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, but not into importing. 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.

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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. The 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 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 multi-product firms. 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 multi-product 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.
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. 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 improvement. More importantly, we also find that the international trade status of firms is potentially affected by their international trade status. See the discussion in De Loecker and Warzynski (2012).

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. Pricing heterogeneity and empirical framework

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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, \( \Theta \) is an index of technical progress, \( i \) is a firm index and \( t \) a time index.

Assuming a Cobb–Douglas function and taking logs:

\[ \log Q_{it} = \alpha_{it} = \log \Theta_{it} + \log X_{it} \]

where lower cases denote logs, \( \alpha \) is a vector of parameters to be estimated, \( \log \Theta_{it} = \alpha_{it} + \xi_{it} \), where \( \alpha_{it} \) is a measure of "true" (observed by the manager but not by the econometrician) productivity and \( \xi_{it} \) 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 de facto price index and \( \log \Theta_{it} \) (industry-level PPI) instead of \( \log Q_{it} \). We start by discussing 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.

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We 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.

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