Markups and Firm-Level Export Status: Appendix

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Forthcoming *American Economic Review*

Abstract

This is the appendix to De Loecker and Warzynski (forthcoming). First, we describe the data in more detail. Second, a short discussion on underlying models of price setting is discussed in light of our methodology. Finally, we discuss a few econometric details of the estimation routine under various specifications of the production function.

1 Data Description

In this appendix, we describe the firm-level data used in more 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 (2007) 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. The industry classification NACE rev. 1 is similar to the ISIC industry classification in the United States. We refer the reader to De Loecker (2007) for more details on the industry classification.

All monetary variables are deflated by the appropriate two digit NACE industry deflators (for output and materials). Investment is deflated using a one digit NACE investment deflator. The variables used in the analysis are: Sales (PQ): Total operating revenue in thousands of Tolars, total operating revenue from exporting in thousands of Tolars, Value added in thousands of Tolars (VA), Employment (L): Number of full-time equivalent employees in a given year, Capital (K): Total fixed assets in book value in thousands of Tolars, Material consumption in thousands of Tolars (M), Total cost of employees (wage bill) in thousands of Tolars (wL), and export status (e) at each point in time. 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 δ_j is the appropriate depreciation rate (5%-20%) varying across industries.

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). The ownership status of a firm serves as an important control by comparing markup 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.

2 Appendix B Price Setting

In the main text we show that we simply require the FOCs from cost minimization. In this appendix we want to show how a few leading cases of price setting fit in our framework and show how they relate to our procedure. The various expressions can be used to further test implications of those price setting theories using our estimates. As such we can interpret the markup under various assumptions regarding the nature of competition in the industry. We consider this flexibility an important strength of our approach.

Consider firms that produce a homogeneous product and compete in quantities (play Cournot) while operating in an oligopolistic market where profits π_{it} are given by $\pi_{it} = P_t Q_{it} - w_{it}L_{it} - p_{it}^m M_{it} - r_{it}K_{it}$ where all firms take input prices (w_{it}, p_{it}^m and r_{it}) as given. The optimal choice of labor is simply given by setting the marginal revenue product equal to the wage,

$$\frac{\partial Q_{it}}{\partial L_{it}} = \frac{w_{it}}{P_t}\left(1 + \frac{s_{it}}{\eta_t}\right)^{-1}$$

where $s_{it} = \frac{Q_{it}}{Q_t}$ is the market share of firm i, η_t is the market elasticity of demand. The second term on the right hand side is exactly equal to the firm's markup in equilibrium. We can then recover a similar expression for the output elasticity of labor as discussed in the main text under more general conditions.

A similar expression can be obtained with a more general model of Bertrand competition (Nash in price) with differentiated products. The markup over marginal cost, P_{it}/C_{it}, in a Nash equilibrium among firms is in fact given by $\left(1 + \frac{1}{\eta_{it}}\right)^{-1}$, which is our measure of the markup, and $\mu_{it} \equiv \left(1 + \frac{1}{\eta_{it}}\right)^{-1}$. A firm's individual residual demand elasticity η_{it} will in general depend on the degree of product differentiation, the number of firms and the elasticities of demand, both own and cross price elasticities.

The same notion applies when considering multiproduct firms 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. A FOC will apply for each product which will allow to recover each product's relevant markup up to observing product specific input expenditures and the ability to estimate product specific output elasticities. The latter is clearly a challenge given current data where input usage is not recorded by product across a wide range of industries (or by destination of the product produced as mentioned before). Our methodology can therefore be thought of providing a firm specific markup, potentially averaged across various products. But we would like to emphasize that our methodology is readily applicable whenever we see input expenditure by product, coupled with estimates on technology.

In this way our empirical model can take into account pricing heterogeneity between firms, and is flexible enough to consider various assumptions regarding the nature of competition and accommodates most commonly used static models of competition used in industrial organization and international trade. It is important to stress that regardless of the exact model of competition we always estimate the correct markup. What is important to note though, is that the estimates μ_{it} will depend on different economic variables depending on the underlying economic model. Our framework can further shed light on the relationship between markups and such economic variables.

3 Estimating Output Elasticities: Application to Exporting and Alternative Approaches

In this Appendix we present the specific estimation routine for our application, where exporters potentially face different demand and hence input demand. In addition, we discuss our estimation routine under a gross output production function. The latter will generate estimates of both the output elasticity of labor and materials, and allows us to rely on materials to compute markups. Furthermore, we describe our estimation routine when relying on investment to proxy for productivity. Finally, we briefly discuss the case of a CES production function to highlight the flexibility of our approach regarding technology.

3.1 Estimation routine: export status.

In our application we need to specify the variables included in $\mathbf{z}_{it}$ which impact input demand choices in addition to a firm's productivity and capital stock. As mentioned in the text we include a firm's export status in all specifications. We therefore rely on $\omega_{it} = h_t(m_{it}, k_{it}, e_{it})$ to proxy for productivity in the production function estimation. Applying our approach to the export case requires the inclusion of a firm's export status e_{it}, in addition to firm-specific input prices (wages, and materials in the case of a gross output production function) and potentially other market characteristics when relevant such as export destination dummies in the control function. As in the main text, for a value added production function our procedure consists of two steps. The first stage is given by

$$y_{it} = \phi_t(l_{it}, k_{it}, m_{it}, e_{it}, \mathbf{z}_{it}) + \epsilon_{it}$$

where we obtain estimates of expected output ($\widehat{\phi}_{it}$) and an estimate for ϵ_{it}.

The second stage provides estimates for all production function coefficients by relying on the law of motion for productivity given by

$$\omega_{it} = g_t(\omega_{it-1}, e_{it-1}) + \xi_{it}$$

Throughout we allow for past export experience to potentially impact current productivity. This specification accommodates the potential learning by exporting effects and takes into account the concerns raised in De Loecker (2007, 2010). Note that the inclusion of the export status e_{it} will not only impact the estimated output elasticities but also the estimate of ϵ_{it} and further impact the markup estimates. The remainder of the estimation procedure is identical as described in the main text.

3.2 Gross output production function

In the main text we present the details of the estimation routine under a value added production function for ease of exposition. The fixed proportion assumption on materials (Leontief) is often made in empirical work and has the advantage of not having to identify the coefficient on an input thought to be perfectly variable and hence require variation in material prices across firms which are serially correlated. Under that assumption we then rely on a translog production function in labor and capital to estimate the output elasticity of labor. In this appendix we discuss the details of an alternative production function, on which we rely in the main text as well, which does not impose the Leontief technology. In essence, we can consider a gross output production function and hereby potentially rely on multiple FOCs to recover markup estimates by relying on the output elastity of both labor and materials. In other datasets additional inputs such as electricity, or other energy use could be excellent candidates, where for instance geographic variation in input prices can be exploited.

Moving to a gross output production function allows us to recover the markup from a potentially more variable input, i.e. materials. However, under this setting we face a trade-off between the ability to identify the coefficient on materials, and being able to recover the markup from a potentially more variable input than labor, and hence eliminating potential frictions that can generate a wedge between the marginal product and the input price, other than the markup, for instance hiring or firing costs. Furthermore, we can allow labor to be a dynamic input and explicitly allow this in our estimation routine.

The second part on computing markups is as before, except that we can calculate them using either the coefficient on materials only, or use both the labor and the materials coefficient.[1] We briefly discuss the estimation of those coefficients. The first stage is now given by

$$y^g_{it} = \phi_t(l_{it}, m_{it}, k_{it}, \mathbf{z}_{it}) + \epsilon_{it}$$

where y^g_{it} is gross output and ω_{it} is replaced by a function of observables $h_t(k_{it}, m_{it}, \boldsymbol{z}_{it})$.[2] In order to rely on lagged (variable) inputs as valid instruments we require input prices to vary across firms and to be correlated over time. We collect those in $\mathbf{z}_{it}$ in addition to a firm's export status. The second stage is similar to the one described in the main text and we rely on the same moments as discussed in the main text. Note that the instrument on labor depends on whether we assume labor to be a variable input or a dynamic one. If labor is decided a period ahead (just like capital), we have potentially two instruments (l_{it} and l_{it-1}) to identify the labor coefficients. The coefficient on materials is obtained by relying on lagged material choices as an instrument since we explicitly allow material input prices to be correlated over time. In order to rely on a gross output production function we explicitly rely on material prices to be serially correlated over time, and differ across firms. The actual choice in an empirical application should therefore depend on whether material prices are observed at the firm level and whether they are serially correlated over time or not. This is exactly the strategy we followed for our preferred estimation procedure. We found that wages vary across firms and are serially correlated, leading to the use of lagged labor choices as instruments.

Having estimated the output elasticity of materials, markups can now be computed using

$$\widehat{\beta}_m \left(\frac{P^M_{it} M_{it}}{P_{it} Q_{it}}\right)^{-1} = \widehat{\mu}_{it}$$

and we can directly compare them using

$$\widehat{\beta}_l \left(\frac{w_{it} L_{it}}{P_{it} Q_{it}}\right)^{-1} = \widehat{\mu}_{it}$$

depending on whether we want to assume that a firm's labor choice is not restricted due to any frictions. Strictly speaking, if the implied markups differ (significantly) using both equations, it would suggest that additional important frictions or adjustment costs in labor demand are present. For presentation purposes we decided to not compare the small differences in point estimates across both, and draw conclusions from them.

[1] Note that the coefficient on capital is not informative for recovering a measure of the markup, since the static first order condition does not hold given capital's fixed nature. In fact, the wedge between the marginal product of capital and the user cost of capital will in general capture capital adjustment costs in addition to markups. Our approach can potentially be informative about the extent of those adjustment cost if we are willing to specify a particular form.

[2] If labor is a dynamic input we have that $h_t(l_{it}, m_{it}, k_{it}, \mathbf{z}_{it})$.

3.3 Using Investment as a Proxy

In order to rely on investment to proxy for productivity, we need to incorporate input prices that are serially correlated. Furthermore, given our focus on markup differences between domestic producers and exporters, we need to incorporate the export status of a firm into the investment policy function, just like in the case where we rely on a static input. This has no implications on our ability to identify the coefficients of interests. The only extra requirement is that the investment function is still invertible when including the export status. We refer to De Loecker (2007) for a detailed discussion, and given that we do not rely on this approach, we simply assume we can follow this approach.

Note that the reasons underlying the need to control for a firm's export status in both approaches (investment and material) is somewhat different. For instance if a firm's export status is not a state variable of the underlying dynamic problem of the firm we do not have to include it in the investment approach. However, if exporters face different demand conditions, the material demand approach requires controlling for a firm's export status. Although this example is at odds with the empirical evidence that export entry decisions face significant sunk costs, we want to highlight the difference.

We briefly describe our approach under a value added (Cobb-Douglas) production function setting. The investment policy function is given by

$$i_{it} = i_t(k_{it}, \omega_{it}, \mathbf{z}_{it})$$

where $\mathbf{z}_{it}$ captures a firm's export status (e_{it}) and serially correlated input prices w_{it}. Note that the firm's export status is either at time t or lagged depending on whether we assume a firm's export entry decision is taken one period ahead. For our purposes the difference is not important. We can write a firm's productivity as a function of its capital stock, investment, wage and export status all collected in $\mathbf{z}_{it}$

$$\omega_{it} = h_t(k_{it}, i_{it}, \mathbf{z}_{it})$$

The first stage of the procedure therefore consists of running

$$y_{it} = \phi_t(l_{it}, k_{it}, i_{it}, \mathbf{z}_{it}) + \epsilon_{it}$$

where we are explicit about the input prices w_{it}, including the wage rate, being serially correlated over time. The latter is important for the identification of the labor coefficient. The second stage is as before, except for the fact that ω_{it} is now calculated using a different estimate for ϕ_{it}. The moments we take to the data are identical to the one in our main approach and are given by

$$E\left(\xi_{it}(\beta_l, \beta_k)\begin{pmatrix} l_{it-1} \\ k_{it} \end{pmatrix}\right) = 0$$

We rely on l_{it-1} as an instrument for l_{it} given we allowed for serial correlated input prices, which create a correlation between labor (material) choices over time, but the productivity shock at t should not be correlated with the labor (material) choice at time $t-1$. We directly observe firm specific wages in the data and include them whenever considering this approach.

Our approach shows that we can easily accommodate various proxy estimator approaches, and also makes it clear that - for the Cobb-Douglas case - differences in parameter estimates for β_l will not affect the variation in markups across firms, since this comes entirely from the variation in the share of the wage bill in total sales. Note that the different procedures do produce different estimates for ϵ_{it} and therefore potentially also change the variation in the labor share as well. The level of the markup is affected, however, by differences in estimates for the labor coefficient.

3.4 CES Production Function

The CES production function relaxes the substitution elasticity among inputs and nests the fixed proportion (Leontief) and Cobb-Douglas production function. For our purpose it is important to note that this production function will, as in the translog case, deliver firm-specific output elasticities and impact the estimate for the markups. Note that for a value added production function, we already assumed that intermediates are used in a fixed proportion to output.

We rely on the same proxy method as before, and replace unobserved productivity by a function in capital, materials and other relevant variables affecting input demand. From this routine we obtain estimates for the CES parameters and using the FOC on labor, $\frac{\partial Q_{it}}{\partial L_{it}} = \frac{w_{it}}{P_{it}}\mu_{it}$, we recover

$$\widehat{\mu}_{it} = \left(\frac{w_{it} L_{it}}{P_{it} \frac{Q_{it}}{\exp(\widehat{\epsilon}_{it})}} \right)^{-1} \widehat{a}_l{}^{1-\widehat{r}} L_{it}^{\widehat{r}} \left[\widehat{a}_l{}^{1-\widehat{r}} L_{it}^{\widehat{r}} + a_k^{1-\widehat{r}} K_{it}^{\widehat{r}} \right]^{-1} \tag{1}$$

where a_l and a_k are parameters to be estimated, and where the elasticity of substitution is given by $\frac{1}{1-r}$. We recover the same expression as in the main text under a Cobb-Douglas production technology when $r = 0$, or equivalently when the elasticity of substitution is equal to one, where $\frac{\alpha_l}{\alpha_l + \alpha_k}$ is then the output elasticity of labor (β_l under Cobb-Douglas).

This appendix illustrates how our methodology can accommodate any production function, as long as the coefficients are common across a set of producers. However, we do not have to restrict the output elasticity of labor (or any other input) to be the same across all firms, as is the case with Cobb-Douglas. The only condition we require is that we can write the FOC of labor as $\frac{\partial Q}{\partial L} = \frac{wL}{PQ}\mu$, where we drop subscripts. Note that this the case as long as the production function can be written as $Q_{it} = F(L_{it}, K_{it}; \beta)\exp(\omega_{it})$, where $F(.)$ is described by a set of technology parameters β constant across firms, as discussed in detail in the main text.

3.5 Extra Results

Table A1. Additional results

Parameters	Markup Estimates obtained using			
	I	**II**	**V**	**IV**
γ_0	0.6980	0.6824	0.6936	0.5042
	0.0174	0.0174	0.0174	0.0174
γ_1	*0.0467*	*0.0467*	*0.0497*	*0.0481*
	0.0127	0.0127	0.0127	0.0128
γ_2	-0.0166	-0.0166	-0.0246	-0.0138
	0.0138	0.0138	0.0138	0.0139
γ_3	0.0160	0.01604	0.0218	0.0151
	0.0094	0.0094	0.0094	0.0094

Standard errors are reported below the coefficients.

References

[1] De Loecker, J. 2007. Do Export Generate Higher Productivity? Evidence from Slovenia. *Journal of International Economics*, 73, 69-98.

[2] De Loecker, J. and Warzynski, F. forthcoming, Markups and Firm-level Export Status, *American Economic Review*