Journal of International Economics 90 (2013) 237–244

Contents lists available at SciVerse ScienceDirect

Journal of International Economics

journal homepage: www.elsevier.com/locate/jie

Estimating productivity with multi-product firms, pricing heterogeneity and the role of international trade

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ARTICLE INFO

Article history:
Received 19 September 2011
Received in revised form 23 January 2013
Accepted 23 January 2013
Available online 30 January 2013

JEL classification:
F14
D24

Keywords:
Productivity estimation
Pricing heterogeneity
International trade decisions
Multi-product firms

ABSTRACT

In this paper, we analyze the relationship between exports, imports and firm productivity taking into account pricing heterogeneity and multi-product firms. We use a rich firm–product level dataset providing both revenue and quantities of all products produced, exported and imported for a large panel of Danish manufacturing firms over the period 1999–2006. With this detailed information, we compute a firm level price index to deflate our measure of output and compare our productivity measures when we deflate output with an industry-level deflator. We find that firms only importing have a large productivity premium, but not firms only involved in exporting, while firms involved in both importing and exporting are the most productive. The international trade premia are found to be significantly larger when output is deflated with our firm-specific price index rather than the traditional sector-level PPI, suggesting that pricing heterogeneity plays an important role in productivity measurement. We also find evidence of a self-selection into exporting but not into importing. Finally, we detect the presence of learning by exporting only when we control for pricing heterogeneity; when looking at learning by importing, we find a positive effect in the long run, but the effect is lower when we deflate revenue with a firm-specific price index. These results suggest that pricing heterogeneity can significantly affect the way we measure productivity and our assessment about the link between productivity and trade.

1. Introduction

A large literature has been devoted to explaining the productivity difference between firms involved in international trade and those only selling on the domestic market (see e.g. Bernard et al., 2012 for a recent survey). Both import and export decisions have been shown to be associated with higher productivity, either as a result of self selection or as a consequence of a learning effect. One potential drawback in this line of research is that studies to date have largely ignored pricing heterogeneity in their analysis. This problem has been discussed though in the productivity literature. Klette and Griliches (1996) formally documented the bias arising from deflating firm-level sales with an industry-level price index instead of firm-level prices when estimating a production function. They also provided a simple indirect method to correct this bias by incorporating a horizontal product differentiation demand system.

Dealing with pricing heterogeneity becomes even more complex in the presence of multiproduct firms.[1] Levinsohn and Melitz (2001) and De Loecker (2011) have provided an elegant solution to this problem by extending the Klette and Griliches framework to the case of multiproduct firms while keeping the analysis at the firm-level.

To address the bias related to pricing heterogeneity, several authors have chosen an alternative way by directly using price and quantity information at the product level (e.g. Foster et al., 2008) or by computing a firm specific price index aggregating the product-level information (Eslava et al., 2004). This latter approach has the advantage that no assumptions have to be made about the nature of competition in a specific market but instead relies on actual price data.

A recent literature in international trade has also studied empirically strategic price setting on different export markets. Manova and Zhang (2012) use customs data for China and show that export prices charged by the same firms tend to be higher in richer and more distant countries. This indicates that pricing heterogeneity can be an important issue for a single firm selling on different markets.

In this paper, we use a detailed sample of Danish manufacturing firms providing both values and quantities of domestic and international trade transactions to study the link between international trade and productivity. We exploit the richness of this dataset to define a firm-specific price index and discuss the importance of pricing heterogeneity in productivity measurement. Using this approach, we do not need to compare physical quantities across firms, as these are generally not comparable not only across firms, but also within firm for multi-product firms. Instead, we compare deflated revenues across firms, where our deflator takes the value of 1 for the base year.

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[1] See e.g. Bernard et al., 2010, 2011; Mayer et al., 2012 and Goldberg et al., 2011a,b for a discussion about the importance of multi-product firms.

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http://dx.doi.org/10.1016/j.jinteco.2013.01.003

We start by computing simple measures of firm-level productivity frequently used in the literature (labor productivity, TFP estimated with OLS and fixed effect). We also use more modern empirical techniques to deal with input endogeneity.[2] We then analyze the relationship between productivity and international trade, and compare the results when we deflate output with our firm-specific price index to those obtained when we use a common deflator for all firms within the same industry. This simple algorithm provides an assessment of how pricing heterogeneity might affect productivity measurement and the estimated link between productivity and international trade in the presence of multiproduct firms.

We find that importing behavior is strongly associated with higher productivity, but the effect of exporting only is not significant. Firms involved in both importing and exporting enjoy an even larger productivity premium. More importantly, we also find that the international trade premia are much larger when output is deflated with our firm-specific price index rather than the traditional industry-level PPI. This suggests that pricing heterogeneity plays an important role in productivity measurement and the way we assess the link between productivity and trade. We explain this finding the following way: exporting firms are on average more efficient; however, standard measurements of productivity (i.e. with revenue deflated by PPI) contain a price component; once controlling for pricing heterogeneity, more efficient firms tend to price at a lower level, so that using a common deflator leads to over-deflation for more efficient firms. This finding is in line with empirical evidence provided by Foster et al. (2008) and also confirms empirical predictions from recent models of international trade such as Melitz and Ottaviano (2008) where more efficient firms charge lower prices and also have higher markups.

This finding could appear surprising as several recent papers have found that more productive firms supplied higher priced products, because they are also more likely to produce high quality products when there is enough scope for differentiation (see e.g. Kugler and Verhoogen, 2012 for domestic prices; Bastos and Silva, 2010 and Manova and Zhang, 2012 for export prices). A caveat of our analysis is that we do not control for differences in initial price level (i.e. during the base year), but use information about changes in firm-product-level prices. Therefore, our findings are not necessarily inconsistent with this other line of research.

We then turn to the estimation of the selection in exporting and exporting using our two deflators. We find in line with the existing literature that more productive firms self-select into exporting, but our coefficients are larger when we use the firm-specific deflator. On the other hand, we do not detect the presence of selection into importing.

We also analyze the learning by exporting (LBE) and learning by importing (LBI) hypotheses using matching estimators. While we do not detect any evidence of LBE when we deflate revenue with our industry-level PPI, we find a significant effect once we properly control for pricing heterogeneity. This finding can be explained if firms that start exporting indeed become more productive and reduce their prices, relative to firms that remain non-exporters, so that output for these firms would be over-deflated with an industry PPI. When we look at learning by importing (LBI), we find that firms that start importing become more productive in the long run for both deflator options, while they appear to suffer from a short-run negative shock. Moreover, productivity gains appear to be overestimated when firms start importing if we ignore pricing heterogeneity. This could be due to imports leading to product upgrading and higher prices, and this effect would be included in the productivity measure when sales are deflated with a common PPI.

Early research had already documented that importers enjoyed a higher TFP premium than exporters (see Table 8 in Bernard et al., 2007). More recent papers (e.g. Muuls and Pisu, 2009; Castellani et al., 2010; Altomonte and Békés, 2009; McCann, 2009) also found that two-way traders were on average more productive than firms only importing or exporting. However, these papers have largely ignored the pricing heterogeneity issue. Our paper focuses on the bias that pricing heterogeneity leads to and suggests a framework to measure and analyze this bias. It also provides some guidance about the expected consequence of pricing heterogeneity for authors who do not have access to price information.

The structure of the paper is the following. We first discuss the pricing heterogeneity problem and our empirical methodology in Section 2. We then describe our data in Section 3, while Section 4 shows our main results. We conclude in Section 5.

2. Pricing heterogeneity and empirical framework

We start by discussing the different kind of biases that we face when estimating our production function. We first describe the pricing heterogeneity bias and explain how we compute our firm level price index using our detailed firm-product level price data. We then discuss the endogeneity bias and the rest of our specification.

2.1. Pricing heterogeneity

Consider a production function:

$$Q_{it} = \Theta_{it} f(X_{it})$$

where Q is a measure of output, X is a vector of inputs, Θ is an index of technical progress, i is a firm index and t a time index.

Assuming a Cobb–Douglas function and taking logs:

$$q_{it} = \alpha x_{it} + \vartheta_{it}$$

where lower cases denote logs, α is a vector of parameters to be estimated, $\vartheta_{it} = \omega_{it} + \ _{it}$, ω is a measure of "true" (observed by the manager but not by the econometrician) productivity and is a true noise (unexpected shock to productivity).

Ideally, we would like to have physical quantity as a measure of Q. However, in reality, most researchers use deflated revenue instead ($\tilde{R}_{it} = R_{it}/P_{jt}$ where $R_{it} = P_{it}Q_{it}$ is firm revenue, P_{it} is the price set by the firm, or a firm-specific price index; and P_{jt} is an industry-level deflator, i.e. a price index in industry j at time t, typically provided by the statistical office based on micro-surveys such as the one we use in this study) so that our typical regression will be:

$$\tilde{r}_{it} = \alpha x_{it} + \left(p_{it} - p_{jt}\right) + \omega_{it} + \epsilon_{it}$$

where $(p_{it} - p_{jt})$ measures the difference between the log of the firm-level price index and the industry-level price index. We refer to this difference as the price bias. Klette and Griliches and De Loecker mention at least two types of biases that might affect our estimates. First, the choice of inputs might be correlated with the price. Existing evidence has found a correlation between capital, labor and price under various assumptions about the extent of product differentation.[3] Second, productivity will be badly measured as the price bias will be part of the error term and will include a (possibly firm-specific) demand shock. An additional issue that has been noted recently is the negative correlation between price and physical productivity (see Foster et al., 2008). While it will not influence the bias in our estimation, it will be an

[2] We use a modified version of the Olley and Pakes (1996) and Ackerberg et al. (2006) methodologies to explicitly take into account the fact that firms' input choices are potentially affected by their international trade status. See the discussion in De Loecker (2007, 2012), Ackerberg et al. (2007) and De Loecker and Warzynski (2012).

[3] See Table 1 in Foster et al. (2008) for evidence of a low negative correlation between price and capital for a set of homogeneous products. See Kugler and Verhoogen (2012) for evidence about the correlation between price and employment with differentiated products.