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A note on the isomorphism of heterogeneous firms models☆

Lisandra Flach *

[a] University of Munich, Germany
[b] CEPR, United Kingdom
[c] CESifo, Germany

HIGHLIGHTS

- This paper investigates the isomorphism of heterogeneous firms models.
- The empirical analysis uses firm-level data on export prices and detailed innovation data.
- Quality or markups may be firm-country specific, whereas efficiency varies only by firm.

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ABSTRACT

Since firm-level data has become available, many papers have studied the relative importance of production efficiency and product quality for firms' export success. Quality sorting models are considered to a large extent as a quality interpretation of the Melitz (2003) model: While firm-level prices decrease monotonically in production efficiency, firm-level prices increase monotonically with quality. Using firm-level information on technology and quality upgrading investments, this paper discusses the isomorphism of heterogeneous firms models. The paper shows that, while the decision to increase product quality or markups within the firm may be firm and market specific, increases in production efficiency are only firm-specific. Hence, the general equilibrium solution of these models may be non-isomorphic.

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1. Introduction

Firm heterogeneity has become a central feature of the international trade literature. Heterogeneous firms models emphasize firms' production efficiency and product quality as determinants of export success. In efficiency sorting models, more productive firms produce their horizontally differentiated products with lower marginal costs and lower prices.[1] In quality sorting models, more productive firms use higher quality inputs to produce higher quality at higher prices.[2] Hence, prices either decrease monotonically in firm productivity or increase monotonically in product quality. As a result, the general equilibrium solution of these models is usually considered to be isomorphic.

Using detailed Brazilian firm-level data, this paper provides empirical evidence on the interplay between firm adjustments in quality and in efficiency. While the empirical literature has investigated quality and efficiency separately, the contribution is to compare different types of firm investments, as they are likely to operate in some degree simultaneously, and to compare their implications for the profile of prices. Moreover, instead of relying on proxies for quality, the unique feature of the data used in this paper is the availability of direct information on firm-level quality adjustments over time.

Our empirical evidence confirms the opposite effects of technology and quality on the profile of prices. However, the analysis

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* Correspondence to: Department of Economics, University of Munich, Ludwigstrasse 28, 80539 Munich, Germany.
E-mail address: Lisandra.Flach@econ.lmu.de.

[1] See Melitz (2003), Melitz and Ottaviano (2008) and several other models with heterogeneity in firm productivity.

[2] Examples of models that add firm heterogeneity in the ability to produce high quality are Baldwin and Harrigan (2011), Crozet et al. (2012) and Antoniades (2015).

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of price patterns *across destinations* suggests that efficiency sorting and quality sorting models may be non-isomorphic, since firm investments have different implications for the profile of prices: While improvements in production efficiency vary only across firms and enter firm revenues through prices, improvements in product quality and markups vary across firms and destination markets. Hence, while prices decrease monotonically in production efficiency, product quality reflects segmentation of markets, depending on the income of the destination.[3] This result might have important policy implications, as discussed in the conclusion.

The result that quality varies across destination markets is by itself not new in the literature. Several papers have shown in theory and empirics that the production of high quality is market specific and that firms upgrade quality to specific destination countries (Brambilla et al., 2012; Verhoogen, 2008; Demir, 2016). However, these papers do not allow for a comparison between different and simultaneous types of within-firm adjustments over time, which is the distinctive feature of our paper.

Two exceptions in the theoretical literature regarding the discussion of quality and efficiency draws are provided by Hallak and Sivadasan (2013) and Hottman et al. (2014). Hallak and Sivadasan (2013) account for two dimensions of heterogeneity (process productivity and product productivity), which explains why conditional on firm size, exporters sell higher quality products and charge higher prices. Because the focus of the paper is on the analysis of the two draws, the authors do not account for within-firm adjustments in quality. Hottman et al. (2014) discuss heterogeneity in cost and quality using barcode data and show that, while technology only affects firm sales through prices, quality affects firm sales through a demand shifter. In comparison to their study, our paper is rather interested in investigating within-firm adjustments in technology and product quality across destination markets and over time. For this purpose, we relate to the literature on trade prices and investigate the relation between within-firm adjustments and the profile of prices across destinations depending on the type of firm investments: Technology or quality upgrading.[4]

2. Data

The paper uses Brazilian firm-level data over the period 1997–2003. A distinctive feature of the data is the possibility to combine, using the unique firm tax number, firm-level export price data by destination over time with detailed information on firm innovation investments.

Export data: The Brazilian Foreign Trade Secretariat collects data on export quantities and export values in U.S. dollars free on board by firm f, 8-digit product g, destination country c, and year t. Using this information, we create the price change ΔP_{fc}, measured as a weighted firm–destination price, as follows: $\Delta P_{fc} = \sum_g \bar{s}_{fcg} \Delta \log p_{fcg}$, where $\Delta p_{fcg} = \log p_{fcgt} - \log p_{fcgt-3}$ and p_{fcgt} is the unit value of product g of firm f in destination country c in time t. $\bar{s}_{fcg} \equiv (s_{fcgt} - s_{fcgt-3})/2$, where s_{fcgt} is the share of exported product g in firm f's export sales to destination country c in year t. p_{fcgt} corresponds to the unit value of exports by firm, product, country and year. In the analysis at the firm–product–country–year level shown in Table 2, we use prices as p_{fcgt}.

Innovation Data: PINTEC is an innovation survey conducted every two/three years that contains information on the firms' innovation efforts. This paper uses information on quality and technology upgrading efforts over the period 1998–2003, as follows. A firm increases production efficiency if it answered affirmatively in the innovation survey the question *undertook process innovation* over the period. A firm upgrades product quality if the following questions are answered affirmatively in the innovation survey: (1) *undertook product innovation* over the period and (2) *product innovation was important to increase product quality*. Quality upgrading Q_{ft} and technology upgrading C_{ft} are defined as dummy variables. In robustness checks, we also use information on the *product upgraded* by the firm, as discussed later.

Income indicator: Using data from the Penn World Table (PWT) 6.2, we create a dummy $INC_c = 1$ for sales to destination countries above the median income per capita, zero otherwise.

Control variables: Firm-level data on average wages by firm ($Wages_{ft}$), number of workers ($Employees_{ft}$), and share of professionals ($SharePrefe_{ft}$) come from the Brazilian Ministry of Labor. Using data on firm sales, we create measures of market power, such as the market share of the firm by destination ($Mktshare_{fct}$) and the number of Brazilian firms active in every destination ($Nfirms_{ct}$).

While the SECEX export data and the employer–employee data are available for the universe of Brazilian manufacturing exporters, PINTEC is available for a representative sample of manufacturing exporters. Because the paper focuses on the within-firm variation over time, only permanent exporters are kept in the sample, which implies a sample of 2220 permanent exporters. More information is provided in the online data appendix.

3. Empirical evidence

According to **efficiency sorting models**, if a firm invests in technology and increases production efficiency ($\Delta C_f = 1$), then $\Delta P_{fc} < 0$, which implies that $\alpha_k < 0$ in Eq. (1). According to **quality sorting models**, if a firm invests in product innovation and increases product quality ($\Delta Q_f = 1$), then $\Delta P_{fc} > 0$, which implies that $\alpha_q > 0$ in Eq. (1). However, we are also interested in the asymmetric effects of both types of innovation across destination markets with different income (INC_c), as shown by the coefficients λ_k and λ_q.

$$\Delta P_{fct} = C_{ft}\alpha_k + \Delta Q_{ft}\alpha_q + INC_c * \Delta C_{ft}\lambda_k + \Delta INC_c * \Delta Q_{ft}\lambda_q + \Delta X_{fcgt}\beta + u_{fcgt}. \quad (1)$$

All results reported in Table 1 include a constant and industry, country, and period fixed effects. The results shown in columns (1)–(4) provide evidence for $\alpha_k < 0$ and $\alpha_q > 0$. In columns (5)–(8) the interaction term is added. The results reveal that the positive effect of quality upgrading on prices is solely captured by the interaction term (λ_q), which suggests that firms upgraded quality to attend demand of high-income destinations and/or they increase markups in these destinations. On the other hand, the interaction term for *cost* shown by the coefficient λ_k is never significant. These results suggest that market segmentation on prices is specific to quality upgrading. The results remain robust when controlling for several firm characteristics. Although the control variables need to be interpreted with care as they are likely endogenous, the important feature is that the coefficients of interest remain stable when adding several control variables.

One important concern with the results shown in Table 1 is that innovation might not impact all products of the firm, in case of multi-product exporters. In particular, this could bias the results in case firms export different mix of products across destination markets.

[3] For these models to be isomorphic, one would need to assume that firm-level technological change is also destination country specific. However, the empirical results reveal that the asymmetric effect across countries is specific to quality upgrading. It does not hold for technology upgrading. See further results in Flach (2016).

[4] Our results are in accordance with Eckel et al. (2015), who provide evidence that sector-level quality or cost competence affects the profile of prices in opposite ways. However, whereas they focus on sectoral differences depending on the degree of differentiation of the industry, we are interested in within-firm adjustments over time following different types of investment, which reveals interesting asymmetries across destinations.

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