

# Markups and Firm-Level Export Status \*

Jan De Loecker  
Princeton University  
NBER and CEPR

Frederic Warzynski  
Aarhus School of Business  
Aarhus University

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## Abstract

Estimating markups has a long tradition in industrial organization and international trade. Economists and policy makers are interested in measuring the effect of various competition and trade policies on market power, typically measured by markups. The empirical methods that were developed in empirical industrial organization often rely on the availability of very detailed market-level data with information on prices, quantities sold, characteristics of products and more recently supplemented with consumer-level attributes. Often, both researchers and government agencies cannot rely on such detailed data, but still need an assessment of whether changes in the operating environment of firms had an impact on markups and therefore on consumer surplus. In this paper, we derive an estimating equation to estimate markups using standard production plant-level data based on the insight of Hall (1986) and the control function approach of Olley and Pakes (1996). Our methodology allows for various underlying price setting models, dynamic inputs, and does not require measuring the user cost of capital or assuming constant returns to scale. We rely on our method to explore the relationship between markups and export behavior using plant-level data. We find that i) markups are estimated significantly higher when controlling for unobserved productivity, ii) exporters charge on average higher markups and iii) firms' markups increase (decrease) upon export entry (exit). We see these findings as a first step in opening up the productivity-export black box, and provide a potential explanation for the big measured productivity premia for firms entering export markets.

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# 1 Introduction

Estimating markups has a long tradition in industrial organization and international trade. Economists and policy makers are interested in measuring the effect of various competition and trade policies on market power, typically measured by markups. The empirical methods that were developed in empirical industrial organization often rely on the availability of very detailed market-level data with information on prices, quantities sold, characteristics of products and more recently supplemented with consumer-level attributes.<sup>1</sup> Often, both researchers and government agencies cannot rely on such detailed data, but still need an assessment of whether changes in the operating environment of firms had an impact on markups and therefore on consumer surplus. In this paper, we derive a simple estimating equation in the spirit of Hall (1986) that nests various price setting models and allows to estimate markups using standard plant-level production data. The methodology crucially relies on the insight that the cost share of factors of production, in our case labor and intermediate inputs, are only equal to their revenue share if output markets are perfectly competitive. However, under (any form of) imperfect competition the relevant markup drives a wedge between revenue and cost shares.

The markup parameter is identified given we observe total expenditures on the inputs and revenue at the plant level, a condition which is satisfied in almost all plant-level datasets. By modelling the firm specific (unobserved) productivity process we can relax a few important assumptions maintained in previous empirical work. First of all, we do not need to impose constant returns to scale, and secondly, our method does not require observing or measuring the user cost of capital. We show that this approach leads to a flexible methodology and reliable estimates and use our empirical model to verify whether exporters, on average, charge higher markups than their counterparts in the same industry, and how markups change upon export entry. However, our framework is well suited to relate markups to any observed firm-level activity, such as R&D, FDI, import status, etc., which is potentially correlated with firm-level productivity.

## 1.1 Recovering markups from production data

Robert Hall published a series of papers suggesting a simple way to estimate (industry) markups based on an underlying model of firm behavior (Hall, 1986, 1988, 1990). These papers generated an entire literature that was essentially built upon the key insight that industry specific markups can be uncovered from production data with information on firm or industry level usage of inputs and total value of shipments (e.g. Domowitz et al., 1988; Waldmann, 1991; Morrison, 1992; Norrbin, 1993; Roeger, 1995 or Basu, 1997)<sup>2</sup>. This approach is based on a production function framework and delivers an average markup using

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<sup>1</sup>See Goldberg (1995) for an application of this for instance.

<sup>2</sup>The literature also spread to international trade. See Levinsohn (1993), Harrison (1994) and Konings and Vandebussche (2005).

the notion that under imperfect competition input growth is associated with disproportional output growth, as measured by the relevant markup. An estimated markup higher than one would therefore immediately reject the perfect competitive model.<sup>3</sup>

However, some important econometric issues are still unaddressed in the series of modified approaches. The main concern is that unobserved factors can impact output growth as well and an obvious candidate in the framework of a production function is productivity (growth).<sup>4</sup> Not controlling for unobserved productivity shocks biases the estimate of the markup as productivity is potentially correlated with the input choice. This problem relates to another strand of the literature that stepped away from looking for the right set of instruments to control for unobserved productivity. Olley and Pakes (1996), and Levinsohn (2003) introduced a full behavioral model to solve for unobserved productivity as a function of observed firm-level decisions (investment and input demand) to deal with the endogeneity of inputs when estimating a production function.<sup>5</sup> We refer to this approach as the proxy approach.

The increased availability of firm or plant-level datasets further boosted empirical studies using some version of the Hall approach on micro data. Dealing with unobserved productivity shocks becomes an ever bigger concern when applying the Hall method to plant-level data given the strong degree of firm-level heterogeneity, as the set of instruments suggested in the literature were mostly aggregate demand factors such as military spending, and oil prices. Moreover, the Hall methodology and further refinements have become a popular tool to analyze how changes in the operating environment - such as privatization, trade liberalization, labor market reforms - have impacted market power, measured by the change in markups. Here again, the correlation between the change in competition and productivity potentially biases the estimates of the change in the markup. Let us take the case of trade liberalization. If opening up to trade impacts firm-level productivity, as has been documented extensively in the literature, it is clear that the change in the markup due to a change in a trade policy is not identified without controlling for the productivity shock.<sup>6</sup>

We introduce the notion of a control function to control for unobserved productivity in the estimation of markups.<sup>7</sup> We show that the proxy approach and the Hall (1986) approach are

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<sup>3</sup>In the original model, Hall actually tests a joint hypothesis of perfect competition and constant returns to scale. However, in an extended version a returns to scale parameter is separately identified (Hall, 1990). Importantly, our approach does not require any assumptions on the returns to scale in production as opposed to the Roeger (1995) approach.

<sup>4</sup>In addition, there has been quite a long debate in the literature on what the estimated markup exactly captures and how the model can be extended to allow for intermediate inputs and economies of scale among others (see Domowitz *et. al* 1988 and Morrison 1992).

<sup>5</sup>Various refinements have since been proposed in the literature. However, Akerberg, Benkard, Berry and Pakes (2007) show that the basic framework remains valid. The methodology is now widespread in industrial organization, international trade, development economics (see e.g. Van Biesebroeck, 2005 and De Loecker, 2007a who apply modified versions in the context of sorting out the productivity gains upon export entry).

<sup>6</sup>The same is true in the case where we want to estimate the productivity response to a change in the operating environment such as a trade liberalization. See De Loecker (2007b) for more on this.

<sup>7</sup>Note that all of this it relevant at the firm-level. Industry wide productivity shocks are controlled for by

linked in a straight forward way. In this way we identify markup parameters by controlling for unobserved productivity relying on clearly spelled out behavioral assumptions. In addition, we identify markups without taking a stand on the exact timing of inputs, adjustment costs of inputs (hiring and firing costs for instance) since we only need to include the control function (in investment or intermediate inputs, capital and potentially other inputs) in a one-stage procedure.

## 1.2 Markups and export status

In addition to providing a simple empirical framework to estimate markups using standard production data, we provide new results on the relationship between firms' export status and markups using a rich micro data set where we observe substantial entry into export markets over our sample period. The latest generation of models of international trade with heterogeneous producers (e.g. Melitz, 2003) were developed to explain the strong correlations between export status and various firm-level characteristics, such as productivity and size. In particular, the correlation between productivity and export status has been proven to be robust over numerous datasets. The theoretical models such as Bernard, Eaton, Jensen and Kortum (2003) and Melitz and Ottaviano (2008) emphasize the self-selection of firms into export markets based on an underlying productivity distribution, creating a strong correlation between productivity and export status.<sup>8</sup> However, these models also have predictions regarding markups and firm-level export status and our empirical framework can be used to test these.

Furthermore, we explore the dynamics of export entry and exit to analyze how it impacts markups. The latter will also allow us to shed more light on an often mentioned learning by exporting hypothesis, which refers to significant productivity improvements for exporters upon export entry. This has recently been confirmed for mostly developing countries.<sup>9</sup> However, almost all empirical studies that relate firm-level export status to (estimated) productivity rely on revenue to proxy for physical output and therefore do not rule out that part of the export premium captures product quality improvements and market power effects. Related to this, recent studies by Kugler and Verhoogen (2008) and Hallak and Savadisan (2009) report higher product quality for exporters, whereas Manova and Zhang (2009) report higher prices for exporters based on observed export prices from transaction level data. Therefore, differences in pricing behavior between exporters and non exporters could, at least partially, be responsible for the measured productivity trajectories upon export entry. Our framework is especially well suited to address this question since our method is designed to control for unobserved productivity shocks which is key to identify a separate markup for exporters.

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the introduction of (a combination of) year dummies and time trends.

<sup>8</sup>A few recent papers have provided similar evidence on importers (Halpern, Koren and Szeidl, 2006).

<sup>9</sup>See eg. Van Biesebroeck (2005) and De Loecker (2007a). The literature also emphasizes the importance of self selection into export markets (e.g. Clerides, Lach and Tybout, 1998).

We study the relationship between markups and export status for a rich panel of Slovenian firms over the period 1994-2000. Slovenia is a particularly useful setting for this. First, the economy was a centrally planned region of former Yugoslavia until the country became independent in 1991. A dramatic wave of reforms followed that reshaped market structure in most industries. This implied a significant reorientation of trade flows towards relatively higher income regions like the EU and led to a quadrupling of the number of exporters over a 7 year period (1994-2000). Second, it has become a small open economy that joined the European Union in 2004, and its GDP per capita is rapidly converging towards the EU average. This opening to trade has triggered a process of exit of the less productive firms, while deregulation and new opportunities facilitated the entry of new firms as well as entry into export markets which contributed substantially to aggregate productivity growth.<sup>10</sup>

We find that markups differ dramatically between exporters and non exporters and are both statistically and economically significantly higher for exporting firms. The latter is consistent with the findings of productivity premia for exporters, but at the same time requires a better understanding of what these (revenue based) productivity differences exactly measure. We provide one important reason for finding higher measured revenue productivity: higher markups. Finally, we find that markups significantly increase for firms entering export markets.

The remainder of this paper is organized as follows. Section 2 introduces our empirical model and shows how our approach is robust to various price setting models and can be easily extended to allow for richer production technologies and various proxy estimators that have been put forward in the literature. Section 3 provides a short discussion on the relationship between markups and firm-level export status, and how our empirical model can be used to test some recent models of international trade. In section 4 we turn to the data and in section 5 we discuss our main results and we provide a few robustness checks and discuss remaining caveats. The final section concludes.

## 2 A Framework to estimate markups

In this section we derive the estimating equation relating output growth to a weighted average of input growth, allowing the identification of a markup parameter. We then provide a simple control function approach to control for unobserved productivity in this context. Importantly, we illustrate our main estimating equation under two popular price setting models, Cournot and Bertrand. However, simple cost minimization is the only requirement of our method.

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<sup>10</sup>See De Loecker and Konings (2006) for more on the importance of entry in aggregate productivity growth in Slovenian manufacturing.

## 2.1 An underlying model of firm behavior

We derive a simple relationship between output growth and input growth which allows us to identify markups from standard production data. The estimating equation is obtained by i) considering a Taylor expansion of a general production function and ii) adding the conditions from profit maximization for firms that take input prices as given and compete in either Nash in prices or quantities.

Let us start by considering a general production function  $f(\cdot)$  that generates an output  $Q_{it}$  from using labor  $L_{it}$ , material inputs  $M_{it}$  and capital  $K_{it}$  and depends on the firm's productivity level  $\Theta_{it}$ . The latter is an input neutral technology shock.

$$Q_{it} = \Theta_{it} f(L_{it}, M_{it}, K_{it}) \quad (1)$$

In a first step we simply take a Taylor expansion of  $Q_{it}$  (around  $Q_{it-1}$ ) and obtain an expression for the change in firm-level output decomposed into the change in inputs, weighted by their marginal product, and productivity growth.

$$\Delta Q_{it} = \Theta_{it} \left( \frac{\Delta f_{it}}{\Delta L_{it}} \Delta L_{it} + \frac{\Delta f_{it}}{\Delta M_{it}} \Delta M_{it} + \frac{\Delta f_{it}}{\Delta K_{it}} \Delta K_{it} \right) + f_{it} \Delta \Theta_{it} \quad (2)$$

In a second step, we can interpret the markup under various assumptions regarding the nature of competition in the industry as suggested by Levinsohn (1993). We consider this flexibility an important strength of the model which can be important if we want to relate a specific theoretical model to the empirical methodology.

We now turn to some specific price setting models to show how we derive our main estimating equation. We show our approach under the standard Cournot/Bertrand homogeneous good model and briefly discuss how we can easily extend it to richer settings. Consider firms producing a homogeneous product and competing in quantities while operating in an oligopolistic market where profits  $\pi_{it}$  are given by

$$\pi_{it} = P_t Q_{it} - w_{it} L_{it} - m_{it} M_{it} - r_{it} K_{it} \quad (3)$$

where all firms take input prices ( $w_{it}$ ,  $m_{it}$  and  $r_{it}$ ) as given. The optimal choice of labor is simply given by setting the marginal revenue product equal to the wage,

$$\Theta_{it} \frac{\Delta f_{it}}{\Delta L_{it}} = \frac{w_{it}}{P_t} \left( 1 + \frac{s_{it} \theta_{it}}{\eta_t} \right)^{-1} \quad (4)$$

and analogous conditions apply for material and capital, where  $s_{it} = \frac{Q_{it}}{Q_t}$  is the market share of firm  $i$ ,  $\eta_t$  is the market elasticity of demand, and  $\theta_{it}$  is equal to zero under perfect competition, and equal to one if firms play Nash in quantities, respectively. The optimal output choice  $Q_{it}$  will satisfy the following F.O.C.

$$\frac{P_t}{c_{it}} = \left( 1 + \frac{s_{it} \theta_{it}}{\eta_t} \right)^{-1} \equiv \mu_{it} \quad (5)$$

where  $c_{it}$  is the marginal cost of production and we define  $\mu_{it}$  as the relevant firm specific markup.<sup>11</sup> Under Cournot differences in markups across firms are generated by differences in productivity and market structure  $(s_{it}, \eta_t)$ .

We follow Levinsohn (1993) and use the optimal input choices for labor and materials (4) together with the pricing rule (5) into the Taylor expansion (2).<sup>12</sup>

$$\Delta Q_{it} = \mu_{it} \left( \frac{w_{it}}{P_t} \Delta L_{it} + \frac{m_{it}}{P_t} \Delta M_{it} + \frac{r_{it}}{P_t} \Delta K_{it} \right) + f_{it} \Delta \Theta_{it} \quad (6)$$

We now have to take one last step to recover a well known estimation equation suggested by Hall (1986) by noticing that  $\frac{\Delta X_{it}}{X_{it}} = \Delta \ln X_{it} = \Delta x_{it}$ .

$$\Delta q_{it} = \mu_{it} \left( \frac{w_{it} L_{it}}{P_t Q_{it}} \Delta l_{it} + \frac{m_{it} M_{it}}{P_t Q_{it}} \Delta m_{it} + \frac{r_{it} K_{it}}{P_t Q_{it}} \Delta k_{it} \right) + \Delta \omega_{it} \quad (7)$$

$$= \mu_{it} (\alpha_{Lit} \Delta l_{it} + \alpha_{Mit} \Delta m_{it} + \alpha_{Kit} \Delta k_{it}) + \Delta \omega_{it} \quad (8)$$

where  $\omega_{it} = \ln(\Theta_{it})$  and  $\alpha_{Lit}$ ,  $\alpha_{Mit}$  and  $\alpha_{Kit}$  are the share of the relevant input's costs in total revenue. Intuitively, if firms set prices equal to marginal costs ( $\mu_{it} = 1$ ), the share of each input in output growth is simply given by the relevant share in total revenue, whereas under imperfect competition it is the cost share ( $\mu_{it} \alpha_{Lit} = \frac{w_{it} L_{it}}{c_{it} Q_{it}}$ ).<sup>13</sup> We stress that the input shares are assumed to be directly observed in the data, except for the capital share  $\alpha_{Kit}$ .

A similar expression can be obtained with a more general model of Bertrand competition (Nash in price) with differentiated products. The Lerner index, or price cost margin,  $\beta_{it}$  would then depend on the own price elasticity  $\eta_{ii} = -\frac{\partial q_i}{\partial p_i} \frac{p_i}{q_i}$  and the cross price elasticity  $\eta_{ij} = -\frac{\partial q_i}{\partial p_j} \frac{p_j}{q_i}$  in the following way,

$$\beta_{it} \equiv \frac{P_{it} - c_{it}}{P_{it}} = \frac{1}{\eta_{ii} - \vartheta' \frac{p_{it}}{p_{jt}} \eta_{ij}} \quad (9)$$

where  $\vartheta' = \frac{\partial p_j}{\partial p_i}$  (see e.g. Röller and Sickles, 2000).

The method could also be adapted to consider multiproduct firms such as in Berry, Levinsohn and Pakes (1995) where the markup is a function of the sensitivity of market share to price, given the set of prices set by competitors, the characteristics of all products on the markets and the characteristics of the consumers on the market. The markup can also reflect the result of more complex dynamic games. In this way our empirical model can take into

<sup>11</sup>See Shapiro (1987) for a discussion of what the markup measures.

<sup>12</sup>This somewhat restricts the underlying class of demand systems we can work with. More precisely, we either do not allow for a change in the curvature of demand during  $t - 1$  and  $t$ , the CES demand system being a well known example of this. Under more general demand systems we consistently estimate the average elasticity and can still bound the estimate of the markup by verifying the interaction between input growth and the change in the markup.

<sup>13</sup>Hall (1986) obtains this estimating equation starting from the observation that the conventional measure of total factor productivity (TFP) growth is biased by a factor proportional to the markup under the presence of imperfect competition. Note how our structural derived equation is exactly the same as the one suggested by Hall (1986).

account pricing heterogeneity between firms, as advocated by Klette and Griliches (1996), Klette (1999), and more recently by Foster, Haltiwanger and Syverson (2008) and De Loecker (2007b). In other words, our method is flexible enough to consider various assumptions regarding the nature of competition and accommodates two of the most common static model of competition used by industrial economists. It is important to stress that regardless of the exact model of competition we always estimate an average markup across a set of firms as the coefficient on input growth. What is important to note though, is that the estimated parameter  $\mu$  will clearly have a different interpretation and will depend on elasticities in various forms depending on the model we assumed.

## 2.2 Estimating markups relying on a control function

Another strand of the literature focuses on the estimation of the coefficients of a production function where output  $Q_{it}$  is generated given various inputs and a residual. This residual can be decomposed into a productivity shock ( $\omega_{it}$ ), which is potentially correlated with inputs, and an *i.i.d.* term ( $\varepsilon_{it}$ ), or in our notation

$$\ln \Theta_{it} = \omega_{it} + \varepsilon_{it} \tag{10}$$

To deal with the potential endogeneity of inputs in the context of a production function, Olley and Pakes (1996) rely on a dynamic model of investment with heterogeneous firms that generates an equilibrium investment policy function ( $i_{it} = i_t(\omega_{it}, k_{it})$ ) which forms the basis of the estimation procedure. Provided that investment is a monotonic increasing function in productivity, we can proxy the unobserved productivity shock by a function of  $i_{it}$  and  $k_{it}$ ,

$$\omega_{it} = h_t(i_{it}, k_{it}) \tag{11}$$

Our approach simply relies on the insight of Olley and Pakes (1996) to control for unobserved productivity shocks in the markup regression, described in equation (7). We provide two alternative strategies to correct for unobserved productivity shocks ( $\Delta\omega_{it}$ ). The first is directly built on the control function approach suggested by Olley and Pakes (1996) and Levinsohn and Petrin (2003). The second relies specifically on the (non parametric) Markov process of productivity and on firms' exit rules. We also discuss a *GMM* version.

Both alternatives allow to estimate the markup using standard semi-parametric regression techniques and GMM techniques. It is important to note, however, that the estimation of the markup is not affected by the presence of non constant returns to scale. As will become clear below, this is related to the fact that we do not need to observe the user cost of capital ( $r_{it}$ ) which is very hard to come by.<sup>14</sup> In terms of studying the relationship between export status

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<sup>14</sup>We have to note that capital is a fixed input and a firm might thus face a cost of adjustment. This will slightly change the optimal input choice condition for capital. However, since we will collect the capital terms in the control function, we do not have to specify the exact adjustment costs and the optimal capital choice. It will imply that expression (7) will look different. For notation purposes we stick to the original expressions.



and markups, we take a very simple approach by simply interacting the markup term with various export status dummies. In this way, we compare average markup differences between exporters and non exporters, and further between various export categories (starters, quitters and always exporters). We provide more details when we discuss the results.

### 2.2.1 First approach: pure difference

As Olley and Pakes (1996) showed, we can proxy unobserved productivity by a function in investment and capital. This implies that productivity growth  $\Delta\omega_{it}$  is simply the difference between the control function at time  $t$  and  $t - 1$ .

$$\Delta\omega_{it} = h_t(i_{it}, k_{it}) - h_{t-1}(i_{it-1}, k_{it-1}) \quad (12)$$

This will generate the following estimating equation for the markup parameter  $\mu$ , where we emphasize that we are only interested to estimate an average markup across a given set of firms. Note that we now decompose  $\ln(\Theta_{it}) = \omega_{it} + \varepsilon_{it}$ , and explicitly allow for measurement error and idiosyncratic shocks to production.<sup>15</sup>

$$\Delta q_{it} = \mu [\alpha_{Lit}\Delta l_{it} + \alpha_{Mit}\Delta m_{it} + \alpha_{Kit}\Delta k_{it}] + h_t(i_{it}, k_{it}) - h_{t-1}(i_{it-1}, k_{it-1}) + \Delta\varepsilon_{it} \quad (13)$$

We collect all terms on capital and investment in  $\Delta\phi_t(\cdot)$  and obtain our main estimating equation

$$\Delta q_{it} = \mu\Delta x_{it} + \Delta\phi_t(i_{it}, k_{it}) + \Delta\varepsilon_{it} \quad (14)$$

where we use the following notation,

$$\Delta x_{it} = \alpha_{Lit}\Delta l_{it} + \alpha_{Mit}\Delta m_{it} \quad (15)$$

$$\Delta\phi_t(i_{it}, k_{it}) = \mu\alpha_{Kit}\Delta k_{it} + h_t(i_{it}, k_{it}) - h_{t-1}(i_{it-1}, k_{it-1}) \quad (16)$$

We note that some terms in the control function will drop out due collinearity that are generated by the law of motion on capital,  $k_{it} = (1 - \delta)k_{it-1} + i_{it-1}$ . In particular, under the assumption that the capital stock depreciates at the same rate for all firms, investment and capital at time  $t - 1$  fully determine the capital stock at time  $t$ .<sup>16</sup>

This approach delivers an estimate for the markup ( $\mu$ ) by running (14) on standard production data, where we simply rely on a non linear function in capital and investment to proxy for productivity. It does, however, not explicitly control for the non random exit of firms. Our second approach enables us to verify the impact on the estimated markup of

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<sup>15</sup>Note that we drop the subscript on the markup to highlight that we do not wish to obtain a firm-level markup, but rather an average across a set of firms. In theory one could rely on a random coefficient model and estimate the distribution of  $\mu_{it}$  by making distributional assumptions.

<sup>16</sup>This will depend on the availability of investment data and whether it needs to be constructed from capital stock data and depreciations.

controlling for the selection process. We stress that we do not have to observe or compute  $\alpha_{kit}$  in order to estimate the markup parameter. We will come back to this later.

However, if we want to depart from the original OP framework and incorporate more state variables, we have to revisit the invertibility conditions of the investment policy function and this might be challenging. Levinsohn and Petrin (2003) provide an alternative by relying on a static input demand equation to proxy for productivity. Therefore the additional state variables of the underlying dynamic problem of the firm need not to be modelled. See De Loecker (2009) for more discussion on this. This advantage will be in particular useful if we want to use our suggested method for identifying different markups for exporters. We turn to the LP version next.

Levinsohn and Petrin (2003), hereafter LP, suggest the use of intermediate inputs instead of investment to control for unobserved productivity shocks. Therefore, the basis of their estimation procedure is to write productivity as a function of  $m_{it}$  and  $k_{it}$ , and rely on  $h_{it}(m_{it}, k_{it})$  to control for unobserved productivity.

Our empirical model can therefore proceed in a similar way. However, the control function will now include capital at  $t$  as there is still independent variation in capital between time  $t$  and  $t - 1$  as investment is not used as a proxy in LP. The estimating equation now becomes

$$\Delta q_{it} = \mu \alpha_{Lit} \Delta l_{it} + \Delta \phi_t(m_{it}, k_{it}) + \Delta \varepsilon_{it} \quad (17)$$

where

$$\Delta \phi_t(m_{it}, k_{it}) = \mu(\alpha_{Mit} \Delta m_{it} + \alpha_{Kit} \Delta k_{it}) + h_t(m_{it}, k_{it}) - h_{t-1}(m_{it-1}, k_{it-1}) \quad (18)$$

Although that this approach has the advantage of not having to revisit the underlying dynamic model when considering additional state variables, such as export status or R&D status, it does require checking the monotonicity of input demand in productivity under imperfect competition. Here we are explicit about the notion of competition in the output market, i.e. we allow for imperfect competition. Essentially, the LP estimator relies on the inversion of the intermediate input demand function which assumes perfect competition in the output market. Therefore more assumptions are needed to still allow for the monotonic relationship of intermediates in productivity conditional on the capital stock. Essentially, we have to assume that more productive firms do not set disproportionately higher markups. A well known example of the latter is the constant markup CES model, which is used extensively in international trade theory and empirical work.<sup>17</sup>

### 2.2.2 Second approach: selection control

We can also rely directly on one of the crucial assumption in Olley and Pakes (1996), namely that productivity follows a first order Markov process, where  $\xi_{it}$  denotes the news term in

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<sup>17</sup>See De Loecker (2009) for a proof under monopolistic competition for instance.

the Markov process. We explicitly rely on the notion that the growth rate of output and the various inputs is only available for surviving firms. This implies that productivity growth  $\Delta\omega_{it}$  at time  $t$  can be written as

$$\Delta\omega_{it} = \omega_{it} - \omega_{it-1} = g(\omega_{it-1}, P_{it}) - \omega_{it-1} + \xi_{it} \quad (19)$$

$$= \tilde{g}(i_{it-1}, k_{it-1}, P_{it}) + \xi_{it} \quad (20)$$

where  $P_{it}$  is the survival probability at time  $t - 1$  to next year  $t$ . Empirically, we obtain an estimate of this survival probability by running a probit regression of survival on a polynomial in investment and capital. The second step uses the result from the inversion  $\omega_{it-1} = h_{t-1}(i_{it-1}, k_{it-1})$ , and the final step simply collects all observables in a function  $\tilde{g}(\cdot)$ . We now have the following estimating equation for our model.

$$\Delta q_{it} = \mu \Delta x_{it} + \tilde{\phi}_t(i_{it-1}, k_{it-1}, P_{it}) + \Delta \varepsilon_{it}^* \quad (21)$$

where

$$\begin{aligned} \tilde{\phi}_t(i_{it-1}, k_{it-1}, P_{it}) &= \mu \alpha_{Kit} \Delta k_{it} + \tilde{g}(i_{it-1}, k_{it-1}, P_{it}) \\ \Delta \varepsilon_{it}^* &= \Delta \varepsilon_{it} + \xi_{it} \end{aligned} \quad (22)$$

The capital stock at  $t$  no longer appears, as we know from the law of motion that capital investment and capital fully determine the next period's capital stock, i.e.  $k_{it} = (1 - \delta)k_{it-1} + i_{it-1}$ . In order to estimate the markup in this specification we need one extra step. The current specification would lead to a biased estimator for the markup since  $E(\Delta x_{it} \xi_{it}) \neq 0$ , since  $E(l_{it} \xi_{it}) \neq 0$  and  $E(m_{it} \xi_{it}) \neq 0$ . This is exactly what causes the simultaneity bias when estimating a production function since  $\omega_{it} = g(\omega_{it-1}, P_{it}) + \xi_{it}$ . This clearly shows that labor (materials) depends on current productivity and therefore reacts to the news term in the productivity Markov process ( $\xi_{it}$ ). However, given the assumption that labor and materials are essentially freely chosen variables and have no adjustment costs, we can rely on  $l_{it-1}$  and  $m_{it-1}$  to instrument for  $l_{it}$  and  $m_{it}$ , respectively, since  $E(l_{it-1} \xi_{it}) = E(m_{it-1} \xi_{it}) = 0$  and estimate the markup ( $\mu$ ) consistently using equation (21).

### 2.3 Returns to scale and the user cost of capital

Before turning to the more general *GMM* framework, we want to stress that the use of the control function has two major advantages in addition to correcting for unobserved productivity shocks in the production function framework. We are not required to measure the capital share ( $\alpha_{Kit} = \frac{r_{it} K_{it}}{P_{it} Q_{it}}$ ) and assume constant returns to scale in order to estimate the markup parameter. The standard Hall approach for instance had to rely on constant returns to scale to step away from the heroic task of measuring a firm-level user cost of capital  $r_{it}$ .<sup>18</sup>

<sup>18</sup>See Hall (1990) however, as already noted in footnote 4, who suggested a simple way to jointly estimate the returns to scale parameter and the markup.

In order to relax the returns to scale assumption researchers had to take a stand on the user cost of capital which has proven to be a very difficult job.

The use of the control function in our simple approach collects all the terms depending on capital and investment and does not require any assumption on the returns to scale and the user cost of capital. Obviously, these advantages do not come without any other assumptions. It is clear that we are able to eliminate them by relying on the result that we can proxy for unobserved productivity shocks using a non parametric function in the firm's state variables, in this case capital and investment. But as we will show below, we can accommodate more state variables and therefore relax some of the assumptions that the original Olley and Pakes (1996) framework relies on.

## 2.4 A GMM Approach

We now show how our estimator can be extended to allow any input to be dynamic and therefore constitute a state variable of the firm's problem. We show that is approach also allows for more flexible production technologies and timing assumptions of the inputs of the production process. In this section we briefly show that we can include all inputs into a non parametric function in a first stage and use the relevant timing assumptions in the second stage to estimate the parameters of interest. Remember that, in our setup, a crucial difference is that the input shares (input elasticities) are computed from data rather than estimates that we wish to obtain. If we believe that, for instance, labor cannot be hired without adjustment costs and similarly for intermediate inputs, therefore lagged labor and materials constitute additional state variables of the firm's problem. We demonstrate this using a proxy variable  $y_{it}$ , such that  $y_{it} = y(l_{it}, m_{it}, k_{it}, \omega_{it})$  is monotonically increasing in productivity  $\omega_{it}$ .<sup>19</sup>

Essentially our model then looks like follows

$$\Delta q_{it} = \Delta \phi_t(y_{it}, k_{it}, l_{it}, m_{it}) + \Delta \varepsilon_{it}^* \quad (23)$$

where  $\Delta \phi_t(y_{it}, k_{it}, l_{it}, m_{it}) = \mu(\alpha_{Lit}\Delta l_{it} + \alpha_{Mit}\Delta m_{it} + \alpha_{Kit}\Delta k_{it}) + \Delta h_t(y_{it}, k_{it}, l_{it}, m_{it})$  and the markup parameter  $\mu$  is not identified in a first stage. The first stage gets rid off all *i.i.d.* shocks, like measurement error. Our second stage, however, only requires one moment condition to identify  $\mu$ .<sup>20</sup> Given the underlying Markov process for productivity and the law of motion on capital, we can rely on several moments and test our model for overidentifying restrictions.

From the first stage we obtain an estimate of productivity up to a markup parameter,

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<sup>19</sup> $y_{it}$  can again be either investment or an intermediate input, and the burden of proving monotonicity greatly depends on the choice. If  $y_{it} = m_{it}$ ,  $y_{it}$  drops out everywhere.

<sup>20</sup>Note that this approach is also valid when considering (explicitly) production functions with higher order terms, such as the translog production function where the input growth term will include additional terms:  $((\Delta l)^2, (\Delta m)^2, (\Delta k)^2, \Delta l \Delta m, \Delta l \Delta k, \Delta m \Delta k)$ . Estimating the markup parameter proceeds in a similar way as described in this section by forming moments on productivity.

where we move from productivity growth to productivity in levels,

$$\omega_{it}(\mu) = \widehat{\phi}_{it} - \mu(\alpha_{Lit}l_{it} + \alpha_{Mit}m_{it} + \alpha_{Kit}k_{it}) \quad (24)$$

From the standard assumption that productivity follows an exogenous Markov process, we obtain moment conditions to identify  $\mu$ .<sup>21</sup> Given that  $\omega_{it} = g_t(\omega_{it-1}) + \xi_{it}$  we can non-parametrically regress  $\omega_{it}(\mu)$  on  $\omega_{it-1}(\mu)$  and obtain  $\xi_{it}(\mu)$  as a residual, for any value of  $\mu$ . The news term in the productivity process is not correlated with lagged labor, lagged intermediates and current and lagged capital. Note that we can select only one moment on capital and not impose that the capital stock at time  $t$  was determined a period ahead from previous capital and investment. The following moment conditions will identify the markup parameter using standard *GMM*,

$$E \left\{ \xi_{it}(\mu) \begin{pmatrix} l_{it-1} \\ m_{it-1} \\ k_{it-1} \end{pmatrix} \right\} = 0 \quad (25)$$

The sample analogue

$$\frac{1}{N} \frac{1}{T} \sum_i \sum_t \left\{ \xi_{it}(\mu) \begin{pmatrix} l_{it-1} \\ m_{it-1} \\ k_{it-1} \end{pmatrix} \right\} = 0 \quad (26)$$

is minimized using standard *GMM* techniques to provide us with an estimate for  $\mu$ . It is clear that we have overidentifying restrictions and can rely on only one the moments. However, as mentioned before the user cost of capital is hard to measure, and was implicitly assumed to be observed for the above *GMM* approach. Therefore we can relax this (as under the previous approaches) by replacing it by a returns to scale parameter  $\lambda$ . The latter shows that we are not able to identify a firm specific user cost of capital parameter and have to restrict it to be common across firms. The moments on  $(k_{it}, k_{it-1})$  can help identifying the returns to scale parameter.

### Special Case: Static intermediate input choice

A special case of the above approach recognizes the fact that intermediate inputs are typically adjusted freely.<sup>22</sup> Therefore, we can restrict our attention to the first stage to identify the markup parameter when relying on investments to proxy  $\omega_{it}$ . This results from the observation that when firms do not face adjustment costs for material inputs, we can identify the markup in a first stage as the coefficient on  $\alpha_{Mit}\Delta m_{it}$ . Formally, we have the following investment function  $i_{it} = i_t(k_{it}, \omega_{it}, l_{it})$ , and therefore can rely on  $\omega_{it} = h_t(i_{it}, k_{it}, l_{it})$

<sup>21</sup>Alternatively, we can rely on the results of Wooldridge (forthcoming) and rely on a system *GMM* approach where both stages are estimated simultaneously, and provide standard *GMM* standard errors as opposed to less efficient bootstrapping methods in the two stage approach.

<sup>22</sup>On a related note this is why often value added production functions are estimated.

as a proxy for unobserved productivity. This implies that the control function for productivity growth will include labor at  $t$  and  $t - 1$ .

$$\Delta q_{it} = \mu \alpha_{Mit} \Delta m_{it} + \Delta \phi_t(i_{it}, k_{it}, l_{it}) + \Delta \varepsilon_{it}^* \quad (27)$$

In fact, this is often a reasonable assumption we can take to the data: firms face hiring/firing costs for employees but can freely adjust their demand for intermediate inputs. We will estimate this specification and compare it to the results of other specifications. This section shows the flexibility of our approach since we can include additional state variables that potentially further control for unobserved productivity shocks. For instance, in the context of firms in international trade the export status could serve as an important additional state variable to take into account. We will come back to this in detail.

### 3 Exporters, productivity and markups

We can now rely on our empirical framework to analyze markup differences between exporters and non exporters. In addition, we are interested in how new exporters' markups change as they enter foreign markets. To answer this, we simply interact the input growth term  $\Delta x_{it}$  with a firm-time specific export status variable. In the context of sorting out markup differences between exporters and domestic firms, controlling for unobserved productivity shocks is absolutely critical given the strong correlation between export status and productivity. We will further explain our empirical model in detail once we have introduced the data and discuss the information we can rely on. We stress that we want to verify whether exporters charge different markups without taking a stand on any specific model of international trade. However, when interpreting the estimated markup parameters, we can turn to various models to interpret and explain our findings.

A number of models of international trade with heterogeneous producers and firm specific markups have predictions on the relationship between a firm's export status and its productivity level. Most of the empirical work in this literature has focussed on the latter, while not much attention has been devoted on the relationship between a firm's export status and its markup. These models generate the result that more productive firms set higher markups, and given that those firms can afford to pay an export entry cost therefore predict that exporters will have higher markups. Bernard et al (2003) rely on a Bertrand pricing game while allowing for firm-level productivity differences and show that on average exporters have higher markups. Recently, Melitz and Ottaviano (2008) model firms in an international trade setting that compete in prices where products are horizontally differentiated. This model generates a firm specific markup which is a function of the difference between the firm's marginal cost and the average marginal cost in the industry. Therefore, when a firm is relatively more productive, it can charge a higher markup and enjoy higher profits. Markups therefore drive a wedge between actual and measured productivity, and disproportionately so for exporting firms.

A wide range of models will predict the aforementioned relationship which essentially comes from a single source of heterogeneity on the supply side (productivity). Another strand of the trade literature explores the role of quality differences between exporters and non exporters. If exporters produce higher quality goods, while relying on higher quality inputs, all things equal they can charge higher markups. For an empirical analysis see Kugler and Verhoogen (2008) and Hallak and Savidasan (2009).

Both mechanisms are thus expected to generate higher markups for exporters in the *cross section*. In the *time series* dimension, however, it is not clear how markups change as firms enter export markets compared to already exporting firms and domestic producers. We therefore see this paper to provide both a check of current models of international trade generating a relationship between export status and markups, as well as providing new evidence on markup dynamics and export status. Since most theories are static in nature, they cannot speak to this time dimension. More recently Cosar, Guner and Tybout (2009) develop a dynamic general equilibrium trade model to explain certain features of the labor market, and their model implies that exporters charge higher markups because factor market frictions prevent them from freely adjusting their capacity as exporting opportunities come and go over time.

We therefore expect higher markups for exporters and our methodology is precisely designed to deliver an estimate of the markup for both domestic and exporting firms. It is clear that markup differences are related to both cost based and demand side mechanisms. However, once we have established our main results we can eliminate the productivity component from the markup difference and provide some suggestive evidence on the role of other factors such as quality for instance.

## 4 Background and data

We rely on a unique dataset covering all firms active in Slovenian manufacturing during the period 1994-2000.<sup>23</sup> The data are provided by the Slovenian Central Statistical Office and contains the full company accounts for an unbalanced panel of 7,915 firms.<sup>24</sup> We also observe market entry and exit, as well as detailed information on firm level export status. At every point in time, we know whether the firm is a domestic producer, an export entrant, an export quitter or a continuing exporter.

Table 1 provides some summary statistics about the industrial dynamics in our sample. While the annual average exit rate is around 3 percent, entry rates are very high, especially at the beginning of the period. This reflects new opportunities that were exploited after transition started.

Our summary statistics show how labor productivity increased dramatically, consistent

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<sup>23</sup>We refer to Appendix A for more details on the Slovenian data, and to De Loecker (2007a).

<sup>24</sup>The unit of observation is an establishment (plant) level, but we refer to it as a firm.

Table 1: Firm Turnover and Exporting in Slovenian Manufacturing

Year	Nr of firms	Exit rate	Entry rate	#Exporters	Labor Productivity
1995	3820	3.32	13.14	1738	14.71
1996	4152	2.60	5.44	1901	16.45
1997	4339	3.43	4.47	1906	18.22
1998	4447	3.94	4.14	2003	18.81
1999	4695	3.26	3.30	2192	21.02
2000	4906	2.69	3.38	2335	21.26

Labor Productivity is expressed in thousands of Tolars.

with the image of a Slovenian economy undergoing successful restructuring. At the same time, the number of exporters grew by 35 percent, taking up a larger share of total manufacturing both in total number of firms, as in total sales and total employment.

We study the relationship between exports and markups since exports have gained dramatic importance in Slovenian manufacturing. We observe a 42 percent increase in total exports of manufacturing products over the sample period 1994-2000. Furthermore, entry and exit has reshaped market structure in most industries. Both the entry of more productive firms and the increased export participation was responsible for significant productivity improvements in aggregate (measured) productivity (De Loecker and Konings, 2006 and De Loecker, 2007a). Therefore, we want to analyze the impact of the increased participation in international markets on the firms' ability to charge prices above marginal cost using our proposed empirical framework.

## 5 Results

In this section we use our empirical model to estimate markups for Slovenian manufacturing firms, and test whether exporters have, on average, different markups. In addition, we rely on substantial entry into foreign markets in our data to analyze how markups change with export entry and exit, and as such we are the first, to our knowledge, to provide robust econometric evidence of this relationship.

### 5.1 Exporters and markups

We collect our main results in Table 2 and compare the result from the standard Hall approach with various specifications of our empirical Model. *Control Function I* simply introduces the control for productivity growth as introduced in section 2.2. Furthermore, we show the estimates using a second approach (*Control Function II*) where we estimate the model without and with the selection correction. Finally, we estimate the markup allowing for adjustment cost in labor (*Control Function III*) and rely on our *GMM* framework.



Table 2: Markups in Slovenian Manufacturing

Specification	Estimated Markup	Standard Error
Standard Hall	1.03*	0.004
Control Function I	1.11*	0.007
Control Function II	1.13*	0.006
Control Function II including Selection	1.11*	0.007
Control Function III ( <i>GMM</i> )	1.14*	0.008
<i>Exporters versus Domestic Producers</i>		
Standard Hall		
average markup	1.0279*	0.006
exporter effect	0.0155	0.010
Control Function		
average markup	1.0543*	0.009
exporter effect	0.1263*	0.013

All regressions include time and industry dummies.

A robust finding is that the estimated markup is higher when we rely on the control function to proxy for unobserved productivity growth and the non random exit of firms. This is consistent with the transition process where firms scaled down employment after long periods of labor hoarding, as well as the entry of *de novo* firms who enter at a much smaller scale.

In the lower panel we verify whether exporting firms (on average) have higher markups (given that exporters tend to produce at lower marginal costs) and compare our results with the standard Hall approach.<sup>25</sup> To identify the potentially different markup for exporters we keep notation general and rely on a proxy  $y_{it}$  and refer to the discussion on the relative advantages of both LP and OP. Therefore,  $\Delta x_{it}$  will not capture materials ( $\alpha_{Mit}m_{it}$ ) when we rely on the LP approach where  $y_{it} = m_{it}$ . We refer to Appendix C for more details of the specific models. In order to estimate the markup for exporters we extend our main estimating equation and interact the relevant term,  $\Delta x_{it}$ , with an exporter dummy  $EXP_{it}$ .

$$\Delta q_{it} = \mu_D \Delta x_{it} + \mu_E \Delta x_{it} EXP_{it} + \delta_E EXP_{it} + \Delta \phi_t(y_{it}, k_{it}) + \Delta \varepsilon_{it} \quad (28)$$

where  $\mu_D$  is the average markup for domestic producers and  $\mu_E$  is the additional markup for exporters. When relying on the standard Hall specification, we cannot find significantly different markups for exporting firms.<sup>26</sup> On the contrary, our approach is better suited to analyze markups differences between exporters and non-exporters, since we can explicitly control for the export-productivity correlation in addition to the standard input growth-

<sup>25</sup>Our results are robust with respect to using firm specific or industry average labor and material shares ( $\alpha_{Lit}, \alpha_{Mit}$ ) to construct  $\Delta x_{it}$ , and considering firms with positive investment. In Appendix B we report the estimated markups for the various industries.

<sup>26</sup>A few papers analyzed this relationship using the Roeger method (Görg and Warzynski, 2003; Bellone et al., 2007) and find higher markups for exporters as well. As mentioned before, we provide a more flexible approach that does not rely on the assumption of constant returns to scale and that capital is a flexible input.

productivity growth correlation.<sup>27</sup> Both correlations need to be controlled for in order to estimate a markup for domestic producers and exporters consistently. Indeed, when we control for unobserved productivity shocks, we find a significant higher markup for exporters. These markup differences can be generated by various mechanisms, ranging from differences in quality of products, to differences in demand elasticities, or simply due to lower costs of production.

As mentioned before, the results established in Table 2 are consistent with recent models of international trade such as the model of Bernard et al (2003) where exporters charge on average higher markups, simply because they are more productive and can therefore undercut their rivals. This prediction is supported by comparing the average markup of exporters to non exporters in the cross section. However, in their model firms of the same productivity will charge the same markup, making productivity differences the only source for markup differences. Relying on a previous study estimating productivity premia for exporters in Slovenia by De Loecker (2007a), our estimates of the markup suggest that productivity differences are not sufficient to explain the markup difference between exporters and domestic producers.

This result has potential important policy implications. The well documented productivity premium of exporters could, at least partly, be reflecting markup differences. Recent models of international trade with heterogeneous firms emphasize the reallocation of market share from less efficient producers to more efficient exporters. This mechanism relies on exporters being more productive, because they can cover the fixed cost of entering foreign markets. A growing list of empirical studies has documented (measured) productivity premia for exporters, and furthermore recent work has found evidence on further improvements in (measured) productivity post export entry (learning by exporting). Our results, however, require a more cautious interpretation of the exporter productivity premium and how exporting contributes to aggregate productivity growth. More specifically, given that measured productivity is a simple residual of a sales generating production function, it is well known that it contains unobserved quality differences in both inputs and output, as well as market power effects broadly defined.<sup>28</sup> Our results therefore provide additional information in explaining the measured productivity premium, and emphasize the importance of studying the export-productivity relationship jointly with market power in an integrated framework. We further investigate the markup trajectory as a function of export status in the next section. The latter will allow us to dig deeper in the (measured) productivity trajectories after export entry.

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<sup>27</sup>Our empirical model can be accommodated to allow a firm's export status to impact investment decisions indirectly by allowing the investment function to differ by export status, or by modelling a firm's export status as a relevant state variable. It will imply that we have to estimate the markup in a second stage.

<sup>28</sup>In fact the markup differences between exporters and domestic producers only fully reflect cost (productivity) differences if both domestic producers and exporters set the same output prices.

## 5.2 Export entry and markup dynamics

So far we have just estimated differences in average markups for exporters and domestic producers. Our dataset also allows us to test whether markups differ significantly *within the group* of exporters. It is especially of interest to see whether there is a specific pattern of markups for firms that enter export markets, i.e. before and after they become an exporter. This will help us to better interpret the results from a large body of empirical work documenting productivity gains for new exporters. These results are used to confirm theories of self-selection of more productive firms into export markets as in Melitz (2003) or learning by exporting. We now turn our attention to the various categories of exporters that we are able to identify in our sample: starters, quitters and firms that export throughout the sample period.

To capture the relationship between how markups change as a firm enters or exits an export market, we run a similar regression interacting the markup with a firm-time specific export status variable, defined as a set of dummies,  $status_{it}$ , as follows

$$\begin{aligned}\Delta q_{it} &= \mu \Delta x_{it} + status_{it} * \Delta x_{it} + \Delta \phi_t(y_{it}, k_{it}) + \Delta \varepsilon_{it} \\ status_{it} &= (\mu_{s,b} B_{it}^{st} + \mu_{s,a} A_{it}^{st} + \mu_{al} AL_{it} + \mu_{q,b} B_{it}^q + \mu_{q,a} A_{it}^q)\end{aligned}\tag{29}$$

In equation (29)  $B_{it}^{st}$  is a dummy equal to 1 if the firm starts exporting (we call these firms ‘starters’) during our period of analysis, say at time  $t_0^{Start}$ , and the observation takes place before it starts exporting ( $t < t_0^{Start}$ ), and equal to 0 otherwise;  $A_{it}^{st}$  is equal to 1 if the firm starts exporting and we observe it after it started exporting ( $t \geq t_0^{Start}$ ), and equal to 0 otherwise;  $AL_{it}$  is equal to 1 if the firm is always exporting during our period of analysis, and 0 otherwise;  $B_{it}^q$  is equal to 1 if the firm stopped exporting during the period (we refer to these firms as ‘quitters’), but is observed while it was still an exporter, and equal to 0 otherwise;  $A_{it}^q$  is equal to 1 if the firm stopped exporting and is observed after it stopped exporting, and equal to 0 otherwise. The default category consists of firms producing only for the domestic market.

		Coefficient	s.e.
Baseline (domestic)		1.04*	0.012
Starters	Before Entering	0.08**	0.033
	After Entering	0.15*	0.021
Always exporters		0.14*	0.020
Stopper	Before Exiting	0.03	0.020
	After Exiting	-0.11*	0.030

Regression includes industry and year dummies in addition to separate dummy variables.

Table 3 shows the results and we clearly see that firms which are always exporting have a

larger markup than firms that sell only on the domestic market, consistent with the evidence reported above. A new set of results emerges in the rows two to six. Firms entering export markets have a larger markup even before they start exporting than their domestic counterparts. The latter is consistent with the self-selection hypothesis whereby more efficient firms find it productive to pay the fixed cost of entering an export market. Here more efficient can mean that a domestic firm might simply produce at a higher cost while charging the same price, or alternatively that they sell higher quality products.<sup>29</sup>

Interestingly, markups increase very substantially, on average, after export entry and the average markup increases to a level slightly above the markup of firms that continue exporting. The difference, however, is not significant.

For firms that stop exporting, their markup did not deviate from the level of non-exporting firms when they were still exporting, but after they stop exporting, the markup drops dramatically.<sup>30</sup> Figure 1 shows this evolution graphically. It is important to note that these patterns are not found when we do not control for unobserved productivity shocks, in fact markups are not significant and much lower in magnitude. The latter shows again the importance of controlling for the correlation between export status and productivity shocks.

It is striking to see that the markup-export patterns are identical to the productivity-export patterns found in De Loecker (2007a). He finds that productivity increases upon export entry and that exporters are more productive than their domestic counterparts. These results are suggestive of changes in performance of new exporters due to higher markups.

Our evidence suggests that the gap between the notion of (physical) productivity in theoretical models of international trade with heterogeneous producers and the empirical measurement of productivity is an important one, i.e. markups are different for exporters and they change significantly, both economically and statistically, when firms enter export markets.

How can we explain our results? A few recent models (Bernard et al., 2003, Melitz and Ottaviano (2008) provide a theoretical analysis of the relationship between firm export status and (market specific) markups. Under various hypotheses regarding the nature of competition, more efficient producers are more likely to have more efficient rivals, more likely to charge lower prices, to sell more on the domestic market and also to beat rivals on export markets. They benefit from a cost advantage over their competitors, set higher mark-ups (under certain conditions regarding the relative efficiency between firms on the domestic and the export market in the case of the Melitz and Ottaviano model) and have higher levels of measured productivity. An alternative explanation could be that the elasticity of demand is different on the export market, or that consumers have different valuation for the good. The exact mechanism underlying these results is not testable given the data at hand. For

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<sup>29</sup>The difference is quite important and relates to the work of Foster et al (2008) where productivity and profitability are addressed separately.

<sup>30</sup>This could suggest that these firms were exporting poor quality products to Eastern European countries.

instance we do not have firm specific information on prices which could allow us to separate out the markup difference into a cost and price effect.<sup>31</sup> However, our results are important to help explain how exporting affects firm performance. We now turn to some implications for measured productivity at the firm and industry level.

### 5.3 Implications for productivity growth

Our framework allows us to back out estimates for productivity growth after estimating markups. However, now we have to take a stand on the returns to scale - or implicitly on the user cost of capital - under which firms produce.<sup>32</sup> It is clear from equation (7) that we can only compute implied productivity growth after imputing values for  $\alpha_{Kit}$ . Let us return to the main estimating equation before introducing the use of the control function and consider productivity growth

$$\Delta q_{it} - \widehat{\mu}(\alpha_{Lit}\Delta l_{it} + \alpha_{Mit}\Delta m_{it} + (\lambda - \alpha_{Lit} - \alpha_{Mit})\Delta k_{it}) = \widehat{\Delta\omega}_{it} \quad (30)$$

We rely on our estimates of the markup  $\widehat{\mu}$  and impose various values for the returns to scale parameter  $\lambda$ . We consider three different cases where  $\lambda$  will take values of 1, 1.1 and 0.9 or constant, increasing and decreasing returns to scale. In this way we can compare the productivity growth estimates between the uncorrected approach (column I) and our control function approach (column II) under the three different cases. It is clear that using standard techniques will lead to biased estimates for productivity growth since they are based on downward biased markup estimates. Within the context of sorting out markup differences between exporters and domestic producers, the uncorrected approach would actually predict no differences in productivity growth, conditional on input use, between the two, which is clearly in contradiction with empirical evidence. Table 4 shows the implied average productivity growth under the various scenarios for both approaches.

Table 4: Implied Productivity Growth (Annual Averages in percentages)

	CRS		IRS		DRS	
	I	II	I	II	I	II
A Manufacturing	3.52	2.16	3.01	1.58	4.03	2.75
B Industry (weighted)	3.21	1.57	2.77	1.03	3.73	2.11
C Manufacturing (status)	3.52	2.45	3.01	1.87	4.03	3.07

I is standard model without correction, II is control function approach.

We report productivity growth as simple average across all firms in Slovenian manufacturing (A), as an average of industry specific sales weighted productivity (B) and as an average obtained from regression (29) averaged over all firms (C). The various comparisons in table 4

<sup>31</sup>Simple calculations based on De Loecker (2007a) estimates of exporters' productivity premia do imply that around a third of the higher markup for exporters is not related to costs or productivity.

<sup>32</sup>Note that we do not have to make any assumptions on returns to scale when estimating the markup parameter.

clearly show that productivity growth is overestimated without controlling for the endogeneity of inputs and markup differences (column I). Indeed, productivity growth is roughly only half of what we obtain when we ignore these two effects (column II). The bias is not specific to the returns to scale we assume, however, the implied productivity estimates do depend on the values for  $\lambda$ .

The last row shows productivity growth under our specification (29) where we allow for markups to change with a change in a firm’s export status. These effects are not present when we do not control for unobserved productivity shocks, and therefore the productivity growth estimates are exactly the same as in row A. Although our method is not intended to directly provide estimates for productivity growth, we see this as an important cross validation of the estimated markup parameters. Our estimates suggest average annual productivity growth rates for Slovenian manufacturing between 3 and 1.5 percent.

Our results have some important implications for aggregate productivity. It is immediately clear that when relying on the standard framework, markups are underestimated for domestic producers and even more so for exporters. It first of all implies that we will overestimate aggregate manufacturing productivity growth, even when ignoring differences in markups between exporters and domestic producers. However, when analyzing productivity growth of sectors or countries during a period where export participation increased, an additional bias kicks in. Based on our estimates it is straightforward to show how aggregate productivity growth is overestimated when not controlling for different markups across domestic producers and exporters. In the case of Slovenia, the bias in aggregate productivity growth becomes larger as resources were reallocated towards exporters and therefore account for a growing share in aggregate output as the number of exporters quadrupled and export sales grew substantially. These results therefore suggest that aggregate productivity gains from increased export participation, as suggested in Melitz (2003), are damped when exporters charge, on average, higher markups. The wedge between *measured* and *actual* aggregate productivity growth increases as a larger share of manufacturing firms are becoming exporters and are accounting for a larger share of total output. This distinction between measured productivity growth and actual productivity due to market power effects is consistent with recent models of international trade with heterogeneous producers.

## 5.4 Robustness and final remarks

We discuss two robustness checks below. In turn we discuss the use of deflated sales to proxy for output and we allow for different markups for exporters in foreign markets and the domestic market.

### 5.4.1 Unobserved prices and revenue data

Implicitly we have treated deflated sales as a measure of physical quantity, and therefore our approach is potentially subject to the same concern as the estimation of production

functions where deflated revenue is used to proxy for output. However, in our context the bias in the markup parameter is reduced to the extent that unobserved growth in firm-level price deviations away from the average price are correlated with input growth. Moreover, our estimating routine already incorporates a full interaction of industry and year dummies which controls for price trends and unobserved demand shocks in the spirit of Klette and Griliches (1996) and Katayama, Lu and Tybout (2009). De Loecker (2007b) shows that not observing prices is mostly severe for obtaining reliable measures for productivity, which is not our main objective.<sup>33</sup>

To see how our main estimating equation is affected by not observing firm-level prices, we explicitly introduce deflated revenue  $\Delta r_{it}$  to proxy for output growth and verify how it potentially biases the markup parameter. The estimating equation then becomes

$$\Delta r_{it} = \mu \Delta x_{it} + \Delta \phi_t(y_{it}, k_{it}) + \Delta(p_{it} - p_t) + \Delta \varepsilon_{it} \quad (31)$$

The main concern is the correlation between  $\Delta x_{it}$  and  $\Delta(p_{it} - p_t)$ . We expect this correlation to be negative as mentioned in the original work by Klette and Griliches (1996) under quite general demand and cost specifications, i.e. all things equal more inputs will lead to higher output and push prices down. This is an important observation for evaluating our results. This implies that if anything we are underestimating markups. The significantly higher estimated markups, while controlling for productivity shocks through the control function, are in fact consistent with this. More specifically, as shown in De Loecker (2007b) the control function  $\Delta \phi_t(y_{it}, k_{it})$  fully controls for unobserved demand shocks following the same process as the productivity unobservable  $\omega_{it}$ . This observation together with the inclusion of a full interaction of industry and year dummies, further eliminates the potential correlation between  $\Delta x_{it}$  and  $\Delta(p_{it} - p_t)$ . In terms of our main set of results, where we estimate different markups for exporters, and how markups change with firms' export status, we further potentially control for unobserved prices growing differently for exporters and non exporters, or more precisely for firms switching their particular export status. Furthermore, including the control function in investment and capital controls for plant size, and eliminates the potential correlation between price changes and export status through plant size.

#### 5.4.2 Export destination and markups

We tested whether exporters' (average) markups are different in the domestic ( $\mu_{E,D}$ ) and foreign markets ( $\mu_{E,E}$ ) to further isolate potential sources of the difference in markups. We proceeded by simply decomposing  $\mu_E$  into  $(\mu_{E,D}s_{it}^D + \mu_{E,E}s_{it}^E)$ , where  $s_{it}^D$  and  $s_{it}^E$  are the share of domestic and foreign sales in total sales, respectively. We find only a slightly lower domestic markup (0.126), but not statistically different from the foreign market's markup (0.132). In fact, using the firm specific shares, the average total export markup parameter is

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<sup>33</sup>The coefficients on the inputs do hardly change when controlling for unobserved prices and demand shocks. Klette and Griliches (1996) document similar findings using U.S. manufacturing data.

0.131, compared to 0.1263 in Table 2. The above test rests on an implicit assumption that the share of domestic (export) sales in total sales are the correct weights, and implies that inputs are used proportional to sales. Under this working assumption, our results indicate that we cannot solely attribute the markup difference to differences in domestic and foreign market elasticities or other aggregate variables. However, for the case of Slovenia exporting includes shipping products to regions formerly part of the Yugoslavian Republic prior to Slovenia's independence in 1991. We therefore rely on firm-level export destination information to check whether markups are different across various export destination markets.<sup>34</sup>

As mentioned above, recent work has documented that exporters produce and ship higher quality products while controlling for a host of firm-level characteristics including size, where quality is measured indirectly by either unit prices or whether a firm has an ISO 9000 certification.<sup>35</sup> In order to see whether markups are higher for exporters sending their products to high income regions such as Western Europe, we simply include interaction terms of  $\Delta x_{it}$  with the various export destination regions to the estimating equation (28). We obtain a positive estimate of 0.045 on the Western European interaction term, but estimated less precise with a standard error of 0.022 as expected given the remaining degree of heterogeneity within the region of Western Europe. This implies that exporters shipping to this region, on average, charge a markup of 1.215, compared to 1.05 for domestic producers. Our results are clearly consistent with the quality hypothesis, given that it is expected that quality standards are higher in Western European markets than in the Slovenian domestic market. Furthermore, the implied productivity differences obtained in the previous section are not able to explain the 16.5 percent higher markups, suggesting an important role for quality differences among exporters and domestic producers. Given the data constraints we cannot measure quality at the firm level and therefore leave this for future research.

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<sup>34</sup>As mentioned in De Loecker (2007a) the destination information is not available at each point in time in our sample. We therefore return to our cross sectional comparison of exporters and domestic producers.

<sup>35</sup>For instance Kugler and Verhoogen (2008) document this for Colombia, and Hallak and Sivadasan (2009) provide evidence for manufacturing establishments in India, the U.S, Chile and Colombia.



## 6 Discussion and Conclusion

This paper investigates the link between markups and exporting behavior. In order to analyze this relationship we propose a simple and flexible methodology to estimate markups building on the seminal paper by Hall (1986) and the work by Olley and Pakes (1996). The advantages of our method are that we explicitly consider the selection process in the estimation and do not rely on the assumption of constant returns to scale and the need to compute the user cost of capital.

We use data on Slovenia to test whether i) exporters, on average, charge higher markups and ii) whether markups change for firms entering and exiting export markets. Slovenia is a particularly interesting emerging economy to study as it has been successfully transformed from a socially planned economy to a market economy in less than a decade, reaching a level of GDP per capita over 65 percent of the EU average by the year 2000. More specifically, the sample period that we consider is characterized by considerably productivity growth and relative high turnover. Our methodology is therefore expected to find significantly different markups as we explicitly control for the non random exit of firms and unobserved productivity shocks. Our results confirm the importance of these controls.

Our method delivers higher estimates of firm-level markups compared to standard techniques that cannot directly control for unobserved productivity shocks. Our estimates are robust to various price setting models and specifications of the production function. We find that markups differ dramatically between exporters and non exporters, and find significant and robust higher markups for exporting firms. The latter is consistent with the findings of productivity premium for exporters, but at the same time requires a better understanding of what these (revenue based) productivity differences exactly measure. We provide one important reason for finding higher measured revenue productivity: higher markups. Furthermore, we provide new econometric evidence that markups increase when firms enter export markets.

Our evidence suggests that the gap between the notion of (physical) productivity in theoretical models of international trade with heterogeneous producers and the empirical measurement of productivity is an important one, i.e. markups are different for exporters and they change significantly, both economically and statistically, when firms enter export markets. We see these results as a first step in opening up the productivity-export black box, and provide a potential explanation for the big measured productivity gains that go in hand with becoming an exporter. In this way our paper is related to the recent work of Costantini and Melitz (forthcoming) who provide an analytic framework that generates export entry productivity effects due to firms making joint export entry-innovation choice, where innovation leads to higher productivity.

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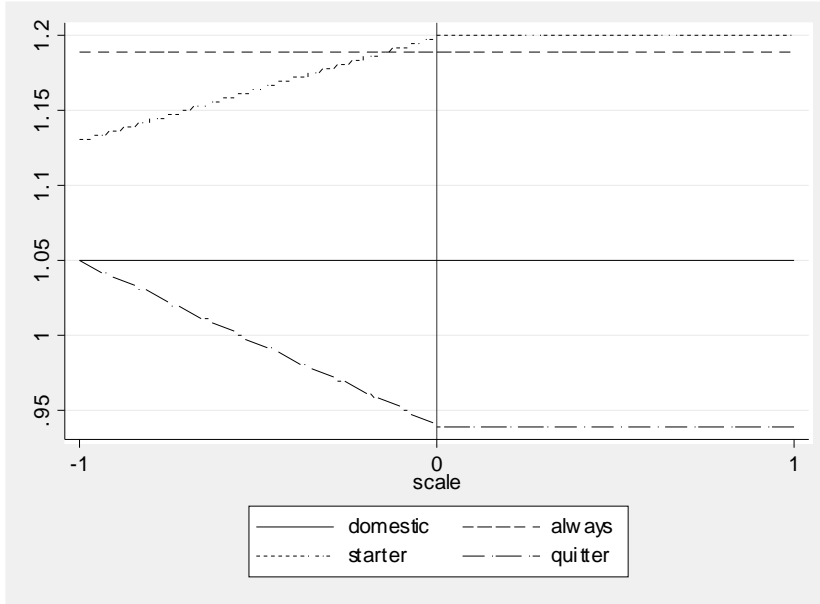


Figure 1: Export-Markup Dynamics in Slovenian Manufacturing.

## Appendix A: Data Description

In this appendix we describe the firm-level data used more in detail. The data are taken from the Slovenian Central Statistical Office and are the full annual company accounts of firms operating in the manufacturing sector between 1994-2000. The unit of observation is that of an establishment (plant). In the text we refer to this unit of observation as a firm. Related work using the same data source includes De Loecker (2007a) and references herein. We have information on 7,915 firms and it is an unbalanced panel with information on market entry and exit and export status. The export status - at every point in time - provides information whether a firm is a domestic producer, an export entrant or a continuing exporter. If we only take into account those (active) firms that report employment, we end up with a sample of 6,391 firms or 29,804 total observations over the sample period.

All monetary variables are deflated by the appropriate two digit NACE industry deflators and investment is deflated using a one digit NACE investment deflator. The industry classification NACE rev. 1 is similar to the ISIC industry classification in the U.S.A. and the level of aggregation is presented in Table A.1 below.

Table A.1.: Industry Classification

Nace 2-Digit	Description
15	Food Products
16	Tobacco Products
17	Textiles
18	Wearing Apparel
19	Leather and Leather Products
20	Wood and Wood Products
21	Pulp, Paper and Paper Products
22	Publishing and Printing
23	Coke and Petroleum Products
24	Chemicals
25	Rubber and Plastic Products
26	Other Non-Metallic Mineral Products
27	Basic Metals
28	Fabricated Metal Products
29	Machinery and Equipment n.e.c.
30	Office Machinery and Computers
31	Electrical Machinery
32	RTv and Communication
33	Medical, Precision and Optical Instr.
34	Motor Vehicles
35	Other Transport Equipment
36	Furniture/ Manufacturing n.e.c.
37	Recycling

We observe all variables every year in nominal values, however, we experimented with both reported investment and computed investment from the annual reported capital stock and depreciation. Investment is calculated from the yearly observed capital stock in the following way  $I_{ijt} = K_{ijt+1} - (1 - \delta_j)K_{ijt}$  where  $\delta_j$  is the appropriate depreciation rate (5%-20%) varying across industries  $j$ . The variables used in the analysis are: sales in thousands of Tolars, Employment: Number of full-time equivalent employees in a given year, Capital: Total fixed assets in book value in thousands of Tolars. Finally, the firm-level dataset has information on the ownership of a firm, whether it is private or state owned. The latter is very important in the context of a transition country such as Slovenia. In our sample around 85 (5,333 in 2000) percent of firms are privately owned and a third of them are exporters (1,769 in 2000).

Year 2000	Export Status			
	0	1	Total	
	0	227	690	917
Private Owned	1	3,564	1,769	5,333
	Total	3,791	2,459	6,250

The ownership status of a firm serves as an important control by comparing productivity trajectories of exporting and non exporting firms with the same ownership status (private or state). All our results are robust to controlling for ownership differences and by comparing exporters to privately owned domestic firms.



## Appendix B: Industry Markups and Export Dynamics

We report the estimated markup coefficients for the various industries of the Slovenian manufacturing sector. These coefficients are obtained after running the exact same regression as in Table 2 (upper panel) by industry to free up the markup parameter. This robustness check shows that our results are not specific to certain sectors or aggregation. Furthermore, the markup-export results are also recovered at the industry level and those tables can be obtained from the authors upon request.

Table 5: Estimated Industry Markups

Industry (2 digit NACE)	Estimated Markup ( $\mu$ )
15	1.1525
17	0.9868
18	1.0764
19	1.0612
20	1.0517
21	1.1037
22	1.0726
24	1.0837
25	1.1279
26	1.0765
27	1.0457
28	1.1099
29	1.1683
31	1.1806
32	1.1996
33	1.0850
34	1.2525
36	1.1627

### Appendix C. Identifying Markups for Exporters

We briefly go over the details of the estimation under both the LP, OP and the *GMM* approach.

#### 1. Static input control ( $y_{it} = m_{it}$ )

The parameters  $(\mu_D, \mu_E)$  are identified in the first stage by running

$$\Delta q_{it} = \mu_D \Delta x_{it} + \mu_E \Delta x_{it} EXP_{it} + \delta_E EXP_{it} + \Delta \phi_t(m_{it}, k_{it}) + \Delta \varepsilon_{it} \quad (32)$$

where  $\Delta x_{it} = \alpha_{Lit} l_{it}$ . It is worth noting that under the LP approach, we do not have to specify the law of motion on productivity and can allow for any. We see this as a substantial advantage especially given the literature on self-selection versus learning by exporting, which might imply to incorporate past export activity in the  $g_t(\cdot)$  function.

#### 2. Dynamic control ( $y_{it} = i_{it}$ )

When relying on the OP control we can identify the parameters in a first stage by considering

$$\Delta q_{it} = \mu_D \Delta x_{it} + \mu_E \Delta x_{it} EXP_{it} + \delta_E EXP_{it} + \Delta \phi_t(i_{it}, k_{it}) + \Delta \varepsilon_{it} \quad (33)$$

where  $\Delta x_{it} = \alpha_{Lit} l_{it} + \alpha_{Mit} \Delta m_{it}$ . However, as noted by LP when extending the original OP setup to allow for exporters, additional state variables are required to enter the model. In our case, lagged export status would be the obvious candidate and imply that  $i_{it} = i_t(k_{it}, \omega_{it}, EXP_{it-1})$ . Van Biesebroeck (2005) and De Loecker (2007a) discuss invertibility in this setting. This gives us

$$\Delta q_{it} = \mu_D \Delta x_{it} + \mu_E \Delta x_{it} EXP_{it} + \delta_E EXP_{it} + \Delta \phi_t(i_{it}, k_{it}, EXP_{it-1}) + \Delta \varepsilon_{it} \quad (34)$$

where  $\Delta \phi_t(i_{it}, k_{it}, EXP_{it-1}) = \mu \alpha_{Kit} \Delta k_{it} + h_t(i_{it}, k_{it}, EXP_{it-1}) - h_{t-1}(i_{it-1}, k_{it-1}, EXP_{it-2})$ . The equation above shows that the export markup parameter is identified of the firms who switch export status between  $t - 1$  and  $t$ .

#### 3. A *GMM* approach

The model is unchanged if we rely on materials to proxy for productivity. However, if we consider investment, we need to include the additional state variable into the *GMM* approach. The steps are as before.

$$\Delta q_{it} = \Delta \phi_t(i_{it}, k_{it}, l_{it}, EXP_{it-1}) + \Delta \varepsilon_{it}^* \quad (35)$$

where  $\Delta \phi_t(y_{it}, k_{it}, l_{it}, m_{it}) = \mu_D \Delta x_{it} + \mu_E \Delta x_{it} EXP_{it} + \delta_E EXP_{it} + \Delta h_t(i_{it}, k_{it}, l_{it}, EXP_{it-1})$ . From the first stage we obtain an estimate of productivity up to a markup parameter, where we move from productivity growth to productivity in levels,

$$\omega_{it}(\boldsymbol{\mu}) = \hat{\phi}_{it} - \mu_D \Delta x_{it} - \mu_E \Delta x_{it} EXP_{it} - \delta_E EXP_{it} \quad (36)$$

where  $\boldsymbol{\mu} = (\mu_D, \mu_E)$ . From the standard assumption that productivity follows an exogenous Markov process, we obtain moment conditions to identify  $(\mu_D, \mu_E)$ .

Given that  $\omega_{it} = g_t(\omega_{it-1}) + \xi_{it}$  we can non parametrically regress  $\omega_{it}(\boldsymbol{\mu})$  on  $\omega_{it-1}(\boldsymbol{\mu})$  and obtain  $\xi_{it}(\boldsymbol{\mu})$  as a residual, for any value of  $\boldsymbol{\mu}$ . The news term in the productivity process is not correlated with lagged labor, lagged intermediates and current and lagged capital, and lagged export status. The following moment conditions will identify the markup parameters using standard *GMM*,

$$E \left\{ \xi_{it}(\boldsymbol{\mu}) \begin{pmatrix} l_{it-1} \\ m_{it-1} \\ k_{it-1} \\ EXP_{it-1} \end{pmatrix} \right\} = 0 \quad (37)$$

As before, the moments on the production function coefficients are used to identify the domestic markup and the differential input variation for exporters is used to pin down the additional markup for exporters.

However, as noted by De Loecker (2010), the exogenous productivity process rules out learning by exporting to take place in the data. This would at the very least imply that  $\omega_{it} = g_t(\omega_{it-1}, EXP_{it-1}) + \xi_{it}^*$ . To accommodate this we can obtain  $\xi_{it}^*(\boldsymbol{\mu})$  as a residual from non parametrically regressing  $\omega_{it}(\boldsymbol{\mu})$  on  $\omega_{it-1}(\boldsymbol{\mu})$  and  $EXP_{it-1}$ . This guarantees that  $E(\xi_{it}^* EXP_{it-1}) = 0$  which identifies  $\mu_E$ .

We ran all the above procedures on the data and found estimates very close to the one reported in the Tables. Again, we see this as a strength of our approach, and allows flexibility on the modelling side depending on the application at hand. In our setting we show a robust result that exporters charge significantly higher markup over cost.