Firm Performance in a Global Market

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Annu. Rev. Econ. 2014. 6:201–27

The *Annual Review of Economics* is online at economics.annualreviews.org

This article's doi:
10.1146/annurev-economics-080113-104741

JEL codes: D2, D4, F00, L1

Keywords

productivity, markups, pass-through, trade reforms

Abstract

In this article, we introduce an empirical framework to analyze how firm performance is affected by increased globalization. Using this framework, we discuss recent work on measuring the impact of various shocks firms face in the global marketplace, such as reductions in trade costs (through lowering tariffs and abolishing quotas). Our analytical framework nests most empirical approaches to estimating the impact of trade and industrial policies on firms active in international markets. We identify outstanding issues surrounding the identification of the underlying mechanisms and conclude with suggestions for future research.

1. INTRODUCTION

Few topics have been researched as extensively as the relationship between trade openness and firm, or industry, performance. A Google Scholar search on the keywords "trade and productivity" returns 1,920,000 papers! The purpose of this article is twofold: First, we develop a general framework for discussing the large empirical literature on the topic. Second, we summarize the main insights from work to date. Although much of the empirical research we draw upon rests on theoretical models, we do not review theoretical work directly, except to the extent that this theoretical work informs empirical specifications and helps identify underlying mechanisms. Furthermore, this article is not intended to be a comprehensive literature review. Instead, we discuss a selected set of papers from the perspective of our empirical framework that nests the productivity and pass-through literatures spanning industrial organization, international trade, and international macro.

Our point of departure is the voluminous empirical literature on the effects of trade on firm productivity. Economists have always postulated that one of the main benefits of opening up markets to foreign competition is to make firms more efficient and have proceeded to estimate the effects of trade liberalizations, or globalization more generally, on efficiency. Early empirical attempts predate theoretical work in this area and for the most part lack a sound theoretical justification for why one would expect efficiency to increase with exposure to foreign markets. With the development of models of firm heterogeneity, however, this literature has experienced a renaissance. There are two main strands. The first one investigates the performance of exporters and relies primarily on cross-sectional comparisons to assess whether exporters are more efficient than firms that sell to domestic markets only. The second strand focuses on trade liberalization episodes and investigates whether industry productivity increases in the postreform period, in which the productivity gains can arise either because of within-firm improvements or because of reallocation of economic activity toward more efficient firms.

Although this literature has established some interesting patterns, we show that with few exceptions, it has been loose in its use of the term productivity. What it actually delivers is a measure of firm performance or profitability. The distinction between productivity and profitability is important; the latter depends not only on physical efficiency, but also on prices, which reflect product differentiation and markups in addition to costs. The framework we develop allows one to explicitly trace these components. This decomposition offers the advantage that one can link improvements in firm performance to specific mechanisms through which globalization affects firms. Understanding these mechanisms is important for assessing the welfare and distributional effects of trade openness; for example, a trade liberalization that improves firm performance by inducing improvements in physical efficiency has different implications than a liberalization that makes firms better off by increasing their profits.

The realization that measured firm performance captures markups as well as physical efficiency naturally leads to two other literatures that were developed in different contexts: the large industrial organization literature on imperfect competition and the international literature on incomplete (exchange rate) pass-through. The first explicitly investigates the measurement and determinants of markups (e.g., the role of market structure, product differentiation, and demand elasticities); the second focuses on how a certain type of cost shock (i.e., exchange rate changes) is passed through to prices. Firms competing in global markets are faced with a different market (and likely also demand) structure and may as a result change their prices and markups or their product characteristics. A tariff reduction, for example, intensifies the import competition domestic firms face, and we would expect them to reduce their prices and markups in response. This is the usual procompetitive effect one associates with trade liberalizations. At the same time, a reduction in tariffs allows firms to purchase imported intermediates that they use as inputs in their production at lower prices; these reductions in input prices are tantamount to a cost shock facing the firm, similar to the exchange rate changes considered in the international literature. Whether this cost shock will be passed through to prices depends on many factors that reflect demand and market structure conditions.

Our review concludes that there is one robust finding that emerges from this literature: Globalization improves industry performance. However, there is less consensus on how these improvements arise. Many studies find that improvements are generated through the reallocation of market shares toward better-performing firms, whereas others document significant within-firm improvements. Several papers find that the effects of input tariff liberalization dominate those of output tariff liberalization in some developing countries. Perhaps more importantly, the majority of studies do not distinguish between physical efficiency and price/markup effects. Hence, it is not clear that the aforementioned improvements represent true productivity gains as opposed to increases in market power. A couple of recent papers emphasizing this distinction show that the effects on markups and prices are significant. However, it is too early to know whether the results from these studies generalize to other contexts. This is an exciting area for future research, and we hope that the current article helps guide future endeavors in this direction.

The remainder of the article is organized as follows. Section 2 introduces a general framework that can be used to discuss existing work and clarify what economic theory suggests should be measured, and what is measured in practice. We use this framework to decompose firm performance into its components. In Section 3, we discuss the particular mechanisms through which trade openness is expected to affect each of these components. Section 4 briefly summarizes the insights obtained from work to date, and Section 5 concludes.

2. A FRAMEWORK FOR MEASURING PERFORMANCE

Performance at the firm level is measured in many different ways. Such ways include accounting measures of profitability, the Lerner index, sales per input, and total factor productivity. Although correlated, the various measures capture different aspects of firm performance, and exposure to a global market is not expected to affect these aspects in the same way. In this section, we first use a simple regression framework to summarize the large empirical literature on the topic. Next we introduce an empirical framework, based on a production function, that allows us to reinterpret the commonly used measures of performance and decompose them into their underlying determinants: demand and cost primitives, as well as the market structure of the industry under study.

2.1. Measuring Performance

We characterize a large literature—spanning industrial organization, international economics, and international macroeconomics—by considering firm performance (π_{it}) as the residual in a regression of sales (s_{it}) on input expenditures ($\mathbf{e}_{it}$).[1] Applied researchers typically consider a log-linear relationship between sales and expenditures:

$$s_{it} = \mathbf{e}'_{it}\boldsymbol{\beta} + \pi_{it}, \tag{1}$$

[1]The vector $\mathbf{e}_{it}$ typically includes expenditures on labor, intermediate inputs (materials), and capital. Unless noted otherwise, lowercase letters denote the log of the corresponding variable throughout this article.

where $\boldsymbol{\beta}$ is the vector of coefficients. The data we have in mind track firms indexed by i for which we observe sales and input use, both expressed in monetary terms (i.e., sales and expenditures), over time t. The residual π_{it} as a measure of performance is closely related to profits because we subtract expenditures from sales.

The fundamental research question economists have been trying to answer over the past few decades is, How do changes in international competition affect the performance of firms (π_{it}) and industries and ultimately the overall welfare of countries or regions? Trade liberalization episodes, preferably exogenous to firms in an industry, are the natural place to turn to analyze this question empirically by relating performance measures to changes in trade protection, such as tariff declines, lifting of quota restrictions, or removal of antidumping duties.

Equation 1 is a point of departure for the literature that typically utilizes firm- or plant-level data across many different sectors of one or more economies. Such data tend to be readily available for a large set of countries and time periods. In contrast, the case study approach commonly employed in modern industrial organization makes use of much more detailed information on product-level prices and product- or firm-specific cost variables to compute performance measures, at the cost of the approach being feasible only for the specific industries and countries for which this information is available. Another approach would be to use accounting data to measure performance as operating profits. However, this article is concerned with recovering measures of firm performance that accurately reflect economic costs and benefits, and it is well known that accounting profits provide poor measures of economic profits (see Schmalensee 1989 for a detailed discussion of the problems of using accounting profits as a measure of firm performance).

With few exceptions, the existing literature has viewed Equation 1 as the empirical analog of a production function and interpreted the residual π_{it} as a measure of total factor productivity. As we argue below, under a set of restrictive assumptions, Equation 1 is indeed a production function, with $\boldsymbol{\beta}$ the estimated production function coefficients. One possible set of such assumptions features firms that produce a homogeneous product and are active in an industry characterized by perfectly competitive output and input markets. In this case, the relationship between sales and expenditures is equivalent to the relationship between physical output and inputs, and consequently, π_{it} is an estimate of (physical) productivity. However, in the general case, the performance residual π_{it} will capture much more than productivity.

When we try to understand how increased international competition impacts firm performance, recovering the residual of Equation 1 is only the first step; to identify the underlying mechanism(s), we need to understand the underlying components of π_{it}. To this end, we need to be more precise about what π_{it} actually measures. We turn to this issue in the next section and use a production function approach to interpret the performance residual (π_{it}).

2.2. Firm Performance: A View from the Production Side

Using a basic production function[2] that relates quantities produced (q_{it}) to a vector of physical input usage ($\mathbf{x}_{it}$) allows us to express sales in a (perhaps) more familiar fashion as

$$\begin{aligned} s_{it} &= \mathbf{x}'_{it}\boldsymbol{\alpha} + \omega_{it} + p_{it} \\ &= \mathbf{e}'_{it}\boldsymbol{\alpha} + \omega_{it} + p_{it} - \mathbf{z}'_{it}\boldsymbol{\alpha}, \end{aligned} \tag{2}$$

[2]To simplify notation, we base our discussion on a Cobb-Douglas production function, but our framework generalizes to any other functional form.

where we rely on the definition of sales, $s_{it} = q_{it} + p_{it}$; a standard Hicks-neutral production function, $q_{it} = \mathbf{x}'_{it}\boldsymbol{\alpha} + \omega_{it}$, with $\boldsymbol{\alpha}$ and ω_{it} the vector of production function coefficients and productivity, respectively[3]; and the definition of input expenditures, $\mathbf{e}_{it} = \mathbf{x}_{it} + \mathbf{z}_{it}$, with $\mathbf{z}_{it}$ the vector of input prices.

This simple framework allows us to immediately connect our structural equation (Equation 2) to the profitability residual in Equation 1 by grouping the last three terms in the equation above to $\pi_{it} = \omega_{it} + p_{it} - \mathbf{z}'_{it}\boldsymbol{\alpha}$. Hence, we can rewrite Equation 2 as an equation relating sales to expenditures:

$$s_{it} = \mathbf{e}'_{it}\boldsymbol{\alpha} + \pi_{it}. \tag{3}$$

Equations 1 and 3 are almost identical up to the coefficients $\boldsymbol{\beta}$ and $\boldsymbol{\alpha}$. We distinguish between the structural coefficients of the production function, $\boldsymbol{\alpha}$, and the coefficients obtained after estimating an equation such as Equation 1. It is only under a set of very restrictive assumptions that these two vectors will be identical.

Consider Equation 1 and assume that the researcher is willing to make the economic assumption that there is neither output nor input price variation across firms.[4] Even in this case, ordinary least squares (OLS) estimation of Equation 1 on a panel data set of firms is not expected to yield the vector of coefficients ($\boldsymbol{\alpha}$) due to the well-known simultaneity and selection biases. Both biases arise from the likely correlation between inputs and unobserved productivity (ω_{it}). This is a well-known problem when estimating production functions and has been addressed in the literature; we refer the reader to a recent overview by Ackerberg et al. (2007) for a detailed discussion. For the remainder of this article, we assume that these biases can be appropriately dealt with when estimating the underlying structural parameters. Of course, the treatment of the unobserved productivity shock is not independent of the unobserved output and input price problem. In fact, the framework we put forward treats both unobservables, price and productivity, jointly in one consistent framework.[5] However, our point is that if output and input prices do not vary across firms, it is possible in principle to recover both the production function coefficients $\boldsymbol{\alpha}$ and firm productivity ω_{it} by applying the techniques suggested in the recent literature. In practice, both price and productivity variation will most likely play an important role, and as a consequence, ignoring (unobserved) prices in the estimation of production functions will lead to biased results, and vice versa.

Consider Equation 1 once more, but let us now allow for both output and input price variation. In this case, the structural error π_{it} contains two more components in addition to productivity: the output price (p_{it}) and the vector of input prices ($\mathbf{z}_{it}$). Relying on sales and expenditure data will clearly not deliver an estimate of productivity, nor will it deliver the vector of production function coefficients. In this case, $\boldsymbol{\beta}$ is a vector of coefficients describing the mapping from expenditures to sales.

To see why estimation of Equation 1 will lead to biased coefficients in the presence of output and/or input price variation, let us explicitly introduce deflators and rewrite Equation 2 to reflect

[3]For the well-known Cobb-Douglas production function in three inputs [labor (l), materials (m), and capital (k)], we get $q_{it} = \alpha_l l_{it} + \alpha_m m_{it} + \beta_k k_{it} + \omega_{it}$.

[4]Time variation in both output and input prices can be accommodated either by deflating the variables appropriately using industry-wide deflators or by including a full set of year fixed effects. In any case, the price variables would not be indexed by i.

[5]De Loecker et al. (2012) provide a framework that considers the joint estimation of productivity, marginal costs, and markups.

the usual practice in empirical work in this area. Let $\overline{p}_t^I$ be the price deflator for industry I; $\overline{\mathbf{z}}_t^I$ be a vector of industry-specific input price deflators; and $p_{it}^* = p_{it} - \overline{p}_t^I, \mathbf{z}_{it}^* = \mathbf{z}_{it} - \overline{\mathbf{z}}_t^I, s_{it}^* = s_{it} - \overline{p}_t^I$, and $\mathbf{e}_{it}^* = \mathbf{e}_{it} - \overline{\mathbf{z}}_t^I$ denote deflated output price, input prices, sales, and expenditures, respectively. Researchers typically take the following version of Equation 2 to the data:

$$
\begin{aligned}
s_{it}^* &= \mathbf{e}_{it}^{*'}\boldsymbol{\alpha} + \omega_{it} + p_{it}^* - \mathbf{z}_{it}^{*'}\boldsymbol{\alpha} \\
&= \left(\mathbf{x}_{it} + \mathbf{z}_{it}^*\right)'\boldsymbol{\alpha} + \omega_{it} + p_{it}^* - \mathbf{z}_{it}^{*'}\boldsymbol{\alpha}.
\end{aligned} \tag{4}
$$

First, consider the case in which there is output price but no input price variation across firms. In this case, $\mathbf{z}_{it}^* = 0$, and the terms related to input price variation drop out from Equation 4. This is the typical case considered in industrial organization studies that assume that input prices are equalized across firms (once regional differences are controlled for). Output price variation captured by p_{it}^* will generally be correlated with $\mathbf{e}_{it}^*$ (which is equal to $\mathbf{x}_{it}$ in this scenario): Ceteris paribus, we expect firms that charge higher prices to sell lower quantities, which in turn implies lower input quantities. Hence, the correlation between p_{it}^* and $\mathbf{x}_{it}$ is likely to be negative, leading to a downward bias in the estimates of the coefficients $\boldsymbol{\alpha}$ as well as the returns to scale. This bias is the focus of the work of Klette & Griliches (1996), as well as De Loecker (2011). We refer to it as the output price bias. A closely related point is made by Katayama et al. (2009), who allow for input prices to vary across firms but presume that this input price variation can be completely controlled for when one observes firm-specific wages (so that $\mathbf{z}_{it}^*$ can be treated as an observable). As we argue below, this assumption is strong—even when wages are observed, the prices of other inputs (e.g., materials) are typically not observed, while a firm-specific price for capital is never available.

Second, consider the case in which there is no output price variation, but input prices vary across firms. This case may seem irrelevant in practice, but as we show below, it corresponds to the case in which we observe firm-specific output prices and hence can control for output price variation, while input price variation remains uncontrolled for. In this case, it is evident from Equation 4 that input price variation will lead to a strong negative bias in the estimated coefficients; a firm that faces higher input prices will have higher input expenditures that will not lead to higher physical output. We refer to this bias as the input price bias. In contrast to the output price bias, the input price bias has received no attention in the literature so far; the only study we are aware of that has attempted to address it is De Loecker et al. (2012).

Realistically, the data will be characterized by both output and input price variation so that estimates of Equation 1 will suffer from both output and input price biases. Unless these two biases interact in a way so as to offset each other, they will lead to biased estimates of the production function coefficients. Furthermore, even conditional on the parameter vector that the estimation delivers in this case, one will be able to recover only a (biased) estimate of the composite residual π_{it}.

The message so far is that with sales and expenditure data alone, one cannot generally recover the underlying components of firm performance or identify productivity. As always in empirical work, there are two ways out of such a situation: Either one collects more data or one makes additional assumptions that will allow identification.

2.2.1. Additional data. One might be tempted to conclude at this point that the solution to all issues discussed in this section would be to collect more data on firms' output and input prices. Obviously, more data are always preferable (at a minimum, one can ignore them). However, the introduction of additional data creates its own challenges; although more data may help alleviate some of the problems discussed above, they are not a panacea.

Output prices tend to be more readily available than input prices in firm- or plant-level surveys. However, these data are often unit values (derived by dividing revenues by quantities over a period of time) and suffer from the well-documented problems associated with them. Furthermore, their use in the context of production function estimation poses additional challenges associated with differences in the units in which quantities are recorded across firms and products. Finally, the attempt to exploit output prices forces the researcher to explicitly confront issues that are specific to multiproduct firms; output prices are recorded at the product level, which calls for estimation of production functions at the product level. However, input expenditures are recorded only at the firm level. Hence, even when output prices are available, estimation of production functions for multiproduct firms is not possible unless one adopts one of three approaches: (*a*) eliminate multiproduct firms from the sample and focus on single-product firms only, (*b*) aggregate product prices to the firm level and conduct the analysis at the firm level, or (*c*) devise a mechanism for allocating firm input expenditures to individual products and conduct the analysis at the product level.

Each of these approaches has its drawbacks. Given that multiproduct firms account for a significant fraction of output in the manufacturing sector, eliminating them from the analysis is hard to defend. Approach (*b*) requires one to specify a demand system that allows aggregation in a consistent manner and creates the need for additional assumptions. Similarly, approach (*c*) requires spelling out the assumptions needed to allocate input expenditures across products.

That the use of output price data requires assumptions is not necessarily a weakness, especially because the assumptions one needs in this context either are already made (albeit implicitly) in the existing literature or are weaker than the ones required under alternative approaches. Nevertheless, our point is that more data do not eliminate the need for assumptions and structure.

Assuming the challenges outlined above can be dealt with, the use of output prices should allow one to eliminate the output price bias discussed above. Syverson (2004) and Foster et al. (2008) provide examples of studies that have accomplished this successfully. They rely on a selected set of plausibly homogeneous good industries (e.g., ready-mixed concrete) and exploit output price data to separate out price variation from productivity. An implicit assumption in their framework is that input prices do not vary across firms. This assumption is indeed plausible in the context of the homogeneous product industries they consider; for example, it is plausible to assume that (conditional on region) the input prices ready-mixed concrete producers face are the same. In this setting, the only bias present in Equation 4 is the output price bias, and this bias can be successfully dealt with when one observes output prices.

However, the focus on homogeneous product industries leaves us with the bulk of economic activity unaccounted for. The set of industries characterized by substantial product differentiation comprises a large share of economic activity. In such industries, controlling for output prices alone is insufficient; differentiated products require differentiated inputs, so that we would expect input prices to vary across firms, even when these firms are located in the same region and even when input markets are perfectly competitive. Input prices are typically unobserved. Controlling for output prices in this case will eliminate the output price bias, but will leave the input price bias intact, and in fact will make its consequences for estimation more salient. In this case, Equation 4 becomes

$$q_{it} = \left(\mathbf{x}_{it} + \mathbf{z}_{it}^{*}\right)'\boldsymbol{\alpha} + \omega_{it} - \mathbf{z}_{it}^{*'}\boldsymbol{\alpha}. \tag{5}$$

The problem with trying to estimate this version of Equation 4 is immediately apparent: Without controlling for the (unobserved) variation in input prices, the coefficients $\boldsymbol{\alpha}$ will be biased. The seriousness of this problem is demonstrated in De Loecker et al. (2012): The authors estimate a physical production function for Indian manufacturing that relates physical output to (deflated) input expenditures. When input price variation is not controlled for, the coefficients $\boldsymbol{\alpha}$ often seem nonsensical and have the wrong sign. Yet these apparently nonsensical results make a lot of sense in the presence of input price bias. Consider, for example, two firms that produce shirts and use the same technology. However, one firm uses silk as an input to produce silk shirts, while the other firm uses less expensive cotton to produce (less expensive) cotton shirts. Suppose that both firms produce the same number of shirts in a period. If we relate the number of shirts produced to (deflated) expenditures on materials, we would find that the firm that uses higher expenditures (silk) produces as much as the firm that uses lower expenditures (cotton). Hence, the coefficient on materials will be negative. Note that if one had not corrected for the output price bias in this case and had used deflated revenues instead of quantities as the left-hand side variable, the problem would have been less transparent as silk shirts would be associated with higher revenues so that higher expenditures would have led to higher revenues. Of course, that the problem is in this case less transparent does not mean that the problem does not exist.

Ultimately, the source of the problem is that products and inputs are differentiated. De Loecker et al. (2012) address this issue by introducing a control function for the (unobserved) input prices. This is based on the premise that conditional on regional variation, input price differences reflect quality differences in the inputs across firms. The authors go on to argue that the assumptions underlying this control function are weaker than the ones required under alternative approaches that develop full-fledged models of product differentiation (with assumptions on particular demand functions and market structure). Nevertheless, their approach once again demonstrates the need for assumptions; data alone do not eliminate the need for economic structure.

Finally, one might argue that if we were able to observe, in addition to output, input prices for every single input, then we would be able to estimate the structural equation (Equation 2) with only a limited set of assumptions. Although in theory this is an appealing prospect, in practice it is unlikely that we will ever be able to control for input price variation using data. To our knowledge, the only survey that contains information on prices of materials purchased is the one for Colombian manufacturing firms, but even there, the firm-specific price of capital is not observed, and utilizing the detailed input price information for materials is a challenge itself because of a variety of measurement issues. We conclude that although the use of additional data on prices can improve on certain aspects of estimation and identification, the need to introduce assumptions remains. The question is not whether one needs assumptions, but which set of assumptions is less restrictive.

2.2.2. Additional assumptions. Let us return to Equation 3 and consider the typical case in which we have a standard data set containing (deflated) sales and expenditures $\left(s_{it}^{*}, \mathbf{e}_{it}^{*}\right)$ for a panel of firms in a given industry. We now ask, Under which assumptions can we recover the structural parameters and the components of firm performance when estimating Equation 3?

One case that allows us to recover productivity (ω_{it}) has already been discussed: the case in which there is neither output nor input price variation across firms. The assumptions required to produce this lack of price variation are strong. Therefore, we ask whether it is possible to achieve the same result with a set of less restrictive assumptions; specifically, we consider a setting in which there is both output and input price variation and ask under which conditions these two types of variation will interact in such a way that the output price bias exactly offsets the input price bias, that is, $p_{it}^{*} - \mathbf{z}_{it}^{*'}\boldsymbol{\alpha} = 0$. We show that the following assumptions are required for the price bias to be completely eliminated:

1. The industry is characterized by monopolistic competition.
2. Firms produce a horizontally differentiated product and face the same constant elasticity of substitution (CES) demand system.

3. Production is characterized by constant returns to scale (CRS).
4. Input price variation (across firms and time) is input neutral, such that $z_{it}^{*h} = \lambda_{it} \forall h = \{1, 2, \ldots, H\}$, with H the total number of inputs.

The first two assumptions imply that firms will pass through costs completely to prices; therefore, any input price variation, both in the cross section and in the time series, will be completely reflected in output price variation so that $p_{it}^* = z_{it}^*$. The fourth assumption is required to make sure that in any cross section of firms, the input price variation is restricted to a scalar. The CRS assumption is important to guarantee that $\sum_h \alpha_h = 1$, and consequently the input price variation exactly offsets the output price variation.[6] To see the impact of this assumption, let $\sum_h \alpha_h < 1$. This would lead to a price error of $p_{it}^* - \sum_h \alpha_h \lambda_{it}$, which, even under complete pass-through, would leave $1 - \sum_h \alpha_h \lambda_{it}$ in the error term, biasing the estimates of interest.

Although the above assumptions are somewhat weaker than the assumption of no output or input price heterogeneity, they are still restrictive and inconsistent with a substantial body of work in the international and macroeconomics literature that has documented incomplete pass-through of cost shocks to prices (see Goldberg & Knetter 1997 for an overview of this literature). Hence, the question arises whether there are alternative assumptions that would allow for a more satisfying treatment of unobserved prices. We briefly discuss the set of assumptions underlying two recent papers that explicitly address these biases: De Loecker (2011) and De Loecker et al. (2012).

Output price heterogeneity. De Loecker (2011) works with standard data in which output and input prices are unobserved. He assumes away input price variation across firms[7] and focuses on addressing the output price bias. To this end, he explicitly introduces a demand system in his empirical model; in the particular application he considers, he works with CES, but his approach works also for alternative demand systems as long as one can relate log quantity to log prices and additional demand shifters; such demand systems include the nested logit and the random coefficient demand model as in Berry et al. (1995), in which log prices enter the indirect utility function.

The basic idea behind De Loecker's approach is to use the demand structure to express the (unobserved) price variation p_{it}^* as a function of observables, in his case, an industry quantity index q_{It} and a set of product dummies $\mathbf{D}_i$. De Loecker (2011) shows that this gives rise to the following version of Equation 4:

$$s_{it}^* = \mathbf{x}_{it}'\boldsymbol{\beta} + \beta_I q_{It} + \mathbf{D}_i'\boldsymbol{\delta} + \tilde{\omega}_{it}, \tag{6}$$

where $\beta_I = 1/|\eta_I|$, with η_I the elasticity of demand of industry I; $\boldsymbol{\beta} = \big((\eta_I + 1)/\eta_I\big)\boldsymbol{\alpha}$, with $\boldsymbol{\alpha}$ denoting the production function coefficients; and $\tilde{\omega}_{it} = \big((\eta_I + 1)/\eta_I\big)\omega_{it}$. Estimation of the above equation delivers the demand elasticity η_I, along with the true production coefficients $\boldsymbol{\alpha}$, and allows one to separate the physical productivity ω_{it} from the output price variation $(\beta_I q_{It} + \mathbf{D}_i'\boldsymbol{\delta})$.

The results are consistent with one's priors; the production function coefficients obtained after correcting for output price bias are larger in magnitude (consistent with the presence of a

[6]Consider a two-input production function with labor and capital (l, k). Under assumption 4, the structural error term can be written as $p_{it}^* - \alpha_l w_{it}^* - \alpha_k r_{it}^* = p_{it}^* - \alpha_l \lambda_{it} - \alpha_k \lambda_{it} = p_{it}^* - (\alpha_l + \alpha_k)\lambda_{it}$, where w and r denote the (log) prices of labor and capital, respectively; asterisks denote deviations from industry averages; and λ_{it} is a scalar that captures the input price–neutral variation of input prices relative to the input price indexes ($\lambda_{it} = w_{it}^* = r_{it}^*$). CRS guarantees that $(\alpha_l + \alpha_k) = 1$, and with complete pass-through, $p_{it}^* = \lambda_{it}$.

[7]This is plausible in the context of Belgian textile producers who are geographically concentrated.

downward bias when output price bias is not controlled for) and suggest increasing returns to scale. The approach rests crucially on assuming a demand system, but assumptions on the demand system and cost pass-through are implicit whenever one estimates Equation 4 without controlling for the output price bias.

Output and input price heterogeneity. De Loecker et al. (2012) work with a different data set from India that contains information on product-specific prices (i.e., unit values). As noted above, the availability of output price data is not a silver bullet, at least not when one considers a large set of differentiated product industries. Although the output price data allow De Loecker et al. (2012) to eliminate the output price bias without resorting to any assumptions, they still need to address the input price bias. To do so, they assume that the only source of input price variation across firms (apart from regional differences) is quality differentiation; this assumption rules out imperfect competition in input markets. Furthermore, they assume an output quality production function that displays complementarities in the qualities of inputs and output: Higher-quality output demands higher-quality inputs, and high-quality inputs are complements to each other. Under these assumptions, the authors show that conditional on regional variation, input prices will be a function of output quality, which can be proxied through a flexible polynomial in output prices, market shares, product dummies, and interactions thereof. This polynomial represents a control function for input prices and is consistent with a large set of alternative demand and market structures and the main models used in industrial organization and international trade. Given that output prices are observed, the output price variation is eliminated from both the left- and right-hand sides of Equation 4, which becomes

$$q_{it} = \mathbf{e}_{it}^{*'}\boldsymbol{\alpha} + \omega_{it} + z_t(p_{it}, \mathbf{ms}_{it}, \mathbf{D}_i, G_i), \tag{7}$$

where p_{it} is the output price of the firm, $\mathbf{ms}_{it}$ is a vector of market share variables (including unconditional and conditional market shares), $\mathbf{D}_i$ captures product dummies, and G_i denotes firm location. The function $z_t(\cdot)$ serves here as a control for the unobserved input price variation $\mathbf{z}_{it}^{*'}\boldsymbol{\alpha}$. Conditional on productivity and input price variation captured by $z_t(\cdot)$, we obtain the correct structural production function parameters by considering how variation in physical input use maps into variation in physical output.

In sum, whereas the bulk of empirical work has focused on estimating the sales generating function (Equation 1), recent papers have focused on estimating the structural equation (Equation 2) by correcting for the output and/or input price biases. In all cases, the correction involves not only additional data, but also explicit statement of the assumptions under which the correction is valid.

2.2.3. A classification of existing work.

In **Table 1**, we classify existing papers on the broad subject of globalization and firm performance based on how they deal with unobserved

Table 1 Output and input prices: a classification[a]

		Output price (p_{it})	
		$\overline{p}_t^I$	p_{it}^*
Input price (z_{it})	$\overline{\mathbf{z}}_t^I$	Case A (standard framework)	Case B (De Loecker 2011)
	$\mathbf{z}_{it}^*$	Case C (observing output prices)	Case D (pass-through literature and De Loecker et al. 2012)

[a] $\overline{p}_t^I$ is the price deflator for industry I; $\overline{\mathbf{z}}_t^I$ is a vector of industry-specific input price deflators; and $p_{it}^* = p_{it} - \overline{p}_t^I$ and $\mathbf{z}_{it}^* = \mathbf{z}_{it} - \overline{\mathbf{z}}_t^I$ denote deflated output prices and input prices, respectively.

output and input prices. The columns and rows indicate which kind of price variation is controlled for.

Case A: standard framework. Most existing work uses output and input price deflators common across firms that capture industry-wide movements in output and input prices. The only price variation occurs in the time series, and any variation away from these industry-wide deflators will introduce the output and input price biases discussed above.

Case B: De Loecker (2011). In the setting considered in De Loecker (2011), price variation across firms is controlled for by explicitly introducing a demand system. On the input side, it is assumed that firms face common input prices.

Case C: observing output prices. In this case, input prices vary across firms, but output prices do not. As noted above, this case corresponds to a specification estimated in De Loecker et al. (2012) for expositional purposes, in which physical quantities are regressed against deflated input expenditures, as in Equation 5.

Case D: pass-through literature and De Loecker et al. (2012). Perhaps the only literature that has allowed for both output and input price variation to characterize firms active in international markets is the pass-through literature. (Representative papers include Goldberg & Verboven 2001, Nakamura & Zerom 2010, Berman et al. 2012, Goldberg & Hellerstein 2013, and Amiti et al. 2014.) This literature recognizes both that prices vary across firms and that firms respond incompletely and differentially to cost shocks; this incomplete response generates not only price dispersion across firms, but also, for a particular firm, price dispersion across destinations. The cost shocks considered in the pass-through literature are exchange rate changes, but the insights of this literature are equally applicable to other cost shocks, including input price shocks or changes in tariff and other trade policies.

In contrast to the literature described above that takes a production function approach, the pass-through literature relies on a demand-based approach in which assumptions on the demand side, market structure, and firm behavior are combined to derive measures of firm performance. Although this literature offers the advantage of a much richer treatment of heterogeneity and product differentiation, it comes at the cost of an extensive set of assumptions. These assumptions seem defendable in the context of case studies of particular industries, for which knowledge of the institutional details can guide the choice of the appropriate structure, but are more controversial when applied to a large cross section of industries. We therefore do not devote any space to discussing this literature here but focus on the production function–based approach instead. From a production function perspective, to our knowledge, only De Loecker et al. (2012) develop a framework that accounts for both output and input price variation and estimate Equation 7. Interestingly, the insights obtained using their approach turn out to be consistent with the main insights of the pass-through literature; not only do the findings indicate substantial heterogeneity across firms, but the authors find evidence consistent with incomplete pass-through of cost shocks to prices.

2.2.4. An example. We conclude this subsection with an example. We have a sample of 318 single-product Indian textile producers over the period 1989–2003 for which we observe (deflated)

Table 2 Estimated coefficients: evaluating the price biases[a]

Coefficients	Revenue	Physical output		
	Specification 1	Specification 2	Specification 3	Specification 4
Labor	0.162	−0.029	0.171	0.227
Materials	0.812	0.576	0.834	0.634
Capital	0.035	−0.514	0.010	0.140

[a]The data were constructed by De Loecker et al. (2012). We observe 318 producers of textiles (industry code PNIC 17). We omit the standard errors, but all coefficients are significant at the 1% level, as is common in the estimation of production functions. Specifications 1, 2, and 3 are ordinary least squares regressions of the relevant dependent variables (revenue in 1 and physical output in 2 and 3) on deflated expenditures, plus a polynomial in output price in 3. Specification 4 estimates the coefficients using generalized method of moments, in which we rely on lagged inputs as instruments exploiting the variation in adjustment costs in labor and capital, while allowing current productivity shocks to affect current material choices. Readers are referred to De Loecker et al. (2012) for further discussion.

sales and expenditures on labor, intermediate inputs, and capital; in addition, we observe product-level prices.[8]

We consider a standard Cobb-Douglas production function and highlight the output and input price biases using four distinct specifications:

1. An OLS regression of sales against expenditures
2. An OLS regression of quantity against expenditures
3. An OLS regression of quantity against expenditures and a control function for input prices that includes only the output price (this control function is a special case of the control function used in De Loecker et al. 2012; it rests on a vertical differentiation model of consumer demand in which the output price is a sufficient statistic for quality and hence input price variation)
4. A special case of De Loecker et al. (2012) that assumes an AR(1) process for productivity and, as in specification 3, a control function for input prices that depends only on output price

Table 2 lists the estimated coefficients.

Specification 1 generates perhaps the most familiar numbers for the various coefficients. This OLS regression is a useful way to describe the underlying data and check that the estimates are within the range of existing studies; there is a long list of papers that estimate production functions using different data sets. Therefore, the literature in this area has settled on what are reasonable-looking estimates.

In specification 2, we consider the case represented in Equation 5: Physical quantity is projected onto deflated expenditures, leaving input price variation uncontrolled for. We get results that are hard to interpret at first, such as negative labor and capital coefficients. But our framework actually predicts, or at least is consistent with, negative coefficients. Just as in our shirt production example, we find that firms that spend more on labor produce less output but generate more sales.

In specification 3, we stick to a simple OLS regression but add a third-order polynomial in the firm's output price. We recover coefficients similar to specification 1.[9] This OLS regression is a very useful diagnostic check for the problem at hand: By merely including output prices, while ignoring

[8]We consider only single-product producers to demonstrate the price bias in isolation. Using multiproduct firms requires a treatment of the unobserved input allocations, which is not the focus of this article [see the discussion under Section 2.2.1, option (*a*)].

[9]We obtain almost identical coefficients if we include output price in a linear fashion.

all other well-known identification problems, we generate plausible production function coefficients.[10] Of course, the proper benchmark should by no means be specification 1. However, it is reassuring that we get positive output elasticities for all three inputs and that the returns to scale now look sensible $\left(\sum_h \hat{\alpha}_h = 1.015\right)$.[11]

Finally, in specification 4, we allow for both unobserved productivity shocks to affect input choices and for heterogeneous input prices. This specification can be thought of as a special case of De Loecker et al. (2012): We control for serially correlated productivity using an AR(1) process for productivity, and for unobserved input price variation by including a control function in output prices as in specification 3. The coefficients are similar to those in specification 3, but there are a few differences, as expected. By controlling for unobserved productivity differences, we undo the negative correlation between capital and productivity and recover a substantially higher capital coefficient; furthermore, we find a lower coefficient on materials owing to the positive correlation between input use and productivity. **Table 2** does not list the remaining structural parameters describing the relationship between input prices and output price—i.e., $z_t(p_{it})$. But, interestingly, we find that $\left(\partial z_t(\cdot)\right)/(\partial p_{it}) > 0$ for all firms and time periods, confirming that output prices are positively correlated with input prices.[12]

2.3. Interpreting the Performance Residual (π_{it})

Equation 2 is useful for the remainder of this article for two reasons. First, it allows us to highlight the potential channels through which globalization can affect firm performance: Firms competing in international markets are likely to adjust their scale of production ($\mathbf{x}_{it}$ and hence $\mathbf{e}_{it}$), productive efficiency (ω_{it}), and prices and associated markups (p_{it}), as well as product and input quality (reflected in both p_{it} and $\mathbf{z}_{it}$). Second, we can classify almost all studies on the subject based on which component(s) of profitability they have focused on in each instance.

Existing work has, in one form or another, studied how episodes of trade reform affect productivity, prices, and quality across a wide range of countries, industries, and time periods. Below we argue that a large part of the literature has recovered only the impact on profits π_{it}, without decomposing it into the separate effects on the underlying factors. But in most instances, we care about the exact mechanisms through which trade affects firm performance, as these have different distributional and potentially also aggregate welfare implications.

Our production function framework suggests ways for identifying the components of the structural error π_{it}. After estimating the structural production function and demand parameters, De Loecker (2011) recovers separate estimates of productivity and markups, and consequently estimates of (average firm-level) prices. This is accomplished by committing to a particular demand system and market structure (i.e., CES demand paired with monopolistic competition). However, even when we are not willing to make assumptions on the underlying demand system and market structure, we may still be able to recover, if not the levels, at least the changes in markups using the

[10]We have found output price to have a first-order effect when we correct for input price variation. The use of output price as the sole control can be justified on the basis of a vertical differentiation model, in which price is a proxy for output quality, and hence also input quality and input prices. Additional variables, such as market shares and product dummies, make the control function more general and consistent with a larger set of demand models but lead to very similar results. Readers are referred to De Loecker et al. (2012) for more discussion on the estimation and identification of this control function, $z_t(\cdot)$.

[11]The OLS regressions do not control for the standard simultaneity bias, so even if we observed q_{it} and $\mathbf{x}_{it}$, we would not recover the production function coefficients $\boldsymbol{\alpha}$.

[12]This positive correlation is also documented by Kugler & Verhoogen (2012), who have the advantage of directly observing some input prices (e.g., wages and the prices of materials) as well as output prices in their Colombian data.

production function framework. If researchers observe prices, they can further obtain estimates of marginal costs.

De Loecker & Warzynski (2012) show how to recover markups from production data. The essential insight is that for any variable input free of adjustment costs, the markup drives a wedge between the input's output elasticity and the input's revenue share. The latter is directly observed in the data; the former is not but can be estimated. In the context of our Cobb-Douglas production function, the markup μ_{it} for firm i at time t is given by

$$\mu_{it} = \alpha_v \frac{S_{it}}{E_{it}^v}, \tag{8}$$

where v stands for variable. Depending on the application, variable inputs can include labor, electricity, or any other intermediate input.

To illustrate this approach, let us consider the same data on Indian textile producers. Let materials be a variable input in production. Using Equation 8, we compute the markup as $0.634 \times (S_{it}/E_{it}^m)$ and obtain an average markup of 1.30 with a standard deviation of 0.65. The markup distribution suggests considerable variation, with the 25th percentile firm breaking even with a markup of approximately 1, while the 75th percentile firm makes substantial profits (excluding fixed costs) with a markup of approximately 1.42.

The markup calculation relies on estimates of the production function, which in turn deliver estimates of productivity. The specifics depend on the data at hand, and we refer readers to De Loecker & Warzynski (2012) and De Loecker et al. (2012) for detailed discussions of the issues that arise in the context of different data sets.

In sum, the production function framework has the potential to generate separate measures of productivity and markups without commitment to specific demand and market structure assumptions, as is common in the demand-oriented industrial organization literature on imperfect competition. Once the components of profitability are identified, one can examine how globalization affects each of these components. This is the subject of the next section.

3. MECHANISMS

We use the framework introduced above to discuss the main mechanisms through which participation in international markets (and, in particular, trade reforms) affects performance. We denote trade reforms by T_{it} and allow them to affect firms differently over time. This specification allows for firms in an industry to produce different products, for instance, so that they end up facing different rates of protection. Whether there is variation across firms is crucial for any identification strategy that tries to recover the causal effect of T_{it} on firm performance and its components. The mechanisms we discuss below can be broadly classified into two categories: mechanisms that induce changes within firms and hence affect firm-level components of profitability and mechanisms that induce the reallocation of economic activity across firms in an industry. In the latter case, firm-level profitability may be unaffected by trade, but trade-induced reallocation of resources from less to more profitable firms can still lead to better performance at the industry level.

3.1. Within-Firm Changes

Firms participate in international markets both as producers/sellers of goods and as buyers of intermediate inputs used in the production of these goods. Trade policies may affect both aspects of firm activity. Specifically, changes in the protection of final products (e.g., reductions in output tariffs) will affect the competition domestic producers face, and changes in the protection of intermediate inputs (e.g., input tariffs) will affect the costs of production. The channels through which trade reforms affect firms will accordingly depend on the specific nature of the trade policy changes, and in particular on whether these affect output versus input markets. Therefore, in the course of our discussion, we often find it necessary to make a distinction between output- and input-oriented trade policies (for expositional purposes, we base our discussion on tariffs given that these are easily measured, but in principle the arguments apply to any other trade policy).

We use Equation 2 as the basis of our discussion to differentiate between mechanisms that affect (*a*) the firm-level productivity ω_{it}, (*b*) the expenditures $\mathbf{e}_{it}$ and their components (input quantities $\mathbf{x}_{it}$ and prices $\mathbf{z}_{it}$), (*c*) output prices p_{it} and markups, and (*d*) none of the above, but induce within-firm reallocation in multiproduct firms.

3.1.1. Reduction of X-inefficiencies and management practices. The perhaps most advocated argument for opening up a country to foreign markets is that exposure to international competition increases the efficiency of the previously protected domestic producers. In terms of our framework, this channel would lead to an increase in the physical efficiency ω_{it}. But why would the efficiency of these producers increase? A popular argument is that intensified competition will reduce X-inefficiencies at the firm level. Although intuitive, this argument has little theoretical appeal in its simplest form; why were firms willing to leave money on the table prior to the trade reforms? A potential answer is that in practice, the reduction of X-inefficiencies is costly, and therefore it takes an increase in competition for firms to find it profitable to undertake the actions necessary to become more efficient. For example, in the face of intensified competition, firms might find it necessary to replace old, inefficient managers by more competent ones, or adopt better management practices. Although these considerations feature prominently in casual discussions of trade and productivity, we are aware of only a handful of papers that formalize these arguments. (Readers are referred to Schmidt 1997, and more recently Bloom et al. 2013, for an explicitly theoretical framework that relates competition to managerial incentives.)

From an empirical point of view, this mechanism suggests a reduced form way of introducing trade policy by making physical efficiency a function of trade policy:

$$\omega_{it} = \omega(T_{it}). \tag{9}$$

Note that the above mechanism suggests that the relevant policy is one that affects the output side of the firm, as the motivation for reducing X-inefficiencies arises from the exposure to intensified competition; in the case of tariffs, for example, the relevant measure of trade policy would be output tariffs.[13]

3.1.2. Feedback effects. The reason we expect firms to increase their productivity in response to a trade shock is that we expect them to undertake actions to become more efficient. Some of these actions may be unobservable to the researcher, in which case they will be subsumed in the residual ω_{it} (e.g., this is the case if firms replace current managers by better ones or adopt better management practices and these actions are not reflected in changes in expenditures). But in many instances, improvements in productivity will be associated with actions that are observable (e.g., investment in new technologies, R&D, and entry in export markets). In these cases, the law of motion of productivity should be modified so as to explicitly allow for these actions to affect productivity:

[13]Below we discuss the importance of including both contemporaneous and lagged trade policy variables to accommodate the role of expectations and dynamics.

$$\omega_{it} = g(\omega_{it-1}, A_{it-1}) + \xi_{it}. \qquad (10)$$

The term A_{it-1}, denoting any action undertaken by the firm to increase its productivity, is lagged given that it likely takes time for actions to take effect. Of course, that these actions (e.g., investment, R&D, exporting) are allowed to affect productivity does not mean that they will in fact do so. The above law of motion is entirely consistent with a finding that the action undertaken by the firm did not have an effect on productivity ultimately; hence, it does not assume the result. Nevertheless, if one believes that a certain action is likely to affect productivity, it is imperative to include it in the law of motion.

Productivity-enhancing actions will typically be correlated with the inputs in the production function so that their omission from the law of motion will generate an omitted variable bias. This is the main point of De Loecker (2013), and it can be made clear using the example of a productivity-enhancing investment. The investment will affect not only productivity, but also the capital stock. Suppose that we do not allow investment (the action) to affect productivity through the law of motion. Then the estimation of the production function will suffer from an omitted variable bias that will generate a biased capital coefficient; specifically, given that higher investment will likely be associated with higher capital, we would expect an upward bias in the capital coefficient estimate. Moreover, a second-stage regression relating productivity to investment would tend to understate the role of investment for the same reason; given that investment was not included in the first stage that estimated the production function, the improvement in firm performance will be attributed to the higher capital and not to the productivity improvement.

In conclusion, recognizing that productivity evolves endogenously in response to firms' actions calls for a modified law of motion for productivity at a minimum. Ideally, one would like to supplement this law of motion with an explicit model of how the actions A are determined. This is done, for example, in recent papers by Bustos (2011) and Aw et al. (2011). The relevant actions are exporting and adoption of new technology in the first paper and exporting and R&D in the second, and in both cases, the authors use structural models to show how these actions are determined and how they respond to trade liberalization.

3.1.3. Input side. In Equation 2, we explicitly distinguish between the two components of expenditures (e_{it}): physical input use ($\mathbf{x}_{it}$) and input prices ($\mathbf{z}_{it}$). Both components will typically vary across firms and will be affected by globalization; for example, a reduction of input tariffs will have a direct effect on the prices of imported inputs, and hence $\mathbf{z}_{it}$. There are three distinct reasons for firm-specific input prices ($\mathbf{z}_{it}$), even for firms active in narrowly defined industries: (*a*) pure geographical variation in input prices (e.g., local labor markets and constrained labor mobility imply regional differences in wages), (*b*) variation in input quality leading to differences in input prices, and (*c*) firm-specific input prices due to monopsony power in input markets. The literature on production function estimation has typically ignored or assumed away heterogeneity in input prices due to quality differences across producers or to imperfect competition in input markets.

To highlight the forces generating variation in expenditures across firms, let us write $e_{it}^h = x_{it}^h + z_{it}^h(\nu_{it}^h, G_{it})$ for a given input h. The term ν_{it}^h refers to the quality of input h.[14] We collect all other firm-specific factors determining input prices, including the firm's geographic location,

[14]We use the term quality to capture differences in observed and unobserved attributes of a given input (e.g., skill differences across workers). Whether one can measure input quality will depend on the data at hand. Standard firm-level data usually provide us with the total use of intermediate inputs in dollars, and sometimes even with physical units, but will typically not record input characteristics or direct measures of quality.

in G_{it}, which will capture, among other things, the (re)location of economic activity (e.g., plant closings, offshoring) induced by a firm's exposure to global markets or other shocks.

Four distinct and largely disconnected literatures have focused on how globalization affects the various components of input expenditures. First, the trade and productivity literature has set out to measure how the transformation of physical inputs (x) to output (q) changes with increased foreign competition; indirectly, this literature also deals with the scale effects that operate through inputs (x). Second, the trade and quality literature has focused on whether producers upgrade (or downgrade) the quality of their products and inputs in response to increased exposure to international trade.[15] Third, the trade and labor literature has focused on how globalization affects workers of different skills. Finally, the literature on multinationals and offshoring has investigated how globalization affects firms' locational choices (part of G_{it}). In all these cases, exposure to global markets affects $\mathbf{e}_{it}$ directly.

A different mechanism through which globalization can affect firm performance is highlighted by Halpern et al. (2011). So far, we have abstracted from the fact that the materials used in the production, m, are a composite of many different domestic and imported intermediate inputs. Acknowledging the aggregation underlying m suggests an additional channel for performance improvements: If the reduction in trade costs leads to the import of new intermediate inputs, then we would expect an increase in production beyond the one predicted by the increase in expenditures. This increase will be more pronounced if the new inputs are of higher quality compared to the ones previously used, but the argument does not rest on quality improvements: As long as the production technology exhibits a taste for variety, a larger number of imported inputs will imply higher output.

The simplest way to make this point is to consider (as in Halpern et al. 2011 or Goldberg et al. 2010) a standard Cobb-Douglas production function in capital, labor, a set of intermediate inputs M, and productivity Ω. To keep notation manageable, we abstract from quality differences between imported and domestic products and suppress the firm and time subscripts. Each intermediate input M_j is assembled from a combination of a domestic and imported variety:

$$Q = \Omega L^{\alpha_L} K^{\alpha_K} \prod\nolimits_{j=1}^{J} M_j^{\alpha_j}, \tag{11}$$

$$M_j = \left[M_{jF}^{\frac{\theta-1}{\theta}} + M_{jD}^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}}, \tag{12}$$

where M_{jF} and M_{jD} denote the quantities of the foreign and domestic inputs, respectively, and θ is the elasticity of substitution. Let us abstract from the output and input price biases. One can show that in this setting, Equation 2 takes the form

$$s_{it}^{*} = q_{it} = \mathbf{x}_{it}'\boldsymbol{\alpha} + F_i(n_{it}) + \omega_{it} = \mathbf{e}_{it}^{*'}\boldsymbol{\alpha} + F_i(n_{it}) + \omega_{it}. \tag{13}$$

The term $F_i(n_{it})$ is a function increasing in the number of imported inputs n_{it}. Hence, if a trade liberalization increases the number of imported intermediates, we will expect to see a rise in

[15]Schott (2004) and Khandelwal (2010) are classic references on the relationship between trade and product quality, and Verhoogen (2008) is a classic reference on the effects of globalization on both product and input quality. The main message of these papers is that producers often need to change/upgrade the quality of their products to enter foreign markets. These changes in product quality induce changes in input quality. Through the link between output and input quality, shocks in output markets affect factor markets.

measured productivity, $F_i(n_{it}) + \omega_{it}$. Why would a reduction in trade costs lead to the import of new intermediates? When deciding whether to import intermediates, firms balance the marginal cost savings associated with the new inputs against the fixed costs of importing. A reduction in the tariffs on inputs increases the cost savings associated with importing, leading to a larger number of imported intermediates. We note that this mechanism does not suggest any improvements in the physical productivity ω_{it}. The issue here is analogous to the well-known gains from the introduction of new products; because the standard deflators used to obtain deflated expenditures $\mathbf{e}_{it}^{*}$ do not account for new imported inputs, these new inputs will ultimately show an increase in measured productivity. This mechanism likely underlies the large within-firm productivity gains found in studies that examine the effects of input tariff liberalization, such as Amiti & Konings (2007) for Indonesia and Khandelwal & Topalova (2011) for India. In fact, Goldberg et al. (2009, 2010) explicitly show that the input tariff liberalization in India led to a large increase in the number of imported inputs.

3.1.4. Price and markup changes. It is natural to expect that firms will adjust prices and markups when faced with a trade shock. Many trade models assume CES preferences with monopolistic competition. Under these assumptions, markups are constant; hence, trade shocks do not affect markups. Recent theoretical work has moved away from these restrictive assumptions and considered alternative demand systems (while maintaining, for the most part, the assumption of monopolistic competition) to investigate how markups and prices respond to trade liberalization (see, e.g., Melitz & Ottaviano 2008, Feenstra & Weinstein 2010, Mayer et al. 2011, Arkolakis et al. 2012).

If we observe prices and have a plausibly exogenous source of variation for the trade policy T_{it}, it is conceptually straightforward to evaluate the price effects of trade reforms. We would start with the reduced form:

$$p_{it} = p(T_{it}) + \epsilon_{it}, \tag{14}$$

where ϵ_{it} is a standard independently and identically distributed error term. A tougher task is to identify the specific channels leading to price changes (i.e., the cost and markup responses to changes in international competition). To highlight these channels, let us write the price as the sum of marginal cost mc and markup μ:

$$p_{it} = mc_{it}(q_{it}, \mathbf{z}_{it}, \omega_{it}) + \mu_{it}(\mathcal{D}, \mathcal{M}). \tag{15}$$

The marginal cost mc is a function of the quantity produced q, the input prices the firm faces $\mathbf{z}$, and firm productivity ω. The markup μ will be a function of the demand structure $\mathcal{D}$ and the market structure and firm behavior, which we summarize in $\mathcal{M}$. Trade shocks are expected to affect each of these components, with the specific effects depending on the particular nature of the trade shock. As noted above, CES preferences and monopolistic competition imply constant markups (in log terms); unless trade liberalization affects the costs mc, it will have no effect on prices. In more general setups, markups will be variable and respond to the trade reform.

To illustrate the mechanisms at work, let us consider a simple example that features linear demand and monopolistic competition. When assessing the effects of trade reforms, one must distinguish conceptually between reforms that affect the input markets (e.g., input tariff liberalization) and reforms that affect the output markets (e.g., output tariff liberalization). Both types of reforms are likely to affect both marginal costs and markups, albeit through different channels.

Consider a unilateral output tariff liberalization first. The decrease in tariffs exposes domestic producers to increased import competition. In the context of Equation 15, this translates to a change in market structure and, consequently, the residual demand curve facing the firm. **Figure 1*a*** plots the initial equilibrium in this market, which occurs at the point at which the original marginal revenue curve intersects the marginal cost. For ease of exposition, we assume that marginal cost is constant and that it is not affected by trade liberalization. Trade liberalization implies intensified competition, so the residual demand curve will shift inward and become flatter. The new equilibrium occurs at a point at which both the price and markup are lower. This case corresponds to the standard intuition that trade liberalization, by intensifying competition, leads to lower prices and lower markups. **Figure 1** allows one to trace the particular forces that shift price from its prereform level p_0 to its postreform level p_1.

Next consider a unilateral input tariff liberalization. Input tariff declines will have direct effects on the marginal cost; they will reduce the input prices $\mathbf{z}_{it}$ and may further lead to improvements in productivity ω_{it} through the import of new intermediates discussed above. In the context of **Figure 1*b***, this implies a downward shift in the marginal cost curve. The decline in input tariffs does not affect competition; hence, we would not expect any effects on markups arising from changes in the residual demand facing the firm. However, as long as the underlying structure does not imply constant markups (as is the case with the CES), markups will change as a result of the incomplete pass-through of the marginal cost change to price. This is shown explicitly in **Figure 1*b***. The marginal revenue curve is not affected by the trade reform, while the marginal cost curve shifts downward. The postreform equilibrium is associated with a higher markup, although the price is lower than before. The reason is not that the environment has become less competitive. The higher markup arises as a result of the incomplete response of the price to the marginal cost change.

This apparently counterintuitive effect to trade and industrial organization economists is completely intuitive to international macro economists who have studied the incomplete response of prices to exchange rates. Just like input tariff shocks, exchange rate changes represent cost shocks to firms. It is well documented that prices respond incompletely to exchange rate shocks, a phenomenon known as incomplete exchange rate pass-through. Tariff and exchange rates have a symmetric effect on firms' profits; applying the insights of the exchange rate pass-through

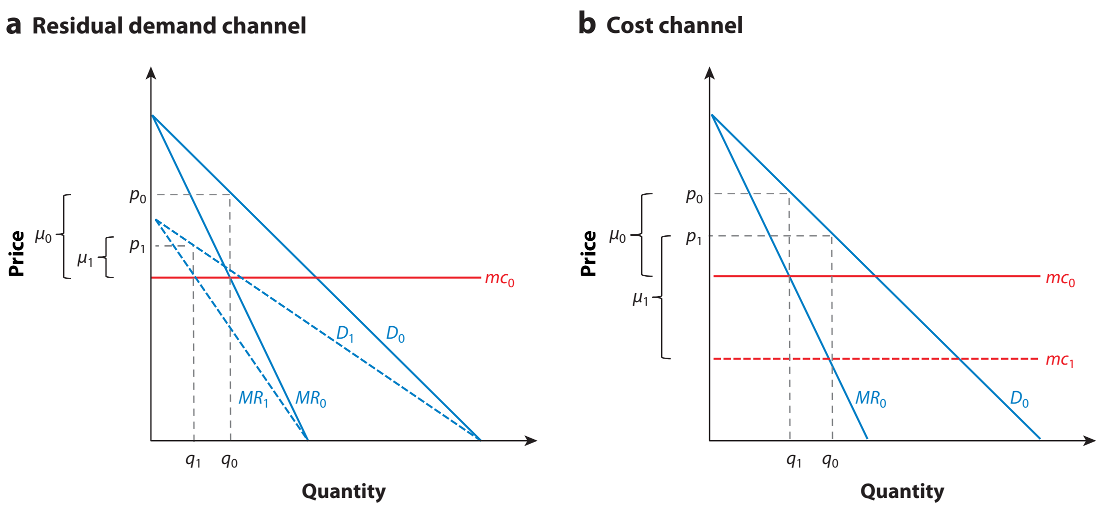

Figure 1

Price, quantity, and markup response to trade liberalization. The solid lines represent the initial demand and cost conditions, and dashed lines indicate the new demand and cost conditions (i.e., post–trade liberalization).

literature to input tariffs immediately yields the result that with variable markups, input tariff reductions will lead to markup increases. To our knowledge, this is an insight that the bulk of the trade literature has missed; only De Loecker et al. (2012) address this issue explicitly and show that incomplete pass-through of input prices led to markup increases in the case of the Indian trade liberalization. Prices did decline as a result of the trade reform, but the price reductions were only a small proportion of the cost declines; the bulk of the cost reductions benefited firms in the form of higher markups.

In reality, most trade reforms, especially those implemented in developing countries, combine input with output tariff liberalization (i.e., the real-world trade liberalizations are characterized by a combination of the channels in **Figure 1**). In such instances, it is particularly important to assess not only the reform's impact on prices, but also its effects on the price determinants. The reason is that the effects on input prices as well as markups can have important distributional implications.

3.1.5. Within-firm reallocation.

A different mechanism that can lead to within-firm performance improvements is highlighted by Bernard et al. (2010) and is specific to multiproduct firms: Firms can improve revenue productivity, that is, $\omega_{it} + p^*_{ijt}$ in the context of Equation 2, by reallocating within-firm resources from the production of less profitable products to the production of more profitable products, where j denotes products. This mechanism is similar in spirit to the one discussed in Section 3.2 on the role of reallocation in increasing aggregate industry performance. The difference is that here this mechanism generates performance improvements at the firm level. Importantly, this mechanism does not hinge on any improvements on the physical firm productivity, ω_{it}, which remains unaffected. The distinction between physical and revenue productivity is therefore important here: It is only revenue productivity that increases, and this increase is brought about entirely through the reshuffling of resources across products with different profitability.

3.2. Reallocation: Aggregate Effects

Above we focus on the potential effects of trade liberalization on individual producers. However, at the end of the day, what we care about is how an industry, country, or group of countries is affected by trade. Reallocation of economic resources from less toward more profitable producers is one way in which industry (or country) performance can increase, even in the absence of any effects on individual firms. There is by now a large theoretical and empirical literature highlighting the aggregate productivity gains arising from such reallocation.[16]

Collard-Wexler & De Loecker (2013) discuss some of the recent findings and point out that although we know by now that this reallocation process plays a substantial role in the data, it has been hard to identify specific forces that induce reallocation. Empirical work in international trade is perhaps the one big exception. The main advantage of studying large and arguably exogenous (at least from the perspective of an individual producer or industry) trade reforms is that they present us with exogenous shocks to the residual demand curves (in the case of output tariffs) and/or costs (in the case of input tariffs) facing domestic producers. We can then trace how the allocation of economic activity, usually measured by the market share in a particular market/industry, changes with the change in trade policy. The reshuffling of market shares toward the more productive/profitable firms has the potential to raise aggregate

[16]For example, this reallocation mechanism is central to the Melitz (2003) model and many other follow-up papers that feature firm heterogeneity.

performance beyond the potential individual firms' improvements discussed in the previous section. The extent to which the reallocation process is important depends of course on how dispersed profitability was initially, prior to the reforms. A well-known and influential study in this line of work is by Pavcnik (2002), who investigates the reallocation effects in the aftermath of the Chilean trade reforms.

Recently, Hsieh & Klenow (2009) put forward a simple theoretical framework to highlight this mechanism by focusing on wedges in marginal revenue products and pointing out distortions that can give rise to such wedges. Changes in both output and input tariffs fall nicely into this framework: Output tariffs present standard distortions in output markets as they constrain competition, whereas input tariffs generate distortions in capital and intermediate input markets. The reduction of these distortions through trade reforms should lead to a more efficient allocation of resources across firms.

This reallocation mechanism is in principle simple to measure in the data: calculate the covariance of productivity and market share for each time period and see how it reacts to the trade liberalization episode. However, the above discussion clearly demonstrates that the interpretation of the results will depend greatly on whether we rely on actual productivity (ω_{it}) or a performance measure (such as π_{it}) that contains cost, demand, and market structure components. For example, if we relied on π_{it} and found that the market share of more profitable firms increased post–trade liberalization, this increase might not be desirable from an aggregate welfare point of view if it represented a shift toward firms with more market power rather than higher efficiency.

3.3. Static Versus Dynamic Effects

So far we have not made a distinction between trade shocks that affect producers instantaneously and shocks that affect producers with a lag. Many theoretical models are static in nature or focus on steady-state predictions that blur the distinction. However, for empirical models that wish to separately identify the impact of trade liberalization on the various components of performance, the difference between static and dynamic effects can be important.

Let us focus on the productivity channel [$\omega(T_{it})$]. It is reasonable to ask whether producers can immediately adjust their productive efficiency when faced with a change in protection. This question boils down to whether the trade reforms were expected, and hence whether producers had time to adjust prior to the actual change.

The standard working assumption is to assume that firm-level productivity moves over time according to a first-order Markov process: $\omega_{it} = g(\omega_{it-1}) + \xi_{it}$. This specification is based on the observation that firm-level productivity (independently of how exactly it is measured) is highly persistent over time. However, the question remains whether we can think of trade liberalization as a shock that immediately affects productive efficiency. Take the example of a trade-induced reorganization of production. It arguably takes time for a firm to change the organization of production. Therefore, we would expect productivity to not react immediately or even possibly drop temporarily during the reorganization.

Therefore, it is important to let the function $\omega(\cdot)$ be sufficiently flexible in how trade policy shocks enter, by including both contemporaneous trade policy changes and lags. For example, in the context of analyzing the impact of trade reforms on firm performance in Indian manufacturing, De Loecker et al. (2012) consider a law of motion that, in addition to lagged productivity, also includes lagged output and input tariffs and the firm's lagged export status.

4. EVIDENCE

4.1. Profitability and Feedback Effects

If there is one robust finding that the literature has delivered to date, it is that industry profitability increases with exposure to foreign competition. This relationship is documented both in the time series, in studies that exploit trade liberalization episodes to identify the effects of trade openness on firm performance, and in the cross section, in comparisons of the performances of exporters and nonexporters. Most papers that exploit trade liberalizations focus on changes in output tariffs (Pavcnik 2002 is a classic reference), but recently, starting with the work of Amiti & Konings (2007), the focus has shifted toward input tariff liberalizations. Indeed, several studies on developing countries find the effects of input tariffs (representing direct cost shocks to firms) to be larger than those of output tariffs (which operate through changes in the competition facing firms). Furthermore, the literature finds evidence of both within-firm performance improvements and reallocation, with the relative importance of each channel depending on the particular setting. These findings are well documented in the literature, and we refer the reader to recent surveys by Melitz & Trefler (2012) and Melitz & Redding (2014) for a more extensive discussion.

At the cost of repeating ourselves, we emphasize once again that these findings of improved performance, although robust across countries and time, refer to profitability only and are therefore not particularly illuminating regarding the mechanisms at work. With this caveat in mind, it is worth pointing out that studies allowing for endogenous productivity evolution along the lines suggested in Section 3.1.2 find significant evidence of feedback effects. These feedback effects have two implications. First, in studies of trade liberalizations, they suggest that performance improvements are heterogeneous across firms, as firms with different characteristics (e.g., initial profitability levels, R&D expenditures, capital intensity) optimally choose different actions in response to trade shocks, which in turn affect their profitability. Bustos (2011), Aw et al. (2011), and Lileeva & Trefler (2010) find evidence of such heterogeneity. Second, in studies that compare exporters to nonexporters, feedback effects can lead to different conclusions regarding the relative importance of the effects of selection versus learning by exporting. De Loecker (2013), for example, demonstrates that in the case of Slovenia, learning by exporting seems to play an important role once one explicitly controls for the fact that entering export markets is associated with higher investment. These findings again point to the importance of employing empirical specifications that are consistent with the underlying mechanisms one has in mind when analyzing the data.

4.2. Mechanisms Underlying Profitability

It is only recently that research has focused on unpacking the mechanisms that generate the aforementioned performance improvements. Although it is still too early to draw general conclusions based on the findings of the few studies that explicitly distinguish between physical productivity and price effects, the evidence to date suggests that demand side and price effects are important and may be the primary factors generating the documented profitability increases.

To demonstrate the significance of these effects, consider De Loecker's (2011) study of the Belgian textile market. As explained above, De Loecker does not have price data but introduces a demand system to separate productivity from price effects. Hence, one can distinguish in his framework between aggregate profitability (Π_t) and aggregate productivity (Ω_t). **Table 3** illustrates the standard decomposition of aggregate (i.e., industry-level) productivity changes. Columns 2–4 refer to revenue productivity, and columns 5–7 refer to physical productivity. Columns 2

Table 3 Reallocation and trade liberalization[a]

Year	Profitability			Productivity		
	Π_t	$\overline{\pi}_t$	cov	Ω_t	$\overline{\omega}_t$	cov
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1994	1.00	0.90	0.10	1.00	0.95	0.05
1995	0.98	0.87	0.11	0.94	0.89	0.05
1996	1.02	0.93	0.10	0.99	0.95	0.03
1997	1.09	0.97	0.13	1.02	0.97	0.05
1998	1.06	0.97	0.10	0.97	0.94	0.03
1999	1.06	0.99	0.07	0.99	0.99	0.00
2000	1.02	0.99	0.03	0.95	0.96	−0.01
2001	1.03	0.96	0.06	0.95	0.95	0.00
2002	1.05	0.96	0.09	0.97	0.95	0.02

[a]This table is based on the estimates obtained from the analysis in De Loecker (2011). Both Π and Ω are normalized to one in 1994. We follow the decomposition in Olley & Pakes (1996), whereby aggregate productivity $\Omega_t = \sum_i ms_{it}\omega_{it} = \overline{\omega}_t + \sum_i(\omega_{it} - \overline{\omega}_t)(ms_{it} - \overline{ms}_t) = \overline{\omega}_t + \mathrm{cov}_t(ms_{it}, \omega_{it})$, with ms_{it} the market share. We apply the same decomposition to the profitability index Π_t.

and 5 show the aggregate changes at the industry level, columns 3 and 6 show the within-firm component, and columns 4 and 7 capture the reallocation.[17]

There are two interesting features of this table. First, the aggregate physical productivity change between 1994 and 2002, a period that spans the removal of major trade restrictions (i.e., quotas) in textiles, displayed in column 5 appears significantly lower than the change in revenue productivity in column 2. Hence, it seems that the usual productivity improvement shown in column 2 primarily reflects changes in prices. Second, column 4 suggests significant reallocation effects, from less profitable toward more profitable firms. The literature has often interpreted these effects as reallocation from less efficient toward more efficient firms. However, column 7 suggests that this interpretation is misguided: The reallocation effects computed using physical productivity are substantially smaller—almost nonexistent. Hence, it appears that the reallocation documented using revenue productivity as a measure of firm performance was reallocation toward higher price and higher markup firms, not toward firms with higher efficiency.

Because De Loecker (2011) works with a CES demand system, albeit one that allows for different demand elasticities across products within the textile industry, markups and prices at the product/firm level are not affected by the trade liberalization; the price and markup effects in his framework are the result of reallocation (across firms, or across products within a firm) toward firms/products with higher markups. However, we would expect trade liberalizations to also affect prices and markups at the firm/product level through both the residual demand (i.e., intensified

[17]Levinsohn & Petrin (2012) criticize this market share–based measure of reallocation as being uninformative in welfare calculations. Although we are sympathetic to their criticism, we simply want to compare our physical productivity–based results to those one would obtain using the standard approach in the literature, and to this end, we adopt the standard practices of this literature throughout the calculations.

competition) and the cost (i.e., lower prices of imported intermediates) channels. To this end, one needs to consider more general demand systems that allow for variable markups and incomplete pass-through of cost changes to prices. Such a framework is considered in De Loecker et al. (2012). As noted above, these authors do not commit to a particular demand or market structure but adopt an empirical specification that nests the main models used in trade and industrial organization, including those that generate variable markups. They use the Indian trade liberalization to separately identify the effects of the residual demand (reductions in output tariffs) versus cost (reductions in input tariffs) channels. The authors find that output tariff declines have the expected procompetitive effects; they lead to lower prices and lower markups. But the striking result is that in the end, the net effect of the Indian liberalization was to increase markups. This increase, which at first seems at odds with the standard intuition that trade has procompetitive effects and hence reduces markups, does not come about because of firm collusion, or any other attenuation of competition. It is the result of the incomplete pass-through of input tariff declines to prices.

These results, which may seem surprising in the context of trade, are consistent with the findings of the exchange rate literature as well as the substantial macro literature on price rigidities. Overall, studies that have attempted to explicitly address the price and markup effects associated with trade openness suggest that the demand side of the market is as important as the cost side; trade liberalizations lead not only to (physical) productivity improvements, but also to changes in prices and markups that need to be modeled explicitly.[18]

5. CONCLUSIONS AND FUTURE WORK

We conclude with some final thoughts on the state of the literature and future work. There are several strands within the trade literature that deal broadly with firm performance and globalization, each employing different assumptions and approaches. Unfortunately, there has been minimal cross-fertilization of ideas across these literatures up to now.

The empirical productivity literature has focused on estimating the effects of trade on firm performance, without distinguishing between physical efficiency and price/markup effects. Mainstream theoretical models in the trade literature often employ assumptions that imply constant markups (e.g., CES preferences with monopolistic competition) and hence abstract from the potential of trade to affect markups. Models that do allow for markup effects have typically focused on the procompetitive effects of trade, paying little attention to the markup effects that arise as a result of incomplete pass-through of trade-induced cost reductions to prices. But this type of incomplete pass-through has been precisely the focus of the large literature on exchange rate pass-through, which tries to understand how prices and markups respond to exchange rate shocks. Its insights have never been applied to trade liberalizations, despite that (input) tariff reductions and exchange rates have similar effects on firm profits. Finally, there have been case studies of the effects of trade liberalization on firm performance in particular industries, for example, automobiles (see Goldberg 1995, Berry et al. 1999), that rest on estimation of structural industry models in the industrial organization tradition, but the results of these studies do not readily generalize to the economy at large.

We believe that the time is ripe for the methods and insights of these separate literatures to be combined in theoretical and empirical work in this area and hope that this article represents

[18]A similar point emphasizing the role of the demand side is made by Foster et al. (2008, 2012) but in the context of the domestic market.

a small step in this direction. Indeed, there are encouraging signs. Recent empirical work on the effects of trade liberalizations has tried to distinguish between efficiency and markup effects, yielding novel insights. Current work on the effects of trade on markups makes an explicit distinction between the competition and the pass-through channels. But much more research, on different countries and different time periods, is needed before we will be able to draw general conclusions. Furthermore, the past few years have seen the emergence of an exciting new literature on assessing the aggregate gains from trade under alternative modeling assumptions. This literature that is primarily, although not exclusively, theoretical has emphasized the role that functional form assumptions, especially ones with implications for markup adjustment, play in evaluating the gains from trade. Careful empirical work that is motivated by and consistent with theoretical models, but does not depend heavily on restrictive functional form assumptions, can play an important role in informing the assumptions of the models used to assess the welfare gains from trade.

DISCLOSURE STATEMENT

The authors are not aware of any affiliations, memberships, funding, or financial holdings that might be perceived as affecting the objectivity of this review.

ACKNOWLEDGMENTS

We would like to thank Tim Bresnahan for early conversations on the topic and especially Pol Antràs for valuable comments. Channing Verbeck Jr provided excellent research assistance.

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