0721	0.0725	0.0785	0.0770	0.0650	0.0715
ex<10%	0.0389	0.0561	0.0641	0.0627	0.0728	0.0699	0.0740	0.0821
10% ≤ ex < 20%	0.0424	0.0542	0.0533	0.0816	0.0810	0.0668	0.0715	0.0779
20% ≤ ex < 30%	0.0035	0.0343	0.0527	0.0800	0.0778	0.0849	0.0884	0.0870
30% ≤ ex < 50%	0.0164	0.0346	0.0677	0.0583	0.0622	0.0437	0.0627	0.0571
50% ≤ ex < 75%	0.0024	0.0333	0.0643	0.0578	0.0749	0.0665	0.0652	0.0627
ex>75%	0.0073	0.0686	0.0807	0.0868	0.0877	0.0966	0.0982	0.0961

All estimates statistically significant at the 1% level.

¹⁵For more on this and Roeger's method of markup estimation see Konings and Vandenbussche.

On one hand, there is no markable difference in size between markup estimates in Tables 4 and 5, on the other, it seems that there is also no linear relationship between markups and export share. Furthermore, some of the highest average markups are achieved by firms that export more than three quarters of their production. The problem, of course lies in the fact that different firms are estimated within each group, which prevents direct comparisons of markups. It is possible therefore that more productive firms also export a larger proportion of their sales and are able to achieve higher markups than their competitors. Finally, in case of decreasing returns to scale, which were revealed to be prevailing in this data set, there may be considerable upward bias on these estimates.

6 Concluding remarks

Recent literature on the relationship between exports and productivity yields a robust support in favor of self-selection hypothesis. However, with a few notable exceptions (Crisuolo et al., 2006) evidence on the hypothesis of learning-by-exporting is far more illusive. In this paper we argue that one possible explanation may be productivity mis-measurement. We first show in extended framework proposed by Martin (2005) that conventional methods for measuring productivity yield biased estimates of productivity when monopolistically competitive firms charge different markups in domestic and foreign markets. The extent of bias depends on the share of exports and markups differential. Based on the sample of Slovenian manufacturing firms active in the period 1994-2002, we find systematically higher markups in domestic market which favors explanation of home-bias. Thus, exporting firms that charge lower prices and thus earn lower markups in foreign markets may have downward biased productivity. The paper also provides evidence on heterogeneity of markups across foreign markets. For Slovenian firms that traditionally export to ex-Yugoslav markets and markets of EU25, we confirm conjecture of higher markups in less developed and thus less competitive ex-Yugoslav and CEEC markets and the lowest markups in EU15. These results suggest that neglecting heterogeneity of markups yields biased measures of TFP.

References

- [1] Baily M.N., Hulten C., Campbell D.: ‘Productivity Dynamics in Manufacturing Plants’. *Brookings Papers: Microeconomics*, 187-267.
- [2] Criscuolo C., Leaver M.: ‘Offshore Outsourcing and Productivity’. Mimeo, 2005
- [3] De Loecker J.: ‘Do Exports Generate Higher Productivity? Evidence from Slovenia’, *LICOS DP* 151.
- [4] Ericson R., Pakes A.: ‘Markov-Perfect Industry Dynamics: A Framework for Empirical Work’, *Review of Economic Studies*, 62(1995), 53-82.
- [5] Griliches Z., Klette T.J.: ‘The Inconsistency of Common Scale Estimators When Output Prices are Unobserved and Endogenous’ *Journal of Applied Econometrics*, 11(1996), 343-361.
- [6] Klette T.J.: ‘Market Power, Scale Economies and Productivity: Estimates from a Panel of Establishment Data’, *Journal of Industrial Economics*, 47(1999), 451-476.

- [7] Levinsohn, J., Melitz M.: ‘Productivity in a Differentiated Products Market Equilibrium’, Harvard University, *Mimeo*, 2002.
- [8] Martin R.: ‘Computing the True Spread’, *Centre for Economic Performance Discussion Paper*, No 692, 2005.
- [9] Melitz M.J.: ‘Estimating Firm-Level Productivity in Differentiated Product Industries’, *Mimeo*, Harvard University, 2001.
- [10] Nickell Stephen J.: ‘Competition and Corporate Performance’. *Journal of Political Economy*, 104(1996), 4, 724-746.
- [11] Olley G.S., Pakes A.: ‘The Dynamics of Productivity in the Telecommunications Equipment Industry’, *Econometrica*, 64(1996), 1263-1297.
- [12] Rizov M., Walsh P.P.: ‘Linking Productivity to Trade in the Structural Estimation of Production within UK Manufacturing Industries’. IIS, *Mimeo*, 2005.
- [13] Roeger W.: ‘Can Imperfect Competition Explain the Difference between Primal and Dual Productivity Measures? Estimates for U.S. Manufacturing’. *Journal of Political Economy*, 103(1995), 2, 316-330.
- [14] Van Biesebroeck J.: ‘Exporting Raises Productivity in Sub-Saharan African Manufacturing Firms’, *Journal of International Economics*, 67(2005), 373-391.

Appendix A

Extension of the correction for mismeasurement of the export share in many country case is

$$ex_{it}^n = \widehat{ex}_{it}^n \frac{\sum_{m=1}^M R_{it}^m}{R_{it}^n + \sum_{m \neq n} R_{it}^m \frac{\mu^n}{\mu^m}} \quad (\text{A1})$$

where ex_{it}^n is the true measure of export share to market n , while $m = 1, \dots, M$ indexes the exporting markets.

Similarly, the measure of bias for the mismeasurement of the index of variable factors (vi_{it}) can be extended for the many country case

$$\widetilde{\mu}^n = \mu^n \left[\left(\mu^h / \mu^n \right) \left(1 - \sum_{m=1}^M ex_{it}^m \right) + \sum_{m \neq n} \left(ex_{it}^m \frac{\mu^m}{\mu^n} \right) + ex_{it}^n \right] \quad (\text{A2})$$

7 Appendix B

Accounting for endogeneity

The endogeneity issues arise from the profit maximization problem of plants. The inclusion of exporting share in the production function estimation introduces an additional source of possible endogeneity. Exporting share serves both as an indicator of export status ($ex = 0$ or $ex > 0$) as well as a measure of the importance of foreign markets for the firm. Based on the learning-by-exporting hypothesis export status (and intuitively export share as well) positively impacts the level of productivity, while the notion of self

selection establishes the reverse causality. Following Van Biesebroeck (2005), the Olley-Pakes framework can be extended to include exporting as a state variable. Whereas Van Biesebroeck explored the possible effects of exporting on productivity growth (learning-by-exporting) we are only interested in obtaining credible measures of exporter productivity.

The Olley-Pakes (1996) approach bases on controlling for simultaneity by inverting the firm-investment function $I_t = i_t(\omega_t, a_t, k_t)$ ¹⁶ to express the unobserved productivity variable (ω_t). In contrast, Van Biesebroeck adapts the investment relationship to encompass exporting by replacing the firm-age variable (a_t) with the lagged exporting status (EX_{t-1}). The reasoning behind the introduction of exporting into the investment function is driven by the commonly observed superiority of exporting firms in terms of capital intensity, investment, size and productivity compared with non-exporters.¹⁷ The added difference in Van Biesebroeck's application is that lagged export status does not evolve deterministically as was the case with age. Instead, current export status is chosen simultaneously with current investment. The state variables at the start of period t hence change to k_t , EX_{t-1} , and ω_t , while the two control variables are $\Delta EX_t = EX_t - EX_{t-1}$ and I_t .¹⁸ The evolution of the state variables is determined by

$$K_{t+1} = (1 - \delta)K_t + I_t \quad (\text{B1})$$

$$EX_t = EX_{t-1} + \Delta EX_t \quad (\text{B2})$$

while ω_{t+1} is assumed to follow a stochastic Markov process as a function of only ω_t (in contrast to Van Biesebroeck we do not presume learning-by-exporting, but do acknowledge the effects exporting status may have on investment and exit decisions and incorporate those in the algorithm).

$$\omega_{it} = E \{ \omega_{it} | \omega_{it-1} \} + \nu_{it} \quad (\text{B3})$$

Similarly, as in Olley and Pakes (1996), the investment function is an unknown function of the three state variables $I_t = i_t(k_t, EX_{t-1}, \omega_t)$. In addition, Van Biesebroeck also proposes a policy function for the change in export status implying self-selection into exporting, $\Delta EX_t = \Delta ex_t(k_t, EX_{t-1}, \omega_t)$, but does not employ it in the estimation algorithm.¹⁹ It is important to note that this exporting decision only affects the firm's productivity level

¹⁶The conditions for monotonicity of the relationship between investment (I_t) and the unobserved productivity variable (ω_t) is given in Pakes (1991).

¹⁷This leads Van Biesebroeck (2005, pp. 385) to state that even controlling for inputs and productivity exporters will make different investment decisions than non-exporters.

¹⁸Additionally, one could consider both outward and inward foreign direct investment as state variables whose evolution would be determined by

$$OFDI_t = OFDI_{t-1} + \Delta OFDI_t$$

and

$$IFDI_t = IFDI_{t-1} + \Delta IFDI_t$$

¹⁹Firm exporting decision for the following period depends on the lagged exporting status, current capital stock, and current productivity level (including the part unobservable to the econometrician).

the following period (as can be seen by inverting the investment function), just as current investment only raises future capital stock.²⁰

Following Martin (2005) home- and foreign-market revenue functions can be rewritten using the above assumptions as

$$r_{it}^h - vi_{it} = \frac{\gamma}{\mu^h} k_{it} + \frac{1}{\mu^h} \ln\left(\frac{1 - ex_{it}}{1 - ex_{Med,t}}\right) + E\{\omega_{it}|\omega_{it-1}\} + \nu_{it} + \varsigma_{it} \quad (\text{B4})$$

$$r_{it}^f - vi_{it} = \frac{\gamma}{\mu^f} k_{it} + \frac{1}{\mu^f} \ln\left(\frac{ex_{it}}{ex_{Med,t}}\right) + E\{\omega_{it}|\omega_{it-1}\} + \nu_{it} + \varsigma_{it} \quad (\text{B5})$$

Employing the inverted investment function to express out the unobserved productivity term $\omega_{it} = \phi_{\omega}(I_{it}, k_{it}, EX_{t-1})$, where $\phi(\cdot) = i^{-1}(\cdot)$, (B4) can be rewritten as

$$r_{it}^h - vi_{it} = \frac{\gamma}{\mu^h} k_{it} + \frac{1}{\mu^h} \ln\left(\frac{1 - ex_{it}}{1 - ex_{Med,t}}\right) + q(I_{it-1}, k_{it-1}, EX_{t-2}) + \nu_{it} + \varsigma_{it} \quad (\text{B6})$$

where $q(\cdot) = E\{\omega_{it}|\phi_{\omega}(\cdot)\}$. Using a higher order polynomial to approximate for $q(\cdot)$ reduces (B6) to a simple least squares problem. We suppose that multicollinearity between ex_{it} and EX_{it-2} is not a critical issue given that the latter is an indicator variable while the former is theoretically continuous. On the other hand, γ/μ may not be identifiable from (B6) as k_{it} will be correlated with k_{it-1} as well as I_{it-1} . Estimates obtained from running a regression on equation B6 will therefore be used for initial values only in a more econometrically efficient procedure. Following Olley and Pakes (1996) we start by estimating

$$r_{it}^h - vi_{it} = \psi(ex_{it}, k_{it}, I_{it}, EX_{it-1}) + \varsigma_{it} \quad (\text{B7})$$

where $\psi(ex_{it}, k_{it}, I_{it}, EX_{it}) = (\gamma/\mu^h)k_{it} + (1/\mu^h) \ln[(1 - ex_{it})/(1 - ex_{Med,t})] + \phi_{\omega}(k_{it}, I_{it}, EX_{t-1})$. As was the case in Olley-Pakes (1996), we are not able to separate the effects of exporting status (and exporting share) on the investment choice from their effect on output. We can therefore use a nonparametric estimator of the above equation to obtain predictions of $\hat{\psi}$ for each observation. Subsequently, (B7) can be reformulated in terms of a nonlinear least squares problem

$$r_{it}^h - vi_{it} = \frac{\gamma}{\mu^h} k_{it} + \frac{1}{\mu^h} \ln\left(\frac{1 - ex_{it}}{1 - ex_{Med,t}}\right) + h(\hat{\psi}_{it-1} - \frac{\gamma}{\mu^h} k_{it-1} + \frac{1}{\mu^h} \ln(1 - ex_{it-1})) + \nu_{it} + \varsigma_{it} \quad (\text{B8})$$

where $h(\cdot) = \{\omega_{it}|\cdot\}$ is approximated by a polynomial. The issue of endogeneity may also be arise in connection with the export share variable (ex_{it}), since more productive firms may choose to export a larger share of their sales and/or larger firms (in terms of revenue) could face higher export shares due to the restricted size of the domestic market. We believe that the issue is not critical though as the dependent variable in our case is in logged deviations from the median while the export share variable is in logs only. In addition, the estimation algorithm presented above corrects for the possible remaining endogeneity.

²⁰The assumptions on the investment function $i(\cdot)$ that ensure its invertibility are stated in Van Biesebroeck (2005).

Accounting for sample selection

Ericson and Pakes (1995) construct a model formalizing the idea plant exit (or plant death) depends, in part, on the firm's expectation of its future productivity and, given serial correlation, its current productivity. This would cause firms in the sample to be chosen (to a certain extent) based on unobserved productivity. This therefore generates a selection bias in traditional estimation procedures. Olley and Pakes (1996) define an exit rule where firms compare the sell-off (scrap) value of the firm to the expected discounted returns of staying in business until next period. As it turns out, since firms with larger capital stock can expect higher future returns for any productivity level²¹, the capital coefficient will be negatively biased if no steps are taken to correct for the bias. Analogous to the Olley and Pakes (1996) approach, Van Biesebroeck (2005) defines the lower threshold level of ω as a function of k_{it} and EX_{t-1} .

$$\underline{\omega}_{it} = \underline{\omega}_{it}(k_{it}, EX_{t-1}) \quad (\text{B9})$$

Following Van Biesebroeck the probability of end-of-period productivity falling below this threshold is hence

$$\Pr(\text{survival}) = \Pr(\omega_{it+1} \geq \underline{\omega}_{it+1}(k_{t+1}, EX_t) | \underline{\omega}_{it+1}(k_{t+1}, EX_t), \omega_{it}) \quad (\text{B10})$$

by the law of iterated expectations and using the transition equations, (B10) can be rewritten as²²

$$P(\text{survival}) = P_t(k_{t+1}, EX_t, \omega_t) = P'_t(k_t, I_t, EX_{t-1}, \Delta EX_t) = P''_t(k_t, I_t, EX_{t-1}, EX_t) \quad (\text{B11})$$

where the lagged export status is needed as one of the predictors of the unobserved productivity term ω_{it} , while the current export status serves as a determinant of the exit threshold (Van Biesebroeck, 2005). To obtain an estimate of exit (or continuation) probability a Probit is run with current capital stock, investment and export status as well as lagged export status as dependant variables. Following OP if P_{it} (the probability of continuation) changes monotonically with ω_{it} , the probability function is invertible and $\underline{\omega}_{it}$ can be expressed as a function of $P(\text{exit})$, k_{it} , EX_{t-1} . As we can control for both the exit threshold (using the exit probability) and the unobserved productivity, equation B4 becomes²³

$$r_{it}^h - v_{it} = \frac{\gamma}{\mu^h} k_{it} + \frac{1}{\mu^h} \ln\left(\frac{1 - ex_{it}}{1 - ex_{Med,t}}\right) + h(P_{it-1}, \hat{\psi}_{it-1} - \frac{\gamma}{\mu^h} k_{it-1} + \frac{1}{\mu^h} \ln(1 - ex_{it-1})) + \nu_{it} + \varsigma_{it} \quad (\text{B12})$$

²¹Therefore they are likely to stay in operation even at lower ω realizations.

²²The second and third equalities follow from (B1) and (B2).

²³The foreign revenue equivalent, which would enable one to retrieve the foreign-market markups, would be

$$r_{it}^f - v_{it} = \frac{\gamma}{\mu^f} k_{it} + \frac{1}{\mu^f} \ln ex_{it} + q(I_{it-1}, k_{it-1}, EX_{t-2}, P_{it-1}) + \tilde{\nu}_{it} + \tilde{\varsigma}_{it}$$

which can be estimated in two steps (in contrast to OP) with the procedure following the one outlined in the previous section. The appropriate estimates of the capital coefficient and the export share coefficient are obtained in the second step. By running parallel regressions on domestic and exporting revenues, one can obtain estimates of domestic and foreign markups and can, by assuming constant markups, obtain an estimate of the exporting correction in MTFP measures.

Correcting for the measurement error

We noted above that data limitations will likely prevent accurate measurement of factor shares in total output evaluated at domestic or foreign prices. These will have to be approximated with factor-cost shares in total revenue which will in turn lead to the missmeasurement of the variable factors index (vi_{it}). In fact, our proposed framework would (at least at the initial stages of the estimation) be unable to differentiate between the variable factors index based on domestic prices and the one based on exporting prices. We, hence, stipulate that in case when home-market revenue²⁴ is considered, the empirically viable variable-factor index \widehat{vi}_{it} will overstate the true variable-factor index, while, at the same time, \widehat{vi}_{it} will likely understate the true index in case of foreign market revenue. In order to compensate for the measurement error, the estimates of the two markups would have to be adjusted by the corrective factor (equation 24) and used in the following step of the iteration. We suggest that in the first stage of the estimation process \widehat{vi}_{it} is used in (B12), where the obtained markups are then used to recalculate \widehat{vi}_{it} . This iterative process would continue until the markup estimates in consecutive stages do not differ substantially

²⁴The case when in the calculation of factor revenue share the total quantity produced is evaluated at domestic prices.