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Differences in Price Markups between Exporters and Non-Exporters: Theory and an Application to Ghana's Manufacturing Sector

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Abstract

This paper builds on a simple model of Cournot competition with differentiated costs to study differences between exporters and non-exporters in terms of their domestic price markup and output shares and considering the case when firms face capacity constraints in the short-run. In the absence of capacity constraints, the model confirms the finding in previous research of a higher domestic markup for exporters than for non-exporters and finds that, in equilibrium, exporters who also produce for the domestic market have higher shares of total domestic output than non-exporters. These results hold regardless of whether exporters are able to exercise market power in export markets. With capacity constraints, exporters are also found to charge a higher domestic markup than non-exporters, but they may not necessarily have larger shares of total domestic output since they export at the expense of selling less at home. Firms in the Ghanaian sample also seem to fit the capacity constraints model better since we observe large exporting firms who produce little or nothing for the domestic market. The prediction that exporters have higher domestic markups is then tested empirically with a panel of manufacturing firms from Ghana using panel data techniques and a Hall-type (production function) approach to estimating markups. Due to endogeneity concerns, results from using instrumental variables (IV) and general method of moments (GMM) estimation techniques are also obtained. The main results suggest Ghanaian exporters have a *domestic* markup between 7.7 and 10.2 percentage points higher than non-exporters. Exporters also seem to face intense competition in export markets outside Africa, where they are not able to charge a positive markup, while in African markets competition may not be as tough.

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1. Introduction

In this paper, differences in domestic markups and output shares between exporters and non-exporters are first analyzed using a model of domestic Cournot competition and considering the possibility that exporters may or may not be able to exert market power abroad. The model also considers what happens to domestic markups and output allocations between exports and the domestic market when firms are capacity constrained. In the empirical part, the prediction that exporters have higher domestic markup than non-exporters is tested using a version of the production function approach by Klette (1994, 1999) with a panel of Ghanaian firms for the period 1991-2002. In this section, a brief overview of the paper and previous work on the subject is first discussed.

The goal of most models of trade under imperfect competition is usually to explore the effects of different trade policies on, among other things, welfare, competition and firm entry and exit, or to explain intra- and inter-industry patterns of trade. A standard prediction in the theoretical literature is that by lowering or eliminating trade barriers a country will experience a reduction in prices due the disciplining effect that imports have on domestic producers. Faced with a higher level of competition from foreign firms, domestic producers who may have had some degree of market power before will be forced to lower their prices and charge a lower price markup over marginal cost. But much less research has been devoted to study what happens to price markups in the domestic market of those firms that produce for both their domestic market and the export market where they are predicted to have this disciplining effect.

Recent trade models focus on differences across firms in terms of size and productivity and find that some firms are able to export because they have a lower marginal costs or higher levels of efficiency than non-exporters producing the same good. As a result, markups in equilibrium are distributed unevenly across firms with different productivity levels and in particular, this leads exporters to have a higher price markup at home than non-exporters. To be sure, the main focus of these models is not solely on markup differences between exporters and non-exporters, but this is a common result of allowing heterogeneity in firms' costs and/or efficiency. Bernard, et al. (2003), for example, develop a model of Ricardian trade in which firms compete in terms of prices (Bertrand competition) to explain differences in size, productivity and export status among firms in the United States. Since their model allows for differences in productivity across firms, their results predict that more efficient firms have a cost advantage over their competitors in domestic markets and only the most efficient firms may be able to cover exporting costs and outcompete their rivals in foreign markets. In Melitz (2003), firms face a demand curve derived from Dixit-Stiglitz preferences and hence maximize profits by choosing to produce different varieties of a certain good. This model also predicts that more productive firms charge higher markups and produce larger amounts of output, even though they face the same marginal costs of production and charge lower prices in equilibrium. As in Bernard, et al. (2003), the key in Melitz (2003) are the productivity differences across firms. Melitz and Ottaviano (2008) extend this model to account for differences in market size and find that firms in larger markets are bigger, more productive and charge lower markups. This is because competition in these markets is tougher and therefore less productive firms do not survive. In both Melitz (2003) and Melitz and Ottaviano (2008), it is the most productive firms that enter export markets and hence, charge higher markups than other less productive firms. Clerides, et al. (1998) follow a similar approach in their theoretical model, but instead of productivity differences they assume firms have different marginal costs. The authors do not explicitly address the issue of markup differences across firms with different costs, but again, the prediction that exporters charge a higher domestic markup at home than non-exporters is implicit in their model. The main purpose in Clerides, et al. (1998) is to determine whether participation in foreign markets results in efficiency gains for exporters and they test their predictions against a panel of Colombian, Mexican and Moroccan firms.

In this paper, the main interest is explicitly on markup differences between exporters and non-exporter and we have seen that, in general, the results from these trade models do predict a higher domestic markup for exporters. Moreover, due to their cost advantage, exporters are also predicted to produce larger amounts of output for the domestic market. In reality, and particularly in developing countries, this last prediction may not necessarily hold. In the sample of Ghanaian manufacturing firms used in this paper, for example, we observe exporters that produce large amounts of output and employ a large number of workers, but sell a much lower share of their output at home than much smaller non-exporters. In fact, some of these exporters produce nothing for the domestic market.

For this reason, the first section of the paper develops a model of Cournot competition with cost differences across firms and the possibility that firms face capacity constraints. In fact, the modeling strategy is very similar to the one employed in earlier trade models such as Dixit (1984), Brander and Krugman (1983) and Horstmann and Markusen (1992), with the key difference that the model in this paper allows marginal costs to vary across firms. Unlike all the studies cited thus far, no assumption is made regarding the form of the demand curve, but as a result, the model is not explicitly solved. Another limitation is that the model focuses only on the domestic market and takes equilibrium in foreign markets as given, without taking into account the reaction by foreign firms to the output decisions of domestic firms. The goal of the model is to first analyze the case of firms in the absence of capacity constraints to capture and highlight the previous results in the literature, discussed above, regarding domestic markup and output differences between exporters and non-exporters. The case of capacity constrained firms is then analyzed, where exporters are also found to charge a higher domestic markup than non-exporters. However, exporters may not necessarily have larger shares of domestic output since they face the decision of whether to export or sell at home. As demand conditions improve in foreign markets, exporters with limits on how much they can produce in any given period decide to export more at the expense of selling less at home.

The results from the capacity constraints model have important policy implications since the output decisions of exporters will have an impact on domestic prices. As exporters sell more in export markets and non-exporters are unable to increase their own production, the total amount of output produced by all firms for the domestic market decreases and the equilibrium price increases. This also means that domestic markups for both exporters and non-exporters also increase. Therefore, a policy of export promotion may come at the cost of increased prices at home and a loss of consumer welfare, unless export promotion is accompanied by other policies aimed at easing the constraints faced by producers.

In the second part of the paper, the prediction that exporters charge a higher markup than non-exporters is tested empirically against a panel of Ghanaian manufacturing firms for the period 1991-2002. The econometric framework used to test this prediction is based on the production-function approach developed by Hall (1988) and extended in Klette (1994, 1999). This method relies on estimating a production function under the assumption of imperfect competition that allows for the joint estimation of markup ratios and returns to scale parameters. By taking log deviations of the output and input variables from their sector medians, the method also avoids the need to use firm-specific output and input prices to deflate the main variables. This approach to estimating markups differs from the more traditional approach in the New Empirical Industrial Organization (NEIO), which mainly relies on estimating demand elasticities to measure price-cost margins and infer market conduct.

As argued in De Loecker (2011), the production-function approach has some advantages over NEIO methods, which include requiring data only on production variables and avoiding the need to impose any assumption on the shape of the demand curve. In addition, the method used in this paper also allows capital to be quasi-fixed, which might be particularly appropriate for the Ghanaian firms in the sample given that there is some evidence that they face capacity constraints. At the same time, the production-function approach also suffers from some limitations. In particular, markups cannot be estimated individually for each firm, forcing the assumption that firms in a given sector, market or even country charge the same markup and interpreting it as an average. The method is also limited since it only allows for recovering markup ratios, but no inference can be made on the sources of market power or conduct. In addition, in most cases, the estimating equation is derived under the assumption of perfect competition in input markets, although in recent work imperfections in the labor market have also been incorporated to the general model (Bottasso and Sembenelli, 2001; Dobbelaere and Mairesse, 2007; Benavente, et al., 2009; Amoroso, et al., 2010). Nonetheless, different versions of the production function approach have been extensively used to measure markups in different countries. In particular, the method has been used to test (and confirm) the prediction that imports have a disciplining effect on domestic producers by lowering markups using firm-level data from Turkey (Levinsohn, 1993), Cote d'Ivoire (Harrison, 1994), India (Krishna and Mitra, 1998), Italy (Botasso and Sembenelli, 2001), Belgium (Konings, et al., 2001), Sweden (Wilhelmsson, 2006) and the United Kindgom (Boulhol, et al., 2009).

In addition, the prediction that exporters have a higher markup than non-exporters has also been recently tested using this method. Bellone, et al. (2008) find a markup premium for exporters of 1.8 to 3.0 percentage points in a sample of French manufacturing firms for the period 1986-2004. Görg and Warzynski (2003) also find markup premiums of similar magnitude for exporters in a sample of UK manufacturing firms between 1990 and 1996. For Slovenian manufacturing firms, De Loecker and Warzynski (2010) find relatively higher export premiums, with markup ratios that are between 13 and 16 percentage points higher for exporters than for non-exporters during the period 1994-2000. One major drawback in these studies is that no distinction is made between the foreign and domestic markups of exporting firms, so that the estimated markups represent the average between the price-cost margin in the domestic and export markets. If exporters in these countries have little or no market power abroad, the average markup estimated will underestimate the true markup these firms are able to charge at home and hence, the markup premium they have over non-exporters.

In this paper, the markup for Ghanaian exporters is divided into its domestic and foreign components and the results confirm that exporters have a higher *domestic* markup than non-exporters. In the main results, the domestic markup premium for exporters is between 7 and 10 percentage points. At the same time, the estimated markup ratio for Ghanaian exporters in international markets is much lower than their domestic markup. In fact, in some of the results, this markup ratio is indistinguishable from one, implying marginal cost pricing for these firms in export markets. Finally, the detailed nature of the Ghana dataset allows us to further separate the foreign markup for exporters according to the destination of their exports. The results suggest the price-cost margin for Ghanaian exporters may be slightly positive for sales within Africa, but it is closer to zero for exports to other countries. Since most of Ghana's trade outside of Africa is with industrialized countries, these results suggest that Ghanaian exporters face stronger competition there than in African export markets.

2. Cournot competition, exports and capacity constraints

Consider a market of n firms each producing a quantity q of a homogenous product for the domestic market and competing in terms of quantities (Cournot). A fraction, but not all, of the n firms also sells some amount $q*$ abroad. Marginal cost, c_i, is assumed to be constant but allowed to vary across firms. In addition, exporters face additional transportation costs (also constant) of t for each unit of output sold abroad. The transport cost is broadly defined to capture not only the actual cost of transporting the goods abroad, but any additional per unit cost associated with selling the product in foreign markets such as relabeling. In order to sell abroad, firms must also pay a fixed cost F, associated with items such as export licenses or the search for distributors and/or customers abroad. This means that firms only incur the fixed cost of exporting F if they actually export[1] so that its derivative with respect to exports is:

$$\frac{\partial F}{\partial q_i^*} = \begin{cases} 0, \text{for } q_i^* = 0 \\ F, \text{for } q_i^* > 0 \end{cases}$$

In addition, the model considers the case when firms have limits on the amount of output they can produce. When capacity constraints are binding, firms can produce at most a total level of output of $\tilde{q}_i$. In the case of capacity constrained firms, the model is describing a short-run situation where firms are unable to make the necessary investments to increase their output due to, for example, a lack of credit or because quantitative restrictions make vital imported inputs impossible to obtain. Note that capacity constraints are also defined broadly so that firms operating below *installed* physical capacity may still be output constrained due to the difficulties in obtaining additional inputs and/or finance.

Why introduce capacity constraints? As shown below, in the absence of capacity constraints partial exporters (firms that produce for both the domestic and export markets) can produce all the output they need in order to maximize profits at the point where marginal revenue is equal to marginal cost in both domestic and export markets. Given the cost advantage of exporters over non-exporters (that is one of the main theoretical explanations for why some firms export), and that firms can produce as much as they need to, this means that partial exporters will have a higher domestic output level than non-exporters and a larger share of the domestic market. But in reality we observe firms that export all of their output or partial exporters with lower domestic output levels than relatively smaller non-

[1] Other models of trade and imperfect competition that explicitly consider these costs in a similar manner include Clerides, et al. (1998), Horstmann and Markusen (1992) and Markusen and Venables (1988).

exporters. This is certainly the case in the sample of Ghanaian firms used in the empirical section of this paper, where exporters with hundreds of workers and high total output levels produce a smaller amount for the domestic market than a small firm with a few employees and a much lower level of total output.

With the possibility of limits to output capacity, the model can be formulated as firms solving a constrained profit maximization problem described as follows:

$$\max_{\{q_i, q_i^*\}} \pi_i = (P(Q) - c_i)q_i + (P^*(Q^*) - c_i - t_i)q_i^* - F \qquad (2.1)$$
$$\text{s.t. } q_i + q_i^* \leq \tilde{q}_i$$
$$q_i, q_i^* \geq 0$$

The profit function in Equation (2.1) summarizes the case of both exporters and non-exporters. For the latter, $q* = 0$, and the last two terms on the right disappear. Firms are assumed to choose the pair of output levels (q_i, q_i^*) that maximize profits. To see what happens to both exporters and non-exporters in terms of output, market shares and markups, it is useful to study the problem's Kuhn-Tucker first order conditions after partial differentiation of the Lagrangian:

$$L(q_i, q_i^*, \lambda) = (P(Q) - c_i)q_i + (P^*(Q^*) - c_i - t_i)q_i - F - \lambda[q_i + q_i^* - \tilde{q}_i]$$

$$\frac{\partial L}{\partial q_i} = q_i \frac{\partial P(Q)}{\partial Q} \frac{\partial Q}{\partial q_i} + P(Q) - c_i - \lambda \leq 0; \qquad q_i \geq 0 \quad \& \quad q_i \frac{\partial L}{\partial q_i} 0 \qquad (2.2)$$

$$\frac{\partial L}{\partial q_i^*} = q_i^* \frac{\partial P^*(Q^*)}{\partial Q^*} \frac{\partial Q^*}{\partial q_i^*} + P^*(Q^*) - c_i - t_i - F - \lambda \leq 0; \qquad q_i^* \geq 0 \quad \& \quad q_i^* \frac{\partial L}{\partial q_i^*} 0 \qquad (2.3)$$

$$\frac{\partial L}{\partial \lambda} = q_i + q_i^* - \tilde{q}_i \leq 0; \qquad \lambda \geq 0 \quad \& \quad \lambda \frac{\partial L}{\partial \lambda} 0 \qquad (2.4)$$

The conditions in (2.2) and (2.3) determine the output levels the firm decides to allocate between the domestic and foreign markets, respectively, and (2.4) embodies the possibility that firms may or may not face limits to how much they can produce. This means that when firms are capacity constrained, the constraint in (2.1) is binding and the Lagrange multiplier is greater than zero ($\lambda > 0$).

2.1 Non-exporters and no capacity constraints

Non-exporters are firms who produce exclusively for the domestic market. In other words, for these firms domestic output is positive ($q_i > 0$) and exports are zero ($q_i^* = 0$) and we can use these values with the conditions in (2.2) to (2.4) to analyze the factors for why these firms are actually non-exporters, as well as the markup they charge in equilibrium. Here, the case when firms are able to produce as much as output as they need to is considered (i.e., no capacity constraints). This means that the constraint in the profit maximization problem in (2.1) is not binding and the Lagrange multiplier in the Kuhn-Tucker conditions is equal to zero. In particular, with a non-binding constraint ($\lambda = 0$) the first condition in (2.4) remains with inequality and firms could be operating just at or below full capacity, so that:

$$\frac{\partial L}{\partial \lambda} = q_i + q_i^* \leq \tilde{q}_i$$

In the absence of capacity constraints, the first condition in (2.2) becomes:

$$\frac{\partial L}{\partial q_i} = q_i \frac{\partial P(Q)}{\partial Q} \frac{\partial Q}{\partial q_i} + P(Q) - c_i = 0 \qquad (2.5)$$

Equation (2.5) describes the factors that enter the domestic output decision of non-exporting firms. In many competition models, it is common to assume a certain form for the demand function in order to obtain firms' best response functions and solve for the equilibrium price and quantities explicitly. But the main concern in this paper is to study how differentiated costs and capacity constraints affect the markups charged by exporters and non-exporters and not to prove the existence of an equilibrium solution or to derive one. Therefore, I opt for keeping the conditions in general form and assume that all firms charge the same price in equilibrium, with no assumption regarding the form of the demand curve. Nonetheless, by solving for q_i in Equation (2.5) it can be readily seen that the quantity of output that non-exporters produce for the domestic market depends positively on the market price (i.e., the level of aggregate demand implied by the inverse demand function, $P(Q)$), and negatively on the firm's own marginal cost (c_i) and on the price response to aggregate changes in output ($\partial P(Q)/\partial Q$), as well as on the aggregate output response to individual firm output decisions ($\partial Q/\partial q_i$)[2]:

[2] Note that by itself, the term $\partial P(Q)/\partial Q$ is negative since a downward-sloping demand curve implies that a higher level of aggregate output will result in a lower equilibrium price. To solve for q_i, the entire term containing the individual firm

$$q_i = \frac{P(Q) - c_i}{\left|\frac{\partial P(Q)}{\partial Q}\right| \frac{\partial Q}{\partial q_i}} > 0 \tag{2.6}$$

In turn, after dividing by price and some re-arranging, Equation (2.6) can be expressed as the well-known Lerner index (L_i), which measures the extent to which price deviates from marginal cost and as such, it is a measure of a firm's market power:

$$L_i \equiv \frac{P(Q) - c_i}{P(Q)} = \frac{\theta_i s_i}{\eta} \tag{2.7}$$

Where,

$$s_i = \frac{q_i}{Q}, \text{is firm i's share of domestic output;}$$

$$\eta = -\frac{\partial Q}{\partial P}\frac{P}{Q}, \text{is the price elasticity of demand; and}$$

$$\theta_i = \frac{\partial Q}{\partial q_i}, \text{is a conjectural variations parameter.}$$

As expressed above in Equation (2.7), a non-exporting firm's market power is positively related to its share of domestic output (s_i) and inversely related to the market price elasticity of demand (η_i), as well as a conjectural variations parameter (θ_i) capturing market conduct. Under Cournot competition, each firm decides how much to produce holding all other firms' output levels constant so that a change in output by an individual firm will result in a one-to-one change in total market output (θ = 1). A value of zero for the conduct parameter (θ = 0), on the other hand, implies firms believe their output decisions have no effect on total market supply and instead compete in prices as in the Bertrand model, where intense competition drives firms to lower prices until they equal marginal costs.

The main implications of Equations (2.6) and (2.7) is that in the absence of capacity constraints, non-exporters choose how much to produce for the domestic market based on the conditions prevailing

output level is moved to the right hand side of Equation (2.5) and it becomes positive. Therefore, the absolute value of $\partial P(Q)/\partial Q$ is included in (2.6) and the quantity of output produced by non-exporters is positive.

in that market only. This means that these firms treat the domestic and foreign markets as separate, as export demand and the costs associated with exporting and transporting goods abroad do not explicitly enter the non-exporting firm's domestic output decisions. As we shall see below, this result also applies to exporting firms when they are not constrained by limits on their productive capacity.

Turning now to the conditions for exporting in (2.3) reveals the main reasons behind the decision by non-exporting firms to produce exclusively for the domestic market and sell nothing abroad. Since these firms export nothing ($q_i^* = 0$) and face no capacity constraints ($\lambda = 0$), the conditions in (2.3) reduce to the following inequality[3]:

$$\frac{\partial L}{\partial q_i^*} = q_i^* \frac{\partial P^*(Q^*)}{\partial Q^*} \frac{\partial Q^*}{\partial q_i^*} + P^*(Q^*) - c_i - t_i - F \leq 0 \tag{2.8}$$

With the exception of transportation costs and the fixed cost of exporting, Equation (2.8) is similar to Equation (2.5) in that it describes the factors entering the firm's decision to produce, but in this case for the foreign market. As before, the absence of capacity constraints means that firms treat the foreign and domestic markets as separate and the decision to export is independent of demand conditions in the domestic market; it depends only on aspects of foreign demand and the costs associated with exporting. Given $q_i^* = 0$, we can further simplify Equation (2.8) to more clearly derive the reasons why it is not profitable for non-exporters to produce for the foreign market:

$$P^*(Q^*) \leq c_i + t_i + F \tag{2.9}$$

The result in Equation (2.9) indicates that non-exporting firms do not export because they cannot cover the costs of producing the goods and exporting them abroad at any level of foreign demand (i.e., marginal revenue for exports is less than or equal to the sum of marginal cost, transportation cost and the fixed cost of exporting). Note also that this result holds for any mode of competition in the foreign market and whether domestic firms *would* be able to exercise some degree of market power in export markets. In the case of an imperfectly competitive export market, non-exporters would face a downward-sloping foreign demand curve, but since the foreigners' marginal willingness to pay is not sufficiently high to cover the costs of producing even the first unit of the good sold abroad, these firms export nothing[4]. With perfectly competitive export markets, non-exporters would face a flat demand curve abroad and would have no market power even if it was profitable to export. But producing for the

[3] Since $q_i^* = 0$, $\partial L / \partial q_i^*$ can be less or equal than zero.

[4] For the case of linear demand, the result in (2.9) implies that the demand curve's intercept is below $c_i + t_i + F$ (see, Figure 2.1 below).

foreign market is not profitable since the flat export demand curve (i.e., the foreign price, which is the marginal revenue of exports in this case) is below marginal and export costs.

2.2 Partial exporters and no capacity constraints

We now turn to the case of partial exporters with no capacity constraints, defined here as firms that produce for both the domestic and foreign markets. Having analyzed the case of non-exporters with some level of detail, the case of partial exporters is now easier to understand. First, note that the decision of how much to produce for the domestic market is virtually the same for non-exporters and partial exporters. In the absence of capacity constraints, this means that partial exporters also treat each of its output decisions as separate and as a result, their domestic markup does not depend on their level of market power in export markets.

Unlike non-exporters, however, solving for the exporting conditions in (2.3) reveals that partial exporters are able to produce for the foreign market due to their lower marginal cost of production. Given $q_i^*,\ \lambda = 0$, the first equation in (2.3) becomes:

$$\frac{\partial L}{\partial q_i^*} = q_i^* \frac{\partial P^*(Q^*)}{\partial Q^*} \frac{\partial Q^*}{\partial q_i^*} + P^*(Q^*) - c_i - t_i - F = 0 \qquad (2.10)$$

If partial exporters in the foreign market also compete in quantities, we can derive a similar expression of the Lerner index for these firms abroad:

$$L_i^* \equiv \frac{P^* - c_i - t_i}{P^*} = \frac{\theta_i^* s_i^*}{\eta^*} \qquad (2.11)$$

As in the previous case, partial exporters' market power abroad will depend on their output share (s_i^*) and the demand elasticity (η^*) in the foreign market. The assumption that firms compete in quantities also implies a conduct parameter abroad that is equal to one ($\theta_i^* = 1$). Just as partial exporters' domestic markup does not depend on foreign market conditions, the result in Equation (2.11) indicates that the degree of market power these firms have abroad is independent of domestic market conditions.

It may be the case that some exporters in developing countries are actually able to exercise some degree of market power in export markets and hence, have a positive markup there. This is perhaps more likely for firms in extractive industries in developing countries that have a significant share of the world's total supply of some natural resource, but a large number of *manufacturing* exporters in these countries tend to be small firms with only a few employees and even the largest manufacturers pale in comparison with their counterparts from developed countries (Tybout, 2000). Therefore, it is highly likely that partial exporters in developing countries, like the Ghanaian firms considered in later sections, perceive themselves to be too small to affect the output decisions of other firms in the markets where they export to. In that case, the conduct parameter in Equation (2.11) is zero and the first term in the export condition in (2.10) disappears. In that case, the inverse foreign demand equation becomes simply the equilibrium price abroad, implying that the profit maximizing partial exporter should produce until the foreign price is equal to the sum of marginal and export costs:

$$P^*(Q^*) = c_i + t_i + F \tag{2.12}$$

Taken literally, Equation (2.12) implies that any partial exporter that can outcompete all other firms in the foreign market would be able to capture that whole market[5]. This, however, is unrealistic even for most manufacturing firms from developed countries and is a direct consequence of assuming that firms can produce as much as they need to in order to maximize profits. When we make the more realistic assumption that (at least in the short run) there is some limit to how much a firm can produce in any given period, the partial exporter's output decisions for the foreign and domestic markets become interdependent and the result in Equation (2.12) no longer holds, a case that will be analyzed in the next sections.

Nonetheless, what the export conditions in either (2.10) and (2.12) reveal is that partial exporters have a marginal cost advantage over non-exporters and this is the main reason why it is profitable for the former to export and not for the latter. Since all firms charge the same price in equilibrium, it is this marginal cost advantage that leads to partial exporters having a higher *domestic* markup than non-exporters, even if partial exporters have little or no market power in export markets (i.e., even if their markup abroad is zero or slightly positive).

This result becomes clearer if we look more carefully at the cost differences between non-exporters and partial exporters. Unless all firms in the home country export and assuming transport costs per unit of output are the same for all firms to simplify matters ($t_i = t,\ \forall\ i \in n$), we can clearly establish that exporters have lower marginal costs than non-exporters. To see this, consider the

[5] This is in fact one implication of the model in Bernard, et al. (2003), where firms are assumed to compete in prices (i.e., Bertrand competition).

exporting conditions in (2.3) for the least cost-efficient partial exporter (firm z). Solving for the amount q_z^* this firm produces for the foreign market and introducing the assumption of common transport costs, we obtain:

$$q_z^* = \frac{-(P^*(Q^*) - c_z - t)}{\frac{\partial P^*(Q^*)}{\partial Q^*}\frac{\partial Q^*}{\partial q_z^*}} > 0 \leftrightarrow P^*(Q^*) - t > c_z \tag{2.13}$$

This means that firm z will not export unless the price abroad, net of transportation costs, is greater than its marginal cost of production. All non-exporters have higher marginal costs than firm z and the rest of exporters all have lower marginal costs. Hence, for non-exporters (indexed by nx), marginal costs are too high to find it profitable to sell abroad and then we have that:

$$c_{nx} \geq P^*(Q^*) - t > c_z$$

Again, since exporters have this marginal cost advantage, they will have a higher degree of market power at home than non-exporters. Furthermore, the difference in domestic market power between partial exporters and non-exporters is also present even if the former have little or no market power abroad. If partial exporters have a very small output share of the foreign market so that s_i^* in the foreign Lerner index equation above is close to zero, their pricing will also be very close to marginal costs ($c_i + t$) and they will have almost no market power abroad. The fact that these firms still find it profitable to export, however, implies that they clearly have a marginal cost advantage over non-exporters in the home market and hence they charge a higher domestic markup[6]. The same result holds if partial exporters are price-takers in export markets except that in this case, these exporters will have no foreign market power at all as they produce until the foreign price is equal to the sum of marginal and export costs, as in Equation (2.12).

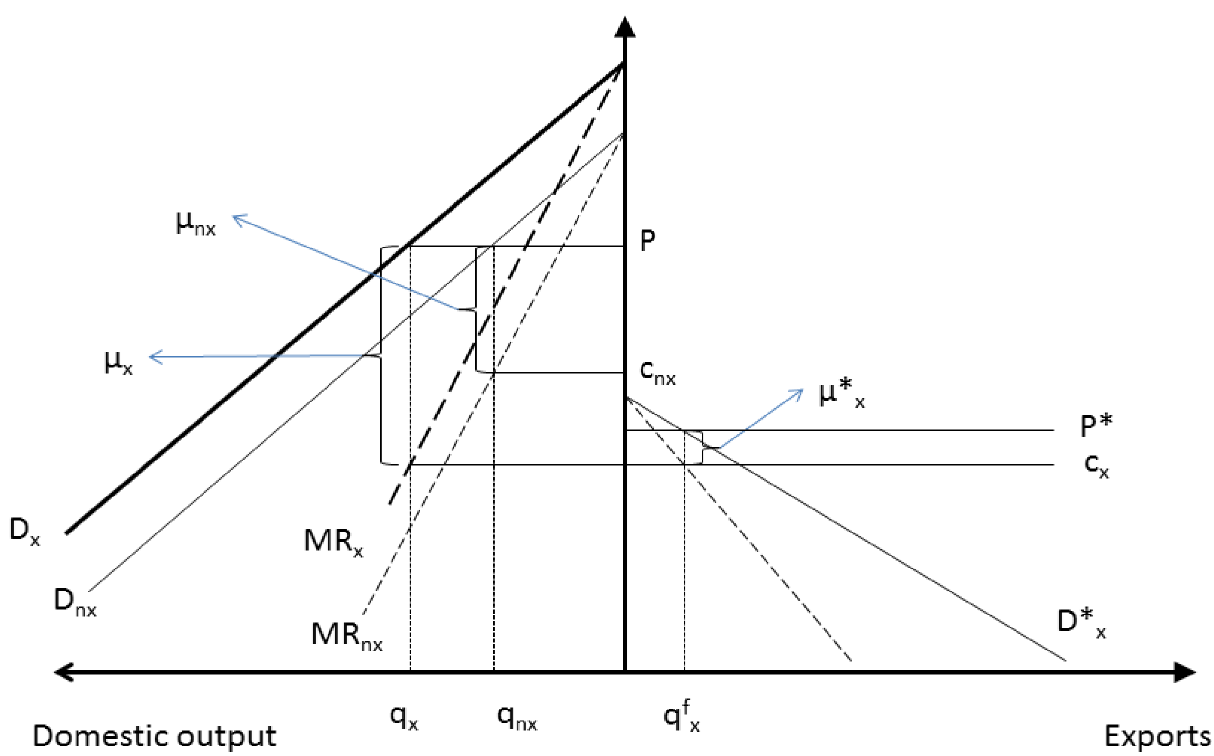
Figure 1 illustrates the 2-firm case in the absence of capacity constraints and where the exporting firm competes in quantities in the export market (i.e., the exporter faces a downward sloping foreign demand curve). The graph is based on Figure I in Clerides, et al (1998, p. 908). Their basic model yields essentially the same results as in the previous sections; namely, that exporters have a higher domestic markup and, with no constraints on output capacity, exporters have a larger share of total domestic

[6] This would also be the case if we add productivity differences to the model as in, for example, Melitz (2003). One way to incorporate productivity differences between exporters and non-exporters could be done by dividing marginal cost in the profits equation by z_i, a measure of the firm's productivity. Then, if in general exporters are more productive than non-exporters, they will have a lower productivity-adjusted marginal cost, even if marginal costs are the same for all firms. Higher productivity would then lead to exporters having a higher markup and a larger share of total output at home.

output than non-exporters.[7] The similarity of the results is not surprising given that their model also assumes firms compete in quantities, have different marginal costs and face transportation and fixed export costs.

To simplify the graph transport costs are assumed to be zero. Note also that because firms must pay a fixed cost to enter the export market, the foreign demand curve intersects the vertical axis at a lower point than the domestic demand curve. The non-exporter has a marginal cost of c_{nx}, which is too high to allow that firm to earn nonnegative profits in the foreign market. Therefore, the non-exporter only produces q_{nx} for the domestic market at the point where its marginal cost crosses its marginal revenue curve (MR_{nx}). On the other hand, the partial exporter produces a higher quantity q_{nx} for the domestic market due to its lower marginal cost of production (c_{nx}), which is also low enough for that firm to earn positive profits in the foreign market by selling an output of q_x abroad.

Figure 2.1: A partial exporter and a non-exporter without capacity constraints



[7] These are also the basic predictions of other models of trade and imperfect competition with no capacity constraints and differentiated costs (Bernard et al. 2003; Melitz 2003; Melitz and Ottaviano 2008). The main difference, however, is that these models have different assumptions regarding the mode of competition and/or introduce firm productivity in addition to differentiated costs. In addition, all of these models, including Clerides, et al. (1998), make specific assumptions about the shape of the demand curve.

In equilibrium, both firms charge a price of P in the domestic market, but because the partial exporter has a marginal cost advantage over the non-exporter, the latter produces a lower quantity. This means that in the home market, the non-exporter's residual demand curve (D_{nx}) is lower than the partial exporter's residual demand curve (D_x). As a result of these cost differences, and given that these firms are not capacity constrained, the partial exporter has a higher domestic price-cost margin (μ_x) than the non-exporter (μ_{nx}), even if the partial exporter's foreign markup (μ^*_x) is very low. The exporter's total level of output ($q_x + q^f_x$) is also much larger than for the non-exporter (q_{nx}).

2.3 Non-exporters and capacity constraints

The next two sections analyze the effect that capacity constraints have on the output decisions that both partial exporters and non-exporters face. Some parts of the analysis are similar to the previous sections but in this case, the constraint in the profit equation is treated as binding and the Lagrange multiplier in the Kuhn-Tucker conditions is then assumed to be positive. With a binding constraint ($\lambda > 0$), the first condition in (2.4) now becomes a strict equality and firms, regardless of export status, always operate at full capacity ($\tilde{q}_i$), so that:

$$\frac{\partial L}{\partial \lambda} = q_i + q_i^* = \tilde{q}_i$$

For non-exporters, the conditions in (2.2) and (2.3) now imply:

$$\frac{\partial L}{\partial q_i} = \left[q_i \frac{\partial P(Q)}{\partial Q} \frac{\partial Q}{\partial q_i} + P(Q) \right] - c_i - \lambda = 0 \tag{2.14}$$

$$\frac{\partial L}{\partial q_i^*} = \left[q_i^* \frac{\partial P^*(Q^*)}{\partial Q^*} \frac{\partial Q^*}{\partial q_i^*} + P^*(Q^*) \right] - c_i - t_i - F - \lambda \leq 0 \tag{2.15}$$

With capacity constraints, the domestic and export production conditions in Equations (2.14) and (2.15) now point out to a major difference with the previous results for non-exporters: a positive, binding constraint creates a wedge between marginal revenue and marginal costs in both markets. For the domestic market, the two terms in brackets in (2.14) represent the perceived marginal revenue per unit of output.[8] With a binding constraint, profit-maximizing now occurs at a point where perceived marginal revenue is higher than marginal cost, where this distance is given by the value of λ. More intuitively, the profit-maximizing firm would like to produce more, until perceived marginal revenue equals marginal cost, but because it is capacity constrained, the best it can do is to produce at full capacity. Therefore, non-exporters produce less than in the absence of capacity constraints.

Solving for the Lagrange multiplier in Equations (2.14) and (2.15) and adding the fact that non-exporters produce at full capacity and exclusively for the domestic market (i.e., $q_i = \tilde{q}_i$) yields:

$$\left[\tilde{q}_i \frac{\partial P(Q)}{\partial Q} \frac{\partial Q}{\partial q_i} + P(Q)\right] - c_i \geq \left[q_i^* \frac{\partial P^*(Q^*)}{\partial Q^*} \frac{\partial Q^*}{\partial q_i^*} + P^*(Q^*)\right] - c_i - t_i - F \tag{2.16}$$

The result in Equation (2.16) indicates that exporting is not profitable (i.e., the condition for q_i^* to be zero) when the difference between the perceived marginal revenue (the term in brackets on the left) in the home market and marginal cost is greater than or equal to the difference between perceived marginal revenue abroad (the term in brackets on the right) and the sum of marginal and transport costs. Note that marginal cost cancels out in Equation (2.16) and the reason why non-exporters sell nothing abroad becomes even clearer: for any combination of domestic output and exports, perceived marginal revenue at home is always higher than perceived marginal revenue abroad, net of transportation and fixed exporting costs.

Intuitively, since the firm is capacity constrained, it must choose where to sell its limited production. Faced with the possibility of earning a higher profit per unit of output at home instead of earning zero or even negative profits per unit of output in export markets, the firm will operate at full capacity (producing $\tilde{q}_i$) and sell only in the domestic market.

2.4 Partial exporters and capacity constraints

With a binding constraint on output capacity (λ > 0), the profit-maximizing level of domestic and foreign output for partial exporters are now given by the following set of conditions:

$$\frac{\partial L}{\partial q_i} = \left[q_i \frac{\partial P(Q)}{\partial Q} \frac{\partial Q}{\partial q_i} + P(Q)\right] - c_i - \lambda = 0 \tag{2.17}$$

[8] The "perceived" here is due to the conjectural variations assumptions. In other words, the relevant marginal revenue curve for a firm accounts for the *perceived* response by other firms to its own output decisions captured by $\partial Q / \partial q_i$.

$$\frac{\partial L}{\partial q_i^*} = \left[q_i^* \frac{\partial P^*(Q^*)}{\partial Q^*} \frac{\partial Q^*}{\partial q_i^*} + P^*(Q^*) \right] - c_i - t_i - F - \lambda = 0 \quad (2.18)$$

Equation (2.17) is the same as the domestic output condition for non-exporters, but Equation (2.18) now holds with equality since partial exporters produce positive amounts of output for export markets. The major change introduced by the presence of capacity constraints is that the domestic and foreign output decisions of partial exporters are now interdependent: producing more for the foreign market comes at the expense of producing less for the domestic market. Solving for λ in the two equations above and defining the terms in brackets as the perceived marginal revenue at home (PMR_i) and abroad (PMR^*_i), respectively, shows this interdependence more clearly:

$$\lambda = PMR_i - c_i = PMR_i^* - c_i - t_i - F \quad (2.19)$$

As in the case of capacity constrained non-exporters, Equation (2.19) shows that when partial exporters face limits to how much output they can produce they also operate at the point where there is a wedge between domestic perceived marginal revenue and marginal cost. Moreover, for partial exporters, this wedge is exactly equal to the difference between perceived marginal revenue abroad and the sum of marginal, transportation and fixed export costs. This implies that the conditions in the foreign market for partial exporters influence these firms' output decisions at home. If, for example, export demand increases, the profit-maximizing exporter will increase its output allocation to the foreign market and produce less for the domestic market, resulting in a lower share of domestic output for partial exporters compared to non-exporters. Note that this interdependence of output decisions for partial exporters is also present even if these firms are price-takers in export markets. In that case, partial exporters would face a flat export demand curve and perceived marginal revenue abroad is substituted by the prevailing price for the good in the foreign market:

$$\lambda = PMR_i - c_i = P^* - c_i - t_i - F \quad (2.20)$$

When partial exporters are price-takers abroad, the result in Equation (2.20) shows that the incentive to export increases with a greater deviation between the foreign price and production costs ($c_i - t_i - F$). But this deviation is nothing more than the markup that partial exporters are able to charge in export markets, at least in the short-run, when firms face limits to their productive capacity.

Nonetheless, regardless of how partial exporters compete in foreign markets and whether they have market power abroad, we obtain the same result as before: in the presence of capacity constraints, partial exporters have a higher domestic markup than non-exporters since all firms charge the same domestic price in equilibrium and partial exporters have lower marginal costs than non-exporters. The main difference is that with capacity constraints, partial exporters will produce lower amounts of output for the domestic market as they export more and may be able to charge a positive markup in foreign markets, even if they behave as price-takers there. When the incentives to export are sufficiently high, the capacity-constrained partial exporter may even allocate a small enough amount of output for the domestic market so that its share of total domestic output is lower than the domestic output shares of some or all non-exporters. Although not obvious from the results above, another major implication of capacity-constrained firms is that as partial exporters allocate higher shares of output to the foreign market, the overall supply of output at home will decrease given that non-exporters are already producing at full capacity and cannot compensate for the decrease in domestic production by partial exporters. As a consequence, the equilibrium price in the domestic market will increase.

Figure 2 illustrates what happens to markups, market shares and prices in the domestic market when firms are capacity constrained for the 2-firm case involving one non-exporter and one partial exporter and with linear demand at home. For partial exporters, the graph illustrates the case when these firms face a flat export demand curve and transportation and fixed export costs are assumed to be zero, for simplicity. In the initial equilibrium, the non-exporter produces exactly at full capacity and this level of output (q_{nx}) occurs exactly where perceived marginal revenue at home (MR_{nx}) is equal to marginal cost (c_{nx}). Similarly, the partial exporter allocates its full-capacity production (q_x) to the domestic market and this level of output occurs where its perceived marginal revenue curve in the domestic market (MR_x) is equal to marginal cost (c_x). The foreign price (P_1^*) is equal to the partial exporter's marginal cost and therefore, the partial exporter produces nothing for the foreign market. At a domestic equilibrium price of p_h, the non-exporter's markup is lower than the partial exporter's *domestic* markup ($\mu_{nx} < \mu_x$).

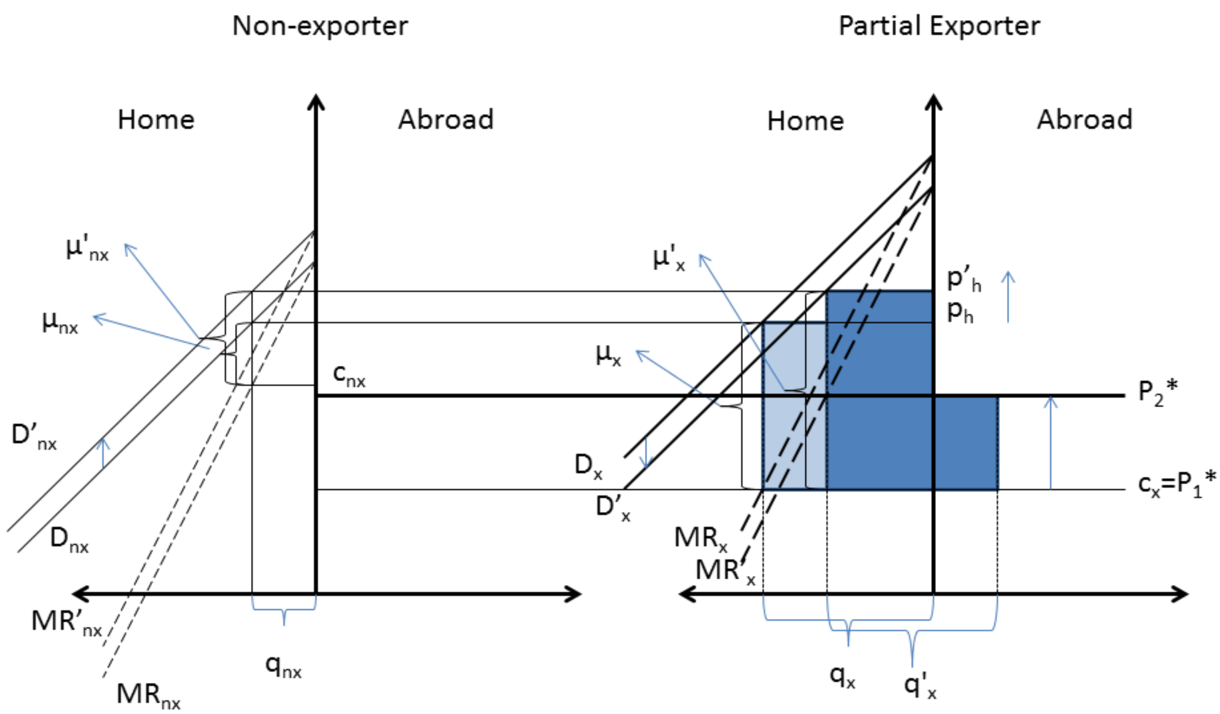
The figure then describes what happens when the incentives to export increase and the partial exporter starts allocating positive amounts of output for the foreign market. An increase in the export price to P_2^*[9] causes the partial exporter to increase its foreign output allocation at the expense of selling less at home (total output allocation shifts from q_x to q'_x). In turn, this causes an increase in the non-exporter's residual demand (to D'_{nx}) and a corresponding decrease in the partial exporter's domestic residual demand (to D'_x), but since the non-exporting firm is already operating at full capacity it cannot produce more and total supply in the domestic market decreases, accompanied by a subsequent increase in the equilibrium price at home to p'_h. The effect of being capacity constrained is that the non-exporter now produces at a point where perceived marginal revenue (MR'_{nx}) is above marginal cost (c_{nx}) (which

[9] Note that the non-exporter's marginal cost is still above this new export price so that it is not profitable for that firm to export.

remains unchanged). This is also the case for the partial exporter, for which the difference between the new perceived domestic marginal revenue curve (MR_x') and marginal cost (c_x) is now positive and equal to the difference between the new foreign price (P_2^*) and the same marginal cost (c_x), since transportation and fixed export costs were assumed to be zero.

The bottom line, however, is that the partial exporter's domestic markup is still higher than the non-exporter's domestic markup, even as the former starts exporting at the expense of producing less for the domestic market. In Figure 2, the partial exporter's allocation to the domestic market after the increase in the foreign price to P_2^* is still higher than the non-exporter's domestic production. Nonetheless, as the incentives to export increase—and as long as the foreign price is below the non-exporter's marginal cost of production— we can expect the partial exporter's domestic level of output to decrease even to the point where it may become lower than the non-exporter's domestic production levels. This does not occur in the absence of capacity constraints, where the partial exporter treats the domestic and foreign markets as separate. In that case, an increase in foreign demand will not affect the partial exporter's allocation to the home market (and hence its domestic markup and market share).

Figure 2.2: Capacity-constrained non-exporter and partial exporter



The results from the capacity constraints model thus point out to a potential transmission mechanism through which positive foreign demand shocks translate into higher inflation at home in countries where exporters produce for both the home and export markets. For example, an increase in world demand for ethanol may lead sugar cane manufacturers to export more at the expense of producing less for their home markets, leading to increased domestic sugar prices and the prices for other products with sugar as an input. Sugar producers could eventually expand production by planting more or by improving yields, but land availability could certainly put an upper bound to how much they can produce (i.e., capacity constraints), at least in the short run. In the absence of capacity constraints, on the other hand, firms could simply produce more for the export market without changing their domestic production levels and the export demand shock would have no consequence for domestic inflation.

To the extent that firms are capacity constrained, the results also have an important policy implication: countries pursuing export promotion strategies should consider also implementing policies aimed at relaxing firms' capacity constraints in order to avoid an increase in domestic prices. Export promotion may take the form of eliminating or reducing export barriers such as taxes and licenses or by encouraging firms to export through tax incentives and the provision of business support services for exporters. In these cases, export promotion may also require additional policies to limit the effect of capacity constraints on firms, such as increased access to credit in order to finance the additional investment and input requirements that exporters need to increase total production. However, export promotion could also be carried out through comprehensive trade liberalization (i.e., removing trade barriers for imports and exports), in which case an increased influx of imports and/or foreign firms may compensate for the reduced domestic output allocations by exporters in the home country to prevent prices from increasing. Even then, countries may still need to consider accompanying trade liberalization with policies aimed at attracting foreign producers, such as macroeconomic stability, in order to ensure domestic supply does not decrease as domestic exporters shift output abroad.

2.5 The case of full-time exporters

The conditions leading firms to become full-time exporters (i.e., firms who produce nothing for the domestic market) can be summarized by the following set of conditions:

$$\frac{\partial L}{\partial q_i} = \left[q_i \frac{\partial P(Q)}{\partial Q} \frac{\partial Q}{\partial q_i} + P(Q) \right] - c_i - \lambda \leq 0 \tag{2.21}$$

$$\frac{\partial L}{\partial q_i^*} = \left[q_i^* \frac{\partial P^*(Q^*)}{\partial Q^*} \frac{\partial Q^*}{\partial q_i^*} + P^*(Q^*) \right] - c_i - t_i - F - \lambda = 0 \tag{2.22}$$

Equation (2.22) is the same as the condition that partial exporters face when deciding on how much to produce for the export market. On the other hand, since full-time exporters sell nothing at home, Equation (2.21) holds with inequality. In the absence of capacity constraints (λ = 0), this equation states that firms will produce nothing for the domestic market as long as perceived marginal revenue at home is less than or equal to marginal cost. Given the condition in Equation (2.22) and no capacity constraints (λ = 0), the same firms that sell nothing at home would export until perceived marginal revenue abroad is equal to the sum of marginal, transportation and fixed export costs. Note that, as before, firms treat these two output decisions as separate. But for both of these conditions to hold, the perceived domestic marginal revenue curve would have to lie below the perceived foreign marginal revenue curve, net of transportation and fixed export costs, at any level of foreign output. This is certainly a theoretical possibility with a sufficiently high foreign demand curve, but it would also imply that all firms in the home market export. In other words, all firms would be either partial or full-time exporters. It would also imply that partial exporters have lower marginal costs than full-time exporters since they are able to produce for the home market and earn non-negative profits there. In that case, full-time exporters would have a zero markup in the domestic market and a lower markup abroad than partial exporters.

Though not impossible, in reality—and particularly in the case of manufacturing firms in developing countries—it is hard to find countries in which all firms in a given sector are either partial or full-time exporters. This highlights yet another reason for why the case of capacity constrained firms may better describe the situation in a large number of markets. In the presence of capacity constraints (λ > 0), the domestic and foreign output decisions by firms are interconnected and the conditions in (2.22) and (2.23) can be combined into the following equation by solving for the Lagrange multiplier and defining the terms in brackets, as before, as the perceived marginal revenue in the home (PMR_i) and foreign (PMR_i^*) markets, respectively:

$$\lambda = PMR_i - c_i \leq PMR_i^* - c_i - t_i - F \qquad (2.24)$$

In this case, the only requirement for a firm to become a full-time exporter is that the gap between perceived marginal revenue abroad and the sum of marginal, transportation and fixed export costs is greater than or equal to the gap between perceived marginal revenue at home and marginal cost. As Figure 2 illustrated, this can happen as the partial exporter allocates increasing amounts of output to the foreign market in response to higher prices abroad. With less and less output being allocated to the domestic market, the partial exporter's residual demand at home can fall to the point where the condition in Equation (2.24) is fulfilled, at which point the firm will cease producing for the domestic market and export all of its full-capacity amount of output.

Because full-time exporters produce nothing for the domestic market, their domestic markup—as well as their share of domestic output—is zero (nonexistent). This result is relevant for empirical work. If, for example, the purpose is to estimate the average *domestic* markup in some market and we fail to distinguish between firms' domestic output and exports, the estimated markup will not correspond to the one we intended to measure. This could also happen in datasets where firms only report on the value of overall production, without distinguishing between how much they produce for the domestic market and how much they export. If all firms in the sample are included in the estimation and if some of these firms are full-time exporters, the estimated markup will be the average between the domestic markups of all firms—including the zero domestic markup of non-exporters—and the foreign markup of partial and full-time exporters.

3. Econometric Framework

Klette (1994, 1999) develops a method to estimate price markups based on Hall's (1988) production function approach with firm-level panel data. Unlike other methods based on Hall (1988), this method relies on the mean value theorem to estimate a firm's production function with quasi-fixed capital. The typical production function in most Hall-type models is:

$$Q_{it} = E_{it}F_t(L_{it}, M_{it}, K_{it}) \tag{3.1}$$

According to equation (3.1), firm *i* produces output Q at time *t* using capital (K_{it}), labour (L_{it}) and materials (M_{it}) as inputs, where F is a linear homogeneous function in all inputs and E is a productivity (or productive efficiency) factor that is firm-specific and can vary over time. Klette (1994, 1999) invokes a multivariate version of the mean value theorem to argue that the production function in (1) can be re-written in terms of log deviations from a point of reference, which is taken to be the representative firm's levels of output and inputs at time *t*:

$$\hat{q}_{it} = \hat{e}_{it} + \bar{\alpha}_{it}^L \hat{l}_{it} + \bar{\alpha}_{it}^M \hat{m}_{it} + \bar{\alpha}_{it}^K \hat{k}_{it} \tag{3.2}$$

In equation (3.2), a variable y with a hat represents the log deviation of the original variable from the point of reference, which for our purposes is the median value of that variable for all firms in the sample each year, so that: $\hat{y}_{\mathrm{it}} \equiv \ln(Y_{it}) - \ln(Y_t)$. The term $\bar{\alpha}_{it}^{J}$, where $J \in \{L, M, K\}$, corresponds to the output elasticity of each respective input X^J evaluated at an internal point $(\bar{X}_{it})$ between the observed value of each input for each firm (X_{it}) and the reference point (X_t):

$$\bar{\alpha}_{it}^{J} \equiv \left[\frac{X_{it}^{J}}{F_t(X_{it})}\frac{\partial F_t(X_{it})}{\partial X_{it}^{J}}\right]_{X_{it}=\bar{X}_{it}}, \qquad \text{where } J \in \{L, M, K\} \tag{3.3}$$

Changing the reference point from year to year has the main advantage of eliminating the need to deflate the output and input variables. This is particularly important since most firm-level datasets report the value of output and inputs used by the firm (as opposed to actual quantities) and researchers often have to rely on industry-specific deflators to convert the nominal values into real ones. By relying on an industry-level price, firms are essentially assumed to charge the same price when ideally firm-specific prices would be preferable since even at the most detailed level of disaggregation, firms within standard industrial classification groups may charge different prices due to product differentiation. Using the same deflator for all firms will therefore introduce some degree of measurement error since the measured output quantities will differ from those actually produced by firms.

Firms are assumed to choose the level of output and inputs that maximize profits. The inverse demand facing each firm, $P_{it}(Q_t)$, is a function of aggregate industry output in each period (Q_t). Given input prices W_{it}^{J}, where $J \in \{L, M, K\}$, firm profits are then given by:

$$\pi_{it} = P_{it}Q_{it}(E_{it}, L_{it}, M_{it}, K_{it}) - W_{it}^{L}L_{it} - W_{it}^{M}M_{it} - W_{it}^{K}K_{it} \tag{3.4}$$

The optimal level of input use is then found by differentiating the profit function in Equation (3.4) with respect to each of the variable inputs (labor and raw materials). The resulting set of first order conditions and after some rearranging yields the following result:

$$E_{it}\frac{\partial F_t(X_{it})}{\partial X_{it}^{J}} = \left[1 + \frac{\theta_{it}S_{it}}{\eta_{it}}\right]^{-1}\frac{W_{it}^{J}}{P_{it}}, \tag{3.5}$$

where, as in the discussion of the Lerner index in the previous section,

$$S_{it} = \frac{q_{it}}{Q_t}, \text{is firm i'share of domestic output;}$$

$$\eta_t = -\frac{\partial Q_t}{\partial P_{it}} \frac{P_{it}}{Q_t}, \text{is the price elasticity of demand; and}$$

$$\theta_{it} = \frac{\partial Q_t}{\partial Q_{it}}, \text{is a conjectural variations parameter.}$$

The term on the left in Equation (3.5) is an expression for the productivity-adjusted change in output as a result of a change in inputs (i.e., the marginal product of input *J*). The term in brackets on the right in Equation (3.5) is just another way of expressing the Lerner index, multiplied by the ratio of the price for input J (W_{it}^J) and the price for the firm's output. Note that under perfect competition in both product and input markets, firms have no market power and the term in brackets disappears. In that case, the term on the right can be multiplied by the price of output (P_{it}) and we obtain the classical result that the variable factors of production are paid the value of their marginal product.

The next step in deriving an estimable equation is to differentiate profits with respect to output levels, which yields:

$$\frac{\partial \pi_{it}}{\partial Q_{it}} = P_{it} + Q_{it} \frac{\partial P_{it}}{\partial Q_t} \frac{\partial Q_t}{\partial Q_{it}} - C_{it} = 0; \text{ where } C_{it} = \sum_J W_{it}^J, \text{for } J \in \{L, M, K\} \tag{3.6}$$

Note that in (3.6), C_{it} represents total marginal costs, given by the sum of all input prices. The condition above gives us an expression for the markup ratio (price over marginal cost), which will be denoted as μ_{it}:

$$\mu_{it} \equiv \frac{P_{it}}{C_{it}} = \left[1 + \frac{\theta_{it} S_{it}}{\eta_{it}}\right]^{-1} \tag{3.7}$$

Substituting (3.5) and (3.7) into the expression for the output elasticity of input J in equation (3.3), we obtain:

$$\bar{\alpha}_{it}^{J} = \mu_{it}\bar{s}_{it}^{J}, \tag{3.8}$$

where

$$\bar{s}_{it}^{J} = \frac{\bar{W}_{it}^{J}\bar{X}_{it}^{J}}{\bar{P}_{it}\bar{Q}_{it}}$$

In equation (3.8), the elasticity of output with respect to each of the labor and raw material inputs is a function of the markup ratio (μ_{it}) and the share of total cost of the respective input (evaluated at the internal point) relative to the total value of output sold/total revenue ($\bar{s}_{it}^{J}$). If firms can freely choose the level of capital used in production, the marginal revenue of capital would be equal to its user cost and equation (3.8) would also hold for the output elasticity of capital. However, this assumption may not always hold. Therefore, capital is treated as a quasi-fixed input, which allows for it to adjust slowly to changing market conditions. By treating capital as quasi-fixed, the econometric framework developed in this section is allowing for the possibility that firms face some sort of constraint on their production capacity, as in the theory section above. This feature of the econometric model seems particularly relevant for firms in developing countries with credit constraints and/or imperfect or incomplete credit markets. It is also particularly suitable for this paper since the framework is applied to a sample of Ghanaian manufacturers that seems to better fit the capacity constraints model of the theory section, as shown in the next section.

The usual method for obtaining the output elasticity of capital in Hall-type models is via the returns to scale equation, where the firm's scale elasticity of production (γ_{it}) is equal to the sum of the output elasticities of the inputs it uses:

$$\gamma_{it} = \bar{\alpha}_{it}^{L} + \bar{\alpha}_{it}^{M} + \bar{\alpha}_{it}^{K} \tag{3.9}$$

Using equation (3.8) and solving for the output elasticity of capital, we obtain:

$$\bar{\alpha}_{it}^{K} = \gamma_{it} - \mu_{it}\bar{s}_{it}^{L} - \mu_{it}\bar{s}_{it}^{M} \tag{3.10}$$

Using the results in equations (3.8) and (3.10), the production function in (3.2) can be now expressed in a suitable format to be empirically estimated:

$$\hat{q}_{it} = \mu_{it}\left[\bar{s}_{it}^{L}\left(\hat{l}_{it} - \hat{k}_{it}\right) + \bar{s}_{it}^{M}\left(\hat{m}_{it} - \hat{k}_{it}\right)\right] + \gamma_{it}\hat{k}_{it} + \hat{e}_{it} \tag{3.11}$$

In equation (3.11), the markup ratio is indexed by firm and period. However, to retrieve estimates of each individual firm's markup ratio at each point in time would not be possible. Instead, what can be recovered in the empirical results is a single estimate of the markup ratio for a given set of firms and over a given number of years. If all firms within an industry are identical this need not be a problem, but with firm heterogeneity this means that the estimated markup will be interpreted as the *average* markup in an industry for a given period, although in essence, the empirical model is imposing the assumption that all firms charge the same markup within a given period.

Notice that the model in (3.11) has only two independent variables. The first one is the term in brackets, where $\bar{s}_{it}^{J}$ is the cost share of input J relative to total revenue, evaluated at an internal point between the observed point of operation of the firm and the median value for the industry at time t. The corresponding parameter for this variable is the markup ratio (μ_{it}), the main parameter of interest in this paper. The second independent variable in (4) is the value of the firm's capital stock in log deviation from the industry's median value at every period. The parameter to be estimated (γ_{it}) is the scale elasticity of production and will be useful to determine whether the industry in question exhibits decreasing, constant or increasing returns to scale (i.e., if $\gamma_{it} \lesseqgtr 1$, then decreasing, constant or increasing returns to scale, respectively).

We also need some assumptions regarding the productivity factor ($\hat{e}_{it}$) in order to obtain the empirical model to be estimated. Note that the productivity term captures the firm's productivity in relation to the reference point. Here, we allow productivity to vary across firms:

$$\hat{e}_{it} = e_i + \varepsilon_{it},\ \varepsilon_{it} \sim N(0, \sigma^2) \tag{3.12}$$

The first component of the productivity factor is a fixed-effect productivity shock specific to each firm (e_i) and may represent differences in productivity across firms arising from, for example, differences in management skills or the quality of labor. This is the standard assumption in most (if not all) the production approaches to estimating markups in the literature. Note that there are no time fixed-effects in (6), since common industry-specific shocks are eliminated by nature of changing the reference firm every year. While this may be true when estimating industry-specific markups, it will not necessarily be the case when grouping sectors. In the case of the Ghanaian sample, used in this paper, estimating markups for each industrial sector is not possible due to the limited number of observations. Instead, one markup for the entire manufacturing sector is estimated and then economy-wide shocks captured by time dummies will prove to be relevant for the results. This means that, although industry-specific shocks disappear, economy-wide productivity shocks are not necessarily eliminated by the process of taking log deviations from industry medians. The final component of the productivity factor is a stochastic, firm- and time-specific shock assumed to be normally distributed with mean zero and variance σ^2. This type of shock may include events such as unexpected losses of output, machine breakdowns or even unanticipated blackouts that cause a factory to stop producing, as well as the loss of output or raw materials due to spoilage (more examples in Levinsohn, 1993).

Productivity shocks are highly likely to be correlated with the input variables since, for example, in a bad year (i.e., a negative productivity shock) firm managers will tend to choose a lower level of input use. Hence, estimating the model in (4) using OLS would result in biased estimates of the markup ratio and the scale coefficient. Therefore, instrumental variables (IV) and general method of moments (GMM) estimates are also presented in the results section below to address the endogeneity bias. As usual, the validity of the instruments used in the regressions depends on how well they explain current input use (since both independent variables are constructed using current values of the three inputs), without being correlated with the part of the productivity factor that enters through the error term.

In order to test the hypothesis that exporting firms have a higher markup than non-exporting ones, the model in (4) must be modified to allow for the estimation of markups for these two kinds of firms separately:

$$\hat{q}_{it} = \mu_{it} A_{it} + \mu_{it}^{X}(d_{it}^{x} A_{it}) + \gamma_{it} \hat{k}_{it} + \beta_{it} d_{it}^{x} + \hat{e}_{it} \tag{3.13}$$

Where,

$$A_{it} = \bar{s}_{it}^{L}(\hat{l}_{it} - \hat{k}_{it}) + \bar{s}_{it}^{M}(\hat{m}_{it} - \hat{k}_{it})$$

The model in equation (3.13) allows markup ratios to be different for exporters and non-exporters by including a dummy variable (d^X) equal to one if a firm exports some portion of its output and zero otherwise. From the results in the theory section we would then expect μ_{it}^{X}, the exporters' markup "premium", to be positive. Notice that Equation (3.13) also includes the export status dummy (d^X) by itself to allow for differences in the intercept between exporters and non-exporters. This can be thought of as the additional effect on productivity that exporting may have on firms.

Since firms usually report the value of their overall production, including exports, the markup premium for exporters in (3.13) represents the average between their domestic and foreign markups. However, the predictions from the theory section refer to partial exporters having a higher *domestic* markup than non-exporters, while their foreign markup could be higher or lower than the markup for non-exporters, depending on trade barriers and degree of market power exporters have abroad. In fact, the foreign markup for exporting firms could even be zero if they are price-takers in international markets. To distinguish between domestic and foreign markups I follow De Loecker and Warzinsky (2009) in separating the exports interaction term in (3.13) into each exporter's respective allocation of output to the domestic and foreign markets.

$$\hat{q}_{it} = \mu_{it} A_{it} + \mu_{it}^{X.domestic}[(1 - x_{it}) d_{it}^{x} A_{it}] + \mu_{it}^{X.foreign}[x_{it} d_{it}^{x} A_{it}] + \gamma_{it} \hat{k}_{it} + \beta_{it} d_{it}^{x} + \hat{e}_{it} \qquad (3.14)$$

In Equation (3.14), the allocation to the foreign market is represented by the percentage of total output that a firm exports (x_{it}) and the rest, $(1 - x_{it})$, is what it produces for the domestic market. Notice that the two interaction terms also include the export status dummy to ensure that both terms are zero for non-exporters. Otherwise, the first interaction term would also be incorporating the markup for non-exporters.

4. The Ghanaian Manufacturing Sector, 1991-2002

This section provides a brief description of the dataset used to test for markup differences between exporters and non-exporters. The summary statistics presented below and the discussion of other relevant variables also provide a brief background on Ghana's manufacturing sector during a period of significant political changes that were accompanied by the continuation of structural reforms and macroeconomic stabilization efforts.[10] In the Data Appendix, the original dataset is described in more detail and the construction of the variables used in the regressions is explained.

The dataset used in this paper comes from a panel of Ghanaian manufacturing firms from the Regional Project on Enterprise Development (RPED), Ghana Manufacturing Enterprise Survey (GMES), made available by the Centre for the Study of African Economies (CSAE) at the University of

[10] Starting in 1983, significant trade liberalization reforms were implemented in Ghana, in combination with other structural adjustment reforms such as privatizations and macroeconomic stabilization (IMF 1996). In addition, the early part of the sample period (1991-2002) was characterized by significant political changes. In 1992, the first elections in more than a decade were held and the pro-liberalization government of Jerry Rawlings was elected to remain in power (Jeong 1998).

Oxford[11]. The dataset set covers the period between 1991 and 2002 and after removing unusable observations, there are between 124 and 184 firms per year.

Table 4.1: Number of exporters and non-exporters by sector and year

		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	All
Food /a	X	1	1	2	4	5	6	8	6	6	6	6	6	57
	NX	34	36	38	34	34	36	34	38	37	26	26	25	398
	Total	35	37	40	38	39	42	42	44	43	32	32	31	455
Textiles	X	...	1	2	...	...	...	1	3	3	1	1	1	13
	NX	4	4	2	2	2	6	5	2	2	2	2	2	35
	Total	4	5	4	2	2	6	6	5	5	3	3	3	48
Garments	X	...	1	4	2	2	2	3	1	1	1	1	1	19
	NX	28	30	25	28	29	27	27	28	28	25	24	24	323
	Total	28	31	29	30	31	29	30	29	29	26	25	25	342
Wood	X	4	5	5	15	16	16	16	16	15	9	9	9	135
	NX	4	3	3	2	2	2	2	3	4	2	2	2	31
	Total	8	8	8	17	18	18	18	19	19	11	11	11	166
Furniture /b	X	5	2	5	4	4	4	4	4	3	1	1	1	38
	NX	26	35	30	35	35	30	30	23	24	20	20	20	328
	Total	31	37	35	39	39	34	34	27	27	21	21	21	366
Chemicals	X	...	...	...	...	...	1	2	5	5	2	2	3	20
	NX	...	...	...	...	...	10	10	8	8	6	6	5	53
	Total	...	...	...	...	...	11	12	13	13	8	8	8	73
Metals	X	6	3	4	7	7	4	6	7	8	4	4	4	64
	NX	33	38	35	35	34	37	36	30	29	22	22	21	372
	Total	39	41	39	42	41	41	42	37	37	26	26	25	436
All Sectors	X	16	13	22	32	34	33	40	42	41	24	24	25	346
	NX	129	146	133	136	136	148	144	132	132	103	102	99	1,540
	Total	145	159	155	168	170	181	184	174	173	127	126	124	1,886

Notes: X refers to the number of exporters and NX to non-exporters.
a/ Includes both the food and beverages sectors.
b/ Includes only wood furniture manufacturers; metal furniture manufacturers are included in the metals sector.

Table 4.1 shows the total number of exporters and non-exporters by sector and year for the final sample used in the regressions. The sectors with the largest number of firms are the food and beverages, garments, furniture and metals sectors. Firms in the chemicals sectors were only added to the sample after 1995, in Waves 5 through 7. During the entire sample period, the number of exporting firms ranges between 13 and 42 and this is partly due to some firms who do not export in all years (i.e., some exit

[11] The survey is available through CSAE's website, at: http://www.csae.ox.ac.uk/datasets/ghana-rped/Ghmain.html. The document "Background Information on Use of Dataset" contains additional details and explanations of the survey methodology. Per request of CSAE, funding for the survey UK Department for International Development (DFID) is acknowledged.

export markets definitely during the period, while some resume exporting in later years). The total sample includes 1,886 observations and it is worth nothing that because some firms with unusable data are dropped (mostly non-exporters), the proportion of exporters in the sample is likely to be higher than the actual percentage of exporters in Ghana's manufacturing sector. Nonetheless, the survey does capture the general distribution of exporters across sectors in Ghana, with only a handful of exporters in each sector except for wood processing. This sector is an important source of foreign exchange for Ghana and has the largest concentration of exporters (between 50 and 81 percent of the firms in the sample in this sector are exporters).

Table 4.2 reports the average export intensity by sector and year for the period 1993-2002[12]. The measure of export intensity employed is the simple average of the export percentages reported by al the firms in each sector and in the sample as a whole. In other words, the export intensities reported in the table are not weighted averages and this is done intentionally because the sample does not contain all (or even most) firms in each sector, although the original 200 firms were randomly selected from a 1987 census of manufacturing firms (CSAE 2011). In addition, large firms are over-represented in the survey (Teal 1999). Therefore, using weighted-averages would have exaggerated the export intensity for all sectors given that some of the bigger firms export a large percentage of their output in any given year—sometimes all of it—and those amounts can be overwhelmingly larger than the total amount produced by the other firms in the sector. For example, a single firm in the food and beverages sector reported exporting 100 percent of its output in 1994 and that amount accounted for 42.6 percent of that sector's total output.

For all sectors, the average export intensity for the entire period is 6.75 percent and a smaller share of exports is sold in countries within Africa (2.58 percent) than elsewhere (10.92 percent). Although 6.75 percent is already a low figure, average export intensities for all other sectors except for wood processing are even lower and range between 1.4 percent for the chemicals sector to 4.62 percent for textiles. Even though some observations are dropped, the distribution of exporters and the average export intensities by sector for the final sample do match other sources. In Teal's (1999) analysis of the first five waves of the survey, for example, he finds that 11 percent of the firms in the sample export and that the average export intensity during that period (1991-1995) was 4.2 percent. This is slightly lower than an average 18.3 percent of exporters in the sample above and the 6.75 percent average export intensity, but as can be seen from Tables 4.1 and 5.2 this discrepancy is to be expected given that exporting activity tends to be higher toward the last years of the sample period.

[12] Exports by destination are not reported in the first two waves of the survey.

Table 4.2: Export intensity by sector and destination

		1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	All
Food [/a]	Avg.	1.20	1.41	2.63	1.91	2.00	3.37	3.52	5.02	5.59	5.87	3.25
	Africa	2.07	0.20	0.25	0.30	0.29	0.13	0.13	4.00	5.09	5.45	1.79
	Other	0.33	2.63	5.00	3.51	3.71	6.62	6.91	6.03	6.09	6.29	4.71
Textiles	Avg.	12.00	0.00	0.00	6.07	6.21	8.30	9.90	0.33	0.67	2.67	4.62
	Africa	11.00	0.00	0.00	0.00	0.29	16.40	19.60	0.33	0.67	2.67	5.10
	Other	13.00	0.00	0.00	12.14	12.14	0.20	0.20	0.33	0.67	2.67	4.14
Garments	Avg.	2.50	1.81	1.76	1.64	1.71	1.00	0.42	1.20	0.80	1.54	1.44
	Africa	2.63	1.39	1.35	0.31	0.55	0.50	0.17	2.41	1.60	2.69	1.36
	Other	2.37	2.22	2.16	2.97	2.88	1.50	0.67	0.00	0.00	0.38	1.52
Wood	Avg.	18.33	34.42	35.24	32.53	32.66	29.87	31.16	36.59	35.68	34.23	32.07
	Africa	2.22	1.11	1.05	8.68	8.53	1.95	1.68	2.73	2.73	3.18	3.39
	Other	34.44	67.72	69.42	56.37	56.79	57.79	60.63	70.45	68.64	65.27	60.75
Furniture [/b]	Avg.	2.64	3.08	3.08	3.63	2.94	2.50	2.39	2.25	2.36	2.25	2.71
	Africa	0.28	0.00	0.00	0.00	0.23	0.89	0.00	0.00	0.00	0.00	0.14
	Other	5.00	6.15	6.15	7.26	5.66	4.11	4.79	4.50	4.71	4.50	5.28
Chemicals	Avg.	0.00	0.00	0.00	0.29	1.08	1.96	2.54	2.19	2.81	3.13	1.40
	Africa	0.00	0.00	0.00	0.58	2.15	3.93	5.07	4.38	5.63	6.25	2.80
	Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Metal	Avg.	1.41	1.63	1.70	1.27	1.49	1.50	1.53	2.22	2.28	2.79	1.78
	Africa	2.83	3.26	3.40	2.31	2.74	2.95	3.00	4.44	4.56	5.58	3.51
	Other	0.00	0.00	0.00	0.24	0.23	0.05	0.05	0.00	0.00	0.00	0.06
All Sectors	Avg.	5.44	6.05	6.34	6.76	6.87	6.93	7.35	7.11	7.17	7.50	6.75
	Africa	3.00	0.85	0.86	1.74	2.11	3.82	4.24	2.61	2.90	3.69	2.58
	Other	7.88	11.25	11.82	11.78	11.63	10.04	10.46	11.62	11.44	11.30	10.92

Notes:
[a/] Includes both the food and beverages sectors.
[b/] Includes only wood furniture manufacturers; metal furniture manufacturers are included in the metals sector.

Exports by destination also seem to be in line with official macroeconomic aggregates, where a larger share of Ghana's exports is sold in markets outside of Africa. According to IMF (2000, 2005) data, between 66.1 and 77.6 percent of all exports went to industrial countries (including Europe and the United States) during the 1992-2002 period. In contrast, only between 17.1 and 28.5 percent of total exports was sold elsewhere. In terms of growth, total exports for the sample grew at an annual rate of 20.1 percent during the sample period, while the growth in total exports (including non-manufacturing export activities) was 3.5 percent per year (IMF 2000, 2003, 2005).[13] Unfortunately, the aggregate

[13] These are geometric average growth rates between 1993 and 2002 for the value of exports in current US dollars. The data for the sample is in *cedis*, while the IMF data is reported in USD. For 1993, the IMF reports an average exchange rate of 822 *cedis* per USD and of 8,438.8 *cedis* per USD for 2002.

information on Ghana's external sector is only available for *total* exports, not just manufacturing, and the specific percentage of exports that is sold within Africa is unavailable. This also explains why

In terms of how the sample fits overall aggregate manufacturing production in Ghana, the sum of all firms' individual output levels covers, on average, 17 percent of the total value of the manufacturing sector. This figure is obtained by dividing the total annual output in the sample by the value of the manufacturing sector from national accounts data in IMF documents (IMF 2000, 2003, and 2005). The average annual growth rate in the value of manufacturing output is 35.4 percent per year for the sample, compared to 32 percent per year from national accounts data. Throughout the sample period, the aggregate data show that the size of the manufacturing sector remained relatively constant, at around 9 percent of total GDP throughout the period.

In Table 4.3, firms are organized into quartiles according to their level of domestic production. This means that for exporters, only their share of domestic production is considered when constructing the quartiles. The purpose of this comparison is to show that the capacity constraints model in the theory section might provide a more accurate picture of the Ghanaian manufacturing sector, and possibly of other similar developing countries, where exporters tend to be bigger firms producing larger total amounts of output, but whose domestic production might be actually smaller than that of smaller non-exporters.

Recall that the results from the theory section indicated that in the absence of capacity constraints, partial exporters have a higher total output and produce more for the domestic market than non-exporters. In terms of Table 4.3, this means that exporters should be concentrated in the lower quartiles, with almost no exporter included in the first quartile (i.e., the quartile of firms with the lowest level of *domestic* output). But in fact, what we observe is that the most export-oriented firms end up in the first quartile because they produce very little or nothing at all for the domestic market. Note that these firms are much bigger, with an average number of employees of 190, than the non-exporters of the first quartile. On the other hand, the exporters in the fourth quartile have a higher average level of domestic production than the non-exporters in that group and the differences between these two types of firms in terms of size (i.e., number of employees) is less pronounced. While on average exporters in the first quartile have more than 20 times more employees than non-exporters, exporters in the fourth quartiles have less than 3 times as many workers as non-exporters.

Table 4.3: Firms by domestic output quartiles

		Value of Output (in millions of *cedis*)						Number of workers		
		Obs.	**Mean**	**Median**	**Std. Dev.**	**Min.**	**Max.**	**Mean**	**Min.**	**Max.**
Quartile 1										
Non-exporters	Total	411	17.0	11.7	16.9	0.1	81.9	8.7	1.0	75.0
Exporters	Home	65	7.8	0.0	16.0	0.0	79.3	190.3	6.0	1,380.0
	Exports	65	8,370.0	598.0	28,200.0	1.2	168,000.0			
	Total	65	8,370.0	600.0	28,200.0	3.5	168,000.0			
Quartile 2										
Non-exporters	Total	393	75.2	51.0	71.9	4.2	375.0	16.8	1.0	140.0
Exporters	Home	77	84.0	67.7	64.2	5.0	284.0	78.8	4.0	701.0
	Exports	77	912.0	129.0	2,830.0	0.5	16,900.0			
	Total	77	996.0	221.0	2,850.0	6.0	17,100.0			
Quartile 3										
Non-exporters	Total	393	314.0	209.0	316.0	14.4	1,600.0	32.6	2.0	173.0
Exporters	Home	80	321.0	268.0	249.0	15.9	1,120.0	124.8	9.0	701.0
	Exports	80	3,470.0	310.0	10,400.0	0.2	59,500.0			
	Total	80	3,790.0	742.0	10,500.0	16.0	60,100.0			
Quartile 4										
Non-exporters	Total	343	6,590.0	1,710.0	17,700.0	64.9	147,000.0	159.4	3.0	1,742.0
Exporters	Home	124	22,700.0	4,430.0	92,000.0	109.0	776,000.0	323.7	25.0	1,800.0
	Exports	124	3,490.0	710.0	11,600.0	0.0	116,000.0			
	Total	124	26,200.0	6,630.0	103,000.0	167.0	892,000.0			

In addition, with no capacity constraints, observing full-time exporters implies that foreign demand is above the domestic market demand in a given market and therefore, all firms would be either partial or full-time exporters but no firm would produce exclusively for the domestic market. As we saw in Table 4.1, this is not the case, since most firms in every manufacturing sector represented in the sample contains a majority of non-exporters. But in Table 4.3 we do observe full-time exporters in the first quartile. In fact, the median level of domestic output for the exporters in that quartile is zero, indicating that at least 50 percent of all exporters in Quartile 1 produce exclusively for the foreign market.

The fact that we observe both full-time exporters and large partial exporters producing much lower levels of output for the domestic market than smaller non-exporters suggests the capacity constraints story fits the Ghanaian data better. According to that story, we observe these patterns because firms have to decide where to sell the limited amount of output they can produce. For the most export-oriented firms, it is more profitable to sell in export markets and allocate very little to the domestic market. According to the capacity constraints model, these are also the firms with the lowest marginal cost and that is why they are able to better compete in foreign markets.

Table 4.4: Summary statistics for core variables

	Full sample	Non-exporters	Exporters
# of observations	1,886	1,540	346
Output		*(In millions of cedis)*	
Mean	3,500.0	1,570.0	12,100.0
Std. dev.	28,700.0	8,750.0	63,700.0
Median	123.0	77.4	1,210.0
Wage bill		*(In millions of cedis)*	
Mean	365.0	136.0	1,380.0
Std. dev.	3,860.0	621.0	8,860.0
Median	12.0	7.0	140.0
Raw materials		*(In millions of cedis)*	
Mean	1,890.0	888.0	6,350.0
Std. dev.	16,000.0	5,300.0	35,400.0
Median	67.9	49.0	418.0
Capital stock		*(In millions of cedis)*	
Mean	3,640.0	1,810.0	11,800.0
Std. dev.	22,700.0	17,700.0	36,600.0
Median	37.0	15.0	1,190.0
Employees		*(number of workers)*	
Mean	77.5	50.4	198.1
Std. dev.	164.6	122.0	252.6
Median	23.0	17.0	121.0
Labor share		*(In percent)*	
Mean	14.064	13.674	15.802
Std. dev.	16.286	16.768	13.830
Median	10.465	9.694	11.752
Materials share		*(In percent)*	
Mean	57.409	60.062	45.603
Std. dev.	20.600	19.674	20.516
Median	60.000	62.838	45.717

Table 4.4 presents summary statistics for the core variables in the econometric framework discussed in the previous section and used to test for markup differences between exporters and non-exporters. These variables include the value of output, used to construct the dependent variable in the model, and the input variables: the wage bill, total number of workers, cost of raw materials and the

value of the capital stock.[14] For the regressions, these core variables are converted to log deviations from sector medians and then the corresponding summary statistics would be harder to interpret. Instead, Table 4.4 compares some summary statistics of the core variables for the full sample, as well as by export status. Here we see again that exporters produce more than non-exporters. The average value of output for the full sample is 3.5 billion *cedis*, but exporters produce on average almost eight times more than non-exporters.

In terms of input use, it is also clear that exporters use more raw materials, labor and capital than non-exporters. While the value of raw materials costs for the average non-exporters is 888 million *cedis*, the average exporter spends seven times that amount. Exporters also employ more workers than non-exporters: the average exporter has a total of 198 employees, while the average non-exporter has 50. As a result, it is not surprising that exporters also spend more on wages than non-exporters. Wage bill costs for the average exporter are around 10 times larger than for the average non-exporter. The differences in the use of capital are also substantial: the value of the capital stock for the median exporter is 79 times more than for the median non-exporter.

In terms input cost shares, non-exporters in the sample seem to have a similar labor cost share and actually use a larger share of raw materials in production than exporters. The difference in the labor cost share, defined as the value of the wage bill divided by the value of total output, is only of around 2 percentage points between exporters and non-exporters. As for the materials cost shares, defined as the value of raw materials costs over the value of total output, non-exporters have a share that is on average 14.5 percentage points higher than for exporters.

5. Results

This section presents the results of estimating Equations (3.11), (3.13) and (3.14) using the panel of Ghanaian manufacturing firms discussed in the previous section. Table 5.1 presents the results of estimating these equations using the fixed-effects estimator. All regressions report standard errors clustered by firm to account for the likely event that the observations for any particular firm are correlated across time.[15] The model in Column (1) is the reference model, where a single markup is estimated for the whole sample without distinguishing between exporters and non-exporters. The markup ratio is estimated with high precision and implies an average markup of 8.3 percent above

[14] The Data Appendix describes these variables in more detail and also explains how the variables are transformed into log deviations from their sector medians, as well as how the input cost shares in the estimating equation are constructed.
[15] The regressions in Table 5.1 were performed using Stata 9.2 and its xtreg command with the fixed-effects and clustering options.

marginal cost for the full sample of Ghanaian manufacturing firms over the period 1991-2002. A more meaningful way to interpret this estimate, however, is to determine whether the markup is significantly above the perfectly competitive level. To do this, a Wald test can be applied to the estimated markup under the null hypothesis that it is equal to one. The test results are shown in Table 5.2 and imply that the estimated markup coefficient for the full sample of firms is not equal to one at the 10 percent level. This would suggest that overall firms in the Ghanaian manufacturing sector do have some degree of market power. As for the returns to scale parameter the results from the basic model in Column (1) show an estimated scale coefficient of 0.765 and the corresponding Wald test strongly rejects the null hypothesis that it is equal to one. These results suggest manufacturing firms in Ghana operate under decreasing returns to scale.

Table 5.1: Individual fixed-effects regressions

ESTIMATES	**(1)**	**(2)**	**(3)**
μ (all firms)	1.083***	…	…
	(0.0485)		
μ^{NX}	…	1.079***	1.081***
		(0.0491)	(0.0491)
μ^{X} (by exports status)	…	0.0276	…
		(0.0380)	
μ^{X} (domestic market)	…	…	0.0666
			(0.0450)
μ^{X} (export market)	…	…	-0.0427
			(0.0897)
γ	0.765***	0.765***	0.765***
	(0.0358)	(0.0358)	(0.0358)
Export status dummy	…	0.0631	0.0709
		(0.0570)	(0.0575)
Constant	-0.0179*	-0.0276**	-0.0306**
	(0.00920)	(0.0134)	(0.0140)
Observations	1,886	1,886	1,886
Number of firms	246	246	246
R^2 (within)	0.661	0.662	0.662
Overall R^2	0.92	0.92	0.921

Notes: μ^{NX}, markup ratio for non-exporters; μ^{X}, markup ratio for exporters; λ, returns to scale parameter. Standard errors in parentheses. Standard errors for all regressions are clustered by firm.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

At this point, the distinction between exporters and non-exporters has not been made. Columns (2) and (3) show the results of making this distinction using the same fixed-effects model with clustered standard errors as for the basic model. In Column (2), the markup premium for exporters is retrieved using a dummy variable that captures a firm's export status; equal to one if the firm exports in the year of observation and zero otherwise. This dummy is then interacted with the markup term and added to the basic model so that the first markup estimated in Column (2), μ^{NX}, is for non-exporters (the reference group) and the second estimate, μ^{X}, is the export premium for exporters. The results suggest non-exporters have a markup of 7.9 percent while the premium for exporters is 2.76 percent, for a total markup of 10.66 percent over marginal cost for this last group of firms. Although the export premium is measured with high error (suggesting it is not significantly different from zero) the results from the Wald tests tell a slightly different story. While the null that the markup ratio for non-exporters is equal to one ($\mu^{NX} = 1$) cannot be rejected[16], the Wald tests do show the markup ratio for exporters ($\mu^{NX} + \mu^{X}$ (by exports status) = 1) as being significantly different from one.

Table 5.2: Wald tests for estimated coefficients in Table 5.1

Null hypothesis	(1)	(2)	(3)
μ (all firms) = 1	2.96*	…	…
$\mu^{NX} = 1$	…	2.58	2.73*
$\mu^{NX} + \mu^{X}$ (by exports status) = 1	…	3.52*	…
$\mu^{NX} + \mu^{X}$ (domestic market) = 1	…	…	5.55**
$\mu^{NX} + \mu^{X}$ (foreign market) = 1	…	…	0.16
μ^{X} (domestic market) = μ^{X} (foreign market)	…	…	0.97
Scale parameter, γ = 1	42.92***	43.22***	43.19***

Notes: μ^{NX}, markup ratio for non-exporters; μ^{X}, markup ratio for exporters; λ, returns to scale parameter.
Wald test statistics. Significance levels:
*** p<0.01, ** p<0.05, * p<0.1

In general, the results seem to provide some evidence in favor of the prediction from the theoretical model that exporters charge a higher markup than non-exporters. Nonetheless, by only separating firms according to their export status, the model in Column (2) ignores the possibility that markups differ across exporters with varying degrees of export intensity. In essence, the export premium estimated in that model represents the average between the domestic and foreign markups for exporters. As shown in the theory section, whether capacity constrained or not, firms that export more will have higher markups at home, but they may be price-takers in international markets and charge a price closer to marginal cost there. If exporters have little or no market power abroad, their average markup will be lower than the price-cost margin for their products at home. Therefore, it is necessary to separate

[16] Notice, however, that the Wald test statistic barely falls under the threshold for rejection of the null hypothesis at the 10 percent level. In fact, the p-value of 10.95 percent is just slightly above the 10 percent threshold.

exporters' markup into their domestic and foreign components to see whether the prediction that exporters have higher domestic markups than non-exporters does indeed hold for the sample of Ghanaian exporters at hand.

The model in Column (3) allows for this separation of markups for exporters by adding the interaction between the markup term and the shares each exporter allocates to the domestic and the foreign market, as in Equation (3.14). Here we see that while the markup ratio for non-exporters (μ^{NX}) is similar to the estimate in Column (2)—with an estimated markup of 8.1 percent—the domestic and foreign markups for exporters differ substantially. At home, exporters have a markup that is 6.66 percent higher than the markup for non-exporters, for a total domestic markup ratio of 1.15. This is also higher than the export premium from Column (2), but this is because the estimated *foreign* markup for exporters is actually 4.27 percent lower than the markup for non-exporters. In sum, the results in Column (3) imply that exporters have a markup of 15 percent at home and a lower markup of 3.83 percent in export markets.

These results are in line with the theoretical model presented earlier and with the general idea that manufacturing exporters from developing countries are likely to have little or no market power in export markets, while still having a higher degree of market power at home than their domestic competitors who do not export. This is further confirmed by looking at the results from the Wald tests. For non-exporters, the null that price is equal to marginal cost is rejected at the 10 percent level, suggesting these firms have some degree of market power. This is also true when it comes to the domestic markup for exporters, but the test results indicate that their foreign markup ratio of 1.0383 is not significantly different from one, suggesting these firms face fierce competition abroad. However, given the large differences in the domestic and foreign markup ratios for exporters, it is surprising to find that the null hypothesis that these markups are equal cannot be rejected (with a Wald test statistic of 0.97). This is likely the result of high standard errors due to endogeneity and heteroskedasticity issues addressed below.

As for the returns to scale parameter allowing for differences in markups between exporters and non-exporters has no effect on the estimated scale coefficients across all three specifications and it remains stable at 0.765 and estimated with a high level of precision.

5.1 Time fixed-effects

The empirical framework suggested by Klette (1994,1999) and used in the regressions above, eliminates industry-specific shocks by taking log deviations of the output and input variables from their sample medians. Indeed, Klette (1994, 1999) applies this framework to a panel of Norwegian manufacturing firms and estimates markups separately for each of the 2-3 digit ISIC code industries in his sample. Because of the limited size of the sample, estimating individual markups for each of the seven sectors identified for the Ghanaian sample is not possible and this forces the estimation of the model on the full sample. This means that while time-varying industry shocks are eliminated by the process of taking log deviations, economy wide shocks may still be present.

Table 5.3: Individual and time fixed-effects regressions with clustered standard errors

ESTIMATES	(1)	(2)	(3)
μ (all firms)	1.070***	…	…
	(0.0476)		
μ^{NX}	…	1.066***	1.068***
		(0.0483)	(0.0483)
μ^{X} (by exports status)	…	0.0255	…
		(0.0376)	
μ^{X} (domestic market)	…	…	0.0668
			(0.0418)
μ^{X} (export market)	…	…	-0.0491
			(0.0912)
γ	0.756***	0.755***	0.755***
	(0.0365)	(0.0365)	(0.0365)
Export status dummy	…	0.0492	0.0572
		(0.0551)	(0.0555)
Constant	-0.176***	-0.182***	-0.186***
	(0.0416)	(0.0429)	(0.0439)
Observations	1,886	1,886	1,886
Number of firms	246	246	246
R^2 (within)	0.677	0.678	0.678
Overall R^2	0.919	0.92	0.921

Notes: μ^{NX}, markup ratio for non-exporters; μ^{X}, markup ratio for exporters; λ, returns to scale parameter. Standard errors in parentheses. Standard errors for all regressions are clustered by firm. Coefficients for year dummy variables (not shown) are all significant at least at the 10 percent level.
*** p<0.01, ** p<0.05, * p<0.1

In other words, taking log deviations from the 'typical' firm within a sector is resolving the issue of deflating the data, but it does not necessarily eliminate the time-specific factors that affect all industries at the same time. In addition, adding time fixed-effects may also aide in correcting for any sample bias introduced when the sector medians are calculated. If medians vary from year to year due to changes in the composition of the sample, as opposed to just following the pure variation in industry conditions, the estimated markup and scale coefficients may be biased.

Some evidence of this problem can be seen in the results below, where time dummies are added to the models in Table 5.1 in order to capture any shocks common to all firms. Adding time-effect has the effect of lowering the estimated markup and scale coefficients. The markup ratio for all firms in the sample suffers a slight drop from 8.3 percent in Table 5.1 to 7.0 percent in Table 5.3, after adding the time dummies. The scale parameter also drops from 0.765 to 0.756 across all models. As for the time dummies, all estimated coefficients are highly significant (although they are omitted from Table 5.3 for brevity), which would not be expected if the regressions were performed at the industry level and the process of taking log deviations did indeed removed industry shocks entirely. In all specifications, the coefficients for all year dummy variables are significant at least at the 10 percent level and most are significant at the 1 percent level.

Table 5.4: Wald tests for estimated coefficients in Table 5.3

Null hypothesis	(1)	(2)	(3)
μ (all firms) = 1	2.17	…	…
$\mu^{NX} = 1$	…	1.88	2.01
$\mu^{NX} + \mu^{X}$ (by exports status) = 1	…	2.68	…
$\mu^{NX} + \mu^{X}$ (domestic market) = 1	…	…	4.93**
$\mu^{NX} + \mu^{X}$ (foreign market) = 1	…	…	0.04
μ^{X} (domestic market) = μ^{X} (foreign market)	…	…	1.11
Scale parameter, $\gamma = 1$	44.78***	45.00***	44.85***

Notes: μ^{NX}, markup ratio for non-exporters; μ^{X}, markup ratio for exporters; λ, returns to scale parameter.
Wald test statistics. Significance levels:
*** p<0.01, ** p<0.05, * p<0.1

One notable difference with the earlier results is that adding the time dummies results in lower standard errors for most of the estimated markup ratios and in particular, the domestic premium for exporters in Column (3) is now almost significantly different from zero at the 10 percent level, with a p-value of 11.1 percent. The reduction in size of the estimates after incorporating the time dummies, combined with lower standard errors, do change the results of the Wald tests somewhat for the estimated markups, but not for the scale coefficient. These results, shown in Table 5.4, now fail to reject the null hypothesis that the markups for non-exporters is equal to one across all specifications and this is the same for the exporters except for their domestic markup ratio. Again, due to the potential for endogeneity bias and other issues with the data these results should be viewed with caution, although the general picture obtained so far does provide some support for the idea that exporters in Ghana have a higher domestic markup than non-exporters and that they face a highly competitive export market.

5.2 Endogeneity bias

A common concern in the literature is the potential correlation between productivity shocks and the variables on the right hand side of the Hall-type models, particularly the input variables. Two consistently cited sources of endogeneity are (1) the potential correlation between input use and a firm's productivity and (2) measurement error. Modeling firm productivity as including a time-invariant, firm-specific productivity term partially addresses the first source of endogeneity. This is the case of the fixed-effects models in Tables 6.1, since they allow for correlation between the firm-specific intercepts—the e_i in Equation (3.14)—and the independent variables, but assume no correlation with the error term— the firm-level random productivity shock, ε_{it}, in Equation (3.14). Furthermore, by adding time fixed-effects in the models in Table 5.2, the potential endogeneity between economy-wide shocks and the independent variables is also partially addressed. But to the extent that the random productivity shocks affect the firm's decision regarding the amount of inputs to use in production, the fixed-effects regressions above will still suffer from endogeneity bias. This is likely to be the case, for example, when a firm experiences a positive shock in any given year (such as an unusually high volume of orders), which leads the firm's managers to hire additional temporary labor and/or purchase more raw materials to fulfill those orders. Given an imperfectly competitive output market, price may also be endogenous, as argued in Levinsohn (1993). Individual demand shocks leading firms to alter their production levels may trigger a reaction from all other firms and result in a different market equilibrium price. As seen in the theory section, this would certainly be the case with foreign demand shocks that lead capacity-constrained exporters to change their output allocations between the domestic and export markets.

The fixed-effects models are also unable to completely address the second source of bias mentioned above: measurement error. This errors-in-variables bias may arise due to misreporting by firm managers, but could also take other forms. As mentioned in the data section, firm managers in the Ghana survey are asked to report on the period they are most comfortable with. So while some firms report values for an entire year, some report for the last week of activity. Then, seasonality and unusual demand conditions will likely induce measurement error when annualizing values that are reported for a period lasting less than a year.

Table 5.5: Random-effects regressions in first-differences

ESTIMATES	(1)	(2)	(3)	(4)	(5)	(6)
μ (all firms)	0.953***	…	…	1.017***	…	…
	(0.0610)			(0.0423)		
μ^{NX}	…	0.948***	0.953***	…	1.013***	1.020***
		(0.0617)	(0.0622)		(0.0425)	(0.0416)
μ^{X} (by exports status)	…	0.0360	…	…	0.0228	…
		(0.0322)			(0.0325)	
μ^{X} (domestic market)	…	…	0.0737**	…	…	0.0701**
			(0.0340)			(0.0351)
μ^{X} (export market)	…	…	-0.0480	…	…	-0.0832
			(0.0902)			(0.0905)
Λ	0.693***	0.693***	0.695***	0.734***	0.733***	0.737***
	(0.0478)	(0.0478)	(0.0482)	(0.0376)	(0.0378)	(0.0378)
Export status dummy	…	0.0392*	0.0399*		0.0345	0.0358
		(0.0211)	(0.0210)		(0.0222)	(0.0222)
Constant	-0.0745*	-0.0813*	-0.0816*	-0.0726	-0.0787*	-0.0791*
	(0.0425)	(0.0430)	(0.0431)	(0.0442)	(0.0448)	(0.0450)
Observations	1,640	1,640	1,640	1,621	1,621	1,621
Number of firms	246	246	246	243	243	243
R^2 (within)	0.614	0.615	0.615	0.652	0.652	0.653
Overall R^2	0.615	0.616	0.617	0.650	0.650	0.652

Notes: μ^{NX}, markup ratio for non-exporters; μ^{X}, markup ratio for exporters; λ, returns to scale parameter.
Standard errors in parentheses. Standard errors for all regressions are clustered by firm and include year dummy variables (coefficients not shown).
*** p<0.01, ** p<0.05, * p<0.1

An instrumental variables approach could resolve these endogeneity issues if we can find valid instruments. Everywhere in the literature, suggested instruments include lagged levels of the independent variable or of the input variables alone, as well as firm-specific input prices (whenever available). However, estimating the fixed-effects models above using lagged values does not eliminate the correlation between the error term and the RHS variables. This is because the fixed-effects estimator is based on taking deviations from the group means (in this case, the average values for each firm over the sample period).[17] Another option—and the most commonly used approach in the literature—is to estimate the models in first-differences using instrumental variables (IV) or general method of moments (GMM) methods. First-differencing the estimating equation eliminates the productivity fixed-effect, but

[17] I would like to thank my thesis supervisor, Måns Söderbom, for pointing this out.

does not eliminate the potential correlation between the random productivity shocks and the independent variables and hence the need for an IV or GMM approach. In addition, first-differencing induces an AR(1) process in the error term. As in the previous regressions, this can be corrected by using clustered standard errors.

Nonetheless, using IV or GMM methods comes at the cost of efficiency losses since the asymptotic variance of these estimators is always larger than for OLS (Baum et al., 2003). In order to determine whether use of these methods is warranted, I proceed in two steps. First, I take a look at how first-differencing affects the results obtained above and in particular, this inspection reveals that measurement error may pose a significant problem for the stability of the estimated coefficients. I then present the results of estimating the models using both IV and GMM methods with a set of instruments that perform well under both validity and relevance tests. The results are also used to obtain an idea of how serious the endogeneity problem is, as well as for testing for the presence of heteroskedasticity in the error term.

Columns (1) through (3) in Table 5.5 show the results of estimating the models in Table 5.3 (i.e., including year dummies and with clustered standard errors). Note that these models are estimated using random-effects since the fixed-effects were eliminated by process of taking first-differences.[18] First-differencing also reduces the sample size by 246 observations. The first obvious difference with the previous results is that the models in first-differences produce significantly lower estimates of the markup ratio and the returns to scale parameters. The estimated markup for the full sample in Column (1) now implies pricing below marginal cost, although the results from the corresponding Wald test in Table 5.6 (Column (1)) indicate the null that this coefficient is equal to one cannot be rejected. Similar results hold for the other markups estimated in Columns (2) and (3). What is still true is that the now lower scale coefficient is significantly different from one across all specifications, suggesting firms operate under decreasing returns to scale as before. One explanation for the smaller coefficients is the presence of measurement error.

As mentioned in Klette (1999), measurement error typically causes a downward bias in OLS estimates and this bias is more pronounced for models in first differences (p. 462). In the case of the Ghana survey, this bias may come, at least in part, in the form of reporting errors as some firms seem to overstate the true cost of labor and raw materials. This can be readily seen by removing three firms (accounting for just 19 observations) with cost shares above 100 percent, which changes the results

[18] In effect, estimating the models in first-differences using fixed-effects produces an F-statistic low enough to prevent the rejection of the null hypothesis that all the individual intercepts are zero with a p-value of above 99 percent across all specifications in Table 5.3.

significantly (shown in Columns (4)-(6) of Table 5.5). It is worth noting that the way shares are computed does help in reducing the bias somewhat, since instead of the actual cost shares the shares used in the regressions correspond to the mid-point between the observed shares and the sector medians. This has the effect of producing lower shares in general, but it also avoids extreme values. The three excluded firms form the models in Columns (4)-(6) are actually those with mid-point shares larger than one in some years, but other firms with actual shares exceeding 100 percent are still included.[19]

After removing these three firms from the sample, both markup and scale coefficients increase in size. In particular, the scale coefficient is much closer to the values obtained from the fixed-effects models. But in general, the results from the Wald tests for these models (Table 5.6, Column (4)-(6)) confirm the earlier results for the markup ratios, when time dummies were included in the fixed-effects models of Table 5.4. As before, the results suggest that non-exporters are closer to marginal-cost pricing than non-exporters in the domestic market and that non-exporters face intense competition abroad, while having some degree of market power at home. Note that the removal of these three firms is only done to show the effects that a few outliers can have on the estimated coefficients without correcting for the endogeneity of measurement error. In the rest of the paper, these firms are kept in the sample.

Table 5.6: Wald tests for estimated coefficients in Table 5.5

Null hypothesis	(1)	(2)	(3)	(4)	(5)	(6)
μ (all firms) = 1	0.6	…	…	0.15	…	…
$\mu^{NX} = 1$	…	0.71	0.58	…	0.09	0.23
$\mu^{NX} + \mu^{X}$ (by exports status) = 1	…	0.06	…	…	0.45	…
$\mu^{NX} + \mu^{X}$ (domestic market) = 1	…	…	0.15	…	…	2.95*
$\mu^{NX} + \mu^{X}$ (foreign market) = 1	…	…	0.95	…	…	0.40
μ^{X} (domestic) = μ^{X} (foreign)	…	…	1.36	…	…	2.08
Scale parameter, γ	41.23***	41.31***	39.96***	50.09***	49.75***	48.56***

Notes: Wald test statistics. μ^{NX}, markup ratio for non-exporters; μ^{X}, markup ratio for exporters; λ, returns to scale parameter.
Significance levels: *** p<0.01, ** p<0.05, * p<0.1

The results do point to a potential problem with Hall-type methods, one that is especially relevant if the primary interest is to accurately determine the degree of competition in a certain country, industry or market. That is, the presence of a few outliers can change the size of the estimated markups and scale coefficients significantly if the bias introduced by measurement error is not corrected. Given

[19] For two of these firms the mid-point share of labor costs in total output exceeds 100 percent, while for the third firm it is the share of the cost of raw materials. In addition, there a few other firms reporting either actual labor or materials cost shares greater than one and many more for which the sum of these shares exceeds 100 percent.

that we have some evidence that measurement error can be a significant source of bias in the case of the Ghanaian sample used in this paper, the use of IV or GMM methods to correct for this problem seems to be partially warranted.

5.3 IV-GMM regressions

The suspicion that random productivity shocks may be correlated with the independent variables in the models discussed so far prompts the question of whether the endogeneity bias is large enough to justify the use of consistent, but less efficient IV and GMM estimators to address the issue. In order to asses this, it is necessary to first find an appropriate set of instruments and obtain a model that we can use to compare the original random-effects results presented above. In other words, it is not possible to test for endogeneity before actually producing IV and/or GMM estimates. Therefore, the first step is to find instruments that are highly correlated with the endogenous variables but that are not correlated with the random productivity shocks. Finding suitable instruments with these characteristics is one of the main challenges in the empirical studies employing the production function approach and different authors opt for a wide variety of strategies. Levinsohn (1993), for example, argues that lagged values of the independent variables in his estimating equation (which resembles the model in Equation (3.11) in this paper) are valid instruments to address the endogeneity between the random productivity shocks and input use. In addition, the author argues that after adding year dummies to account for common industry shocks, the current values of the input variables can be used to instrument for the endogeneity between price and the error term. Other authors argue instead that valid instruments include two-period lags either of the input variables and cost shares in levels (Bottasso and Sembenelli, 2001) or even of output in levels (Konings, et al., 2001). Klette (1994) opts for performing exogeneity tests on different sets of instruments to arrive at a preferred set for his industry-level GMM estimates, starting with the most restrictive set with the labor and capital variables (in levels) lagged two periods and earlier to less restrictive sets in which current and lagged levels of these two variables are included. In their study on Indian firms, Krishna and Mitra (1998), on the other hand, find that due to a lack of appropriate instruments, their IV regressions did not provide meaningful results and instead opt for presenting only the results from random-effects regressions with the model in first-differences.

In this paper, I employed a similar approach as in Klette (1994, 1999) and start with a set of instruments which includes only the two-period lags of the labor, materials and capital variables in log deviations from their sector medians (i.e., l_{it}, m_{it}, k_{it} at t-2). These instruments were then tested both in terms of their validity and relevance with the tests discussed below. The instrument set was then expanded to include one-period lags and current levels of these variables and the same tests were used to determine whether these additional instruments could be included in the final set. However, only with the addition of the one-period lag and the current level of raw materials did the instruments satisfy both criteria. For the labor and capital inputs, including their one-period lags and current levels proved not only to be weakly correlated with the independent variables, but the test hypothesis that the instruments were *not* correlated with the error term was strongly rejected. Therefore, the preferred set of instruments in the regressions below includes the two-period lags of all three labor, materials and capital input variables, as well as the one-period lag and current level of raw materials (all in log deviations from their sector medians).

In order to test the validity of these instruments the Hansen J test of overidentifying restrictions is employed, which jointly tests whether the model is specified and whether the instruments satisfy the conditions of being uncorrelated with the error term. As argued in Baum et al. (2003), the Hansen J test can accommodate the cases of heteroskedastic errors and arbitrary correlation within groups as opposed to the common Sargan test, which assumes conditional homoskedasticity. As discussed below, heteroskedasticity is likely to be present if the variance of the error term is proportional to firm size and test results do provide evidence that this is the case with the Ghanaian sample. Under the null hypothesis of the J statistic, the instruments under testing are orthogonal to the error term and are correctly being excluded from the main regression. Therefore, rejection of the null is an indication that the instruments under question are not valid.

The instruments must also fulfill the condition of high correlation with the endogenous variables (i.e. the instruments must not be weakly correlated with the endogenous variables). To this end, I use a variant of the Anderson canonical correlations LM test due to Kleibergen and Paap (2006), which is valid when the error is not assumed to be independent and identically distributed (i.e. adequate when errors are suspected of being heteroskedastic).[20] Under the null hypothesis of this test, the model is underidentified so that rejection of the null implies the instruments under question are relevant (Baum and Schaffer, 2007).

Another econometric issue commonly raised in the literature is heteroskedasticity. Levinsohn (1993), for example, argues that the random productivity error term is unlikely to be homoskedastic given the differences in output between firms of different sizes. For larger firms, it is reasonable to expect a larger variance in productivity shocks given that the volume of sales for these firms is also bigger. As we saw in Section 5, the differences in output among the firms in the sample are significantly

[20] This and the Hansen J test are implemented in Stata using the *ivreg2* routine by Christopher Baum, Mark Schaffer and Steven Stillman and explained in detail in Baum et al. (2003) and Baum and Schaffer (2007).

large. Even a small change in demand for a large firm will lead to a change in output that may be several orders of magnitude larger than what a microenterprise produces in a single year. Therefore, in the results below I also include heteroskedasticity tests, which consistently reject the null of homoskedastic errors.

Table 5.7: IV and GMM results

ESTIMATES	IV (1)	GMM (2)	IV (3)	GMM (4)	IV (5)	GMM (6)
μ (all firms)	1.286***	1.289***	…	…	…	…
	(0.0393)	(0.0386)				
μ^{NX}	…	…	1.287***	1.282***	1.304***	1.296***
			(0.0410)	(0.0404)	(0.0429)	(0.0421)
μ^{X} (by exports status)	…	…	0.0115	0.0192	…	…
			(0.0643)	(0.0567)		
μ^{X} (domestic market)	…	…	…	…	0.0765	0.102**
					(0.0590)	(0.0517)
μ^{X} (foreign market)	…	…	…	…	-0.282	-0.231*
					(0.181)	(0.134)
λ	0.934***	0.942***	0.928***	0.949***	0.945***	0.964***
	(0.0521)	(0.0426)	(0.0506)	(0.0414)	(0.0525)	(0.0417)
Export status dummy	…	0.277***	-0.00158	0.00142	-0.00764	-0.00770
		(0.0520)	(0.0248)	(0.0198)	(0.0272)	(0.0211)
Constant	-0.0971***	…	-0.0952***	-0.106***	-0.0954***	-0.106***
	(0.0309)		(0.0291)	(0.0258)	(0.0293)	(0.0249)
Observations	1,394	1,394	1,394	1,394	1,394	1,394
Centered R^2	0.539	0.536	0.540	0.537	0.530	0.530
Uncentered R^2	0.541	0.539	0.542	0.539	0.532	0.532
Underidentification test[/a]	62.57***	62.57***	63.45***	63.45***	65.60***	65.60***
Hansen J statistic[/b]	1.847	1.847	4.989	4.989	7.464	7.464
Endogeneity test[/c]	23.26***	23.26***	20.86***	20.86***	21.11***	21.11***

Notes: μ^{NX}, markup ratio for non-exporters; μ^{X}, markup ratio for exporters; λ, returns to scale parameter.
IV regressions with clustered standard errors; GMM regressions with HAC consistent clustered standard errors.
Significance levels: *** p<0.01, ** p<0.05, * p<0.1.
Instrument set: labor, capital at *t-2*; raw materials at *t*, *t-1*, *t-2* (all in levels and log deviations from sector medians). For models (3)-(6), the instruments were combined with the additional interaction terms in the regressions.
[a/] Kleibergen-Paap rk LM statistic. Null hypothesis: estimating equation is underidentified.
[b/] Null hypothesis: instruments are uncorrelated with the error term and instrument set is correctly excluded from the estimating equation.
[c/] Test statistic: Difference in Sargan-Hansen statistics. Null hypothesis: all independent variables can be treated as exogenous.

This brings us to the choice between using IV or GMM estimation techniques. As shown in Baum et al. (2003), with a heteroskedastic error term, the IV estimator is less efficient than the GMM estimator, although it still produces consistent estimates of the coefficients. Therefore, in the presence of heteroskedasticity, GMM estimation would be preferred in order to obtain consistent and efficient standard errors. In the results below, the tests consistently suggest the presence of heteroskedasticity, but I opt to show both IV and GMM results of the same models to show the differences in the estimated standard errors. For the markup ratios, this difference has no significant impact on the general results, but in the case of the returns to scale parameter, it becomes unclear whether constant returns to scale can be rejected or not.

Table 5.7 presents the IV and GMM estimates of models in the previous sections with the set of instruments that satisfy both the validity and the relevance criteria discussed above. In the models where the markup for exporters and non-exporters is estimated separately, the instruments were interacted with the relevant export status dummy and export percentages discussed earlier to produce the corresponding instruments for the additional variables in the regression. In Table 5.7, we can see that in both IV and GMM estimates across all specifications, the Hansen J test suggests the instruments used are valid (i.e., the null that the instruments are not correlated with the error term and that they are correctly excluded from the main equation). In addition, the underidentification test provide strong indication that the preferred set of instruments is also relevant since the null hypothesis that the instruments are weakly correlated with the endogenous regressors is rejected at the 1 percent level across all specifications.

It is worth nothing, however, that these tests can only serve as a guide for assessing the appropriateness of the instruments used. The fact that the instruments perform well under both tests in no way implies that the endogeneity concerns raised earlier have been fully corrected for. Nonetheless, the results in Table 5.7 do tell us something about the extent to which endogeneity biases affect the estimated markups and scale coefficients. In particular, the IV and GMM estimates produce higher markups and a scale parameter that is closer to one, suggesting endogeneity in this case may have an overall downward bias.

After arriving to the preferred specifications in Table 5.7, testing for the presence of endogeneity is now possible and endogeneity tests are also presented with every specification in the table. The tests presented (the difference between two Sargan-Hansen statistics[21]) are robust to the presence of heteroskedasticity, but are similar in principle to the well-known Hausman specification test. Under such a test, two models are compared: the results from employing the estimator which is argued to be

[21] The endogeneity test presented in Table 5.7 is an additional option of the *ivreg2* routine cited above and the test statistic corresponds to the difference between two Sargan-Hansen statistics where one is the statistic obtained from the model where the variables believed to be endogenous are indeed treated as endogenous (the consistent, but inefficient estimator) and the other statistic comes from the model treating these suspected variables as exogenous (the efficient, but inconsistent estimator). When no correction for heteroskedastic errors is made, the test produces a test statistic that is numerically the same as a Hausman test statistic (see Baum et al. (2003) and Baum and Schaffer (2007) for the details of this test and how it is implemented in Stata through their *ivreg2* routine).

consistent, but inefficient under both the null and alternative hypothesis, and the results from the model which is consistent and efficient under the null, but inconsistent under the alternative hypothesis. In our case, the IV or GMM results are the less efficient, but consistent estimates under both hypotheses and the results from the random-effects models (i.e., treating all independent variables as exogenous) are the more efficient estimates, which are consistent under the null hypothesis of no endogeneity, but inconsistent when this is not the case. In sum, a rejection of the null hypothesis suggests the presence of endogeneity and as we can see from the results, this is the case in all models in Table 5.7.

We can now turn to the actual estimated markups and scale coefficients, which are significantly higher than the ones we obtained earlier, before correcting for endogeneity. The estimated markup for the full sample is now in the range of 28.6 and 28.9 percent above marginal cost (Columns (1) and (2)) and the Wald tests (Table 5.8) indicate these estimates are significantly different from one. After correcting for endogeneity, the picture we had before of a fairly competitive Ghanaian manufacturing sector has now changed substantially. The same is true when markups are separated according to firms' export status into non-exporters and exporters in Columns (3) and (4). While the markup ratio for non-exporters is between 1.282 and 1.287, exporters charge an average markup that is between 11.5 and 19.2 percentage points higher, although these export premium coefficients are not significantly different from zero. Nonetheless the Wald tests indicate these markup ratios are significantly different from the perfectly competitive level and in fact, this is the case for all the estimated markups in Table 5.7, except for the markup ratio that non-exporters charge in foreign markets.

Table 5.8: Wald and heteroskedasticity tests for estimated coefficients in Table 5.7

Null hypothesis	(1)	(2)	(3)	(4)	(5)	(6)
μ (all firms) = 1	53.08***	56.02***	…	…	…	…
μ^{NX} = 1	…	…	48.93***	48.79***	50.16***	49.47***
$\mu^{NX} + \mu^{X}$ (by exports status) = 1	…	…	21.01***	29.55***	…	…
$\mu^{NX} + \mu^{X}$ (domestic market) = 1	…	…	…	…	27.84***	36.37***
$\mu^{NX} + \mu^{X}$ (foreign markets) = 1	…	…	…	…	0.02	0.29
μ^{X} (domestic) = μ^{X} (foreign)	…	…	…	…	2.93*	4.41**
Scale parameter, $\gamma = 1$	1.59	1.85	2.02	1.54*	1.09	0.74
No Heteroskedasticity[/a]	34.657***	34.383***	36.670**	36.020**	36.735	36.186

Notes: Wald test statistics, except heteroskedasticity test. μ^{NX}, markup ratio for non-exporters; μ^{X}, markup ratio for exporters; λ, returns to scale parameter. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.
[a/] Pagan-Hall heteroskedasticity test statistic.

The models in Columns (5) and (6) in both Tables 5.7 and 5.8 reveal a similar pattern to the one observed earlier, where exporters have a higher domestic markup than non-exporters (around 7.65-10.2 percentage points higher) but where these same exporters have little or no market power in export markets. Notice that the Wald tests in Table 5.8 strongly suggest that the domestic markup for exporters is significantly different from one (fourth row), while their foreign markup (between 2.2 and 6.5 percentage points above marginal cost) is practically indistinguishable from the markup in a perfectly competitive market where firms charge a price equal to marginal cost (fifth row). The Wald tests also reject the null that the two markups for exporters are equal to each other (sixth row).

As with the markup ratios, the estimated scale parameter (between 0.928 and 0.964) is also significantly higher than the previous estimates. With scale parameters now closer to one, the null of constant returns to scale cannot be rejected across all specifications in Table 5.7, except in the results in Column (4) where the coefficient is significantly different from one at the 10 percent level. Therefore, it after correcting for endogeneity bias, firms do seem to be operating at constant returns to scale (or close to).

The results in Table 5.8 also indicate the presence of heteroskedasticity in the first four models, but once we distinguish between exporters' domestic and foreign markups the null of no heteroskedastic errors cannot be rejected at any standard level of significance. However, the p-values for the Pagan-Hall heteroskedasticity test statistics in Columns (5) and (6) are only slightly above 10 percent (12.48 and 13.79 percent respectively). In any case, given that the estimated markup ratios and scale parameters, as well the Wald tests in Table 5.8, lead to similar conclusions under both IV and GMM estimates, heteroskedasticity concerns play a secondary role and do not affect the overall findings.

5.4 Markups by export destination

Are foreign markups for exporters different across destinations? This question has not been necessarily at the center of most theoretical research. Nonetheless, we do find one relevant theoretical prediction in Melitz and Ottaviano (2008). In their model of trade with imperfect competition, they show that markups are in general lower in larger markets. As discussed in Section 4, the main destination for most Ghanaian exports is industrial countries in Europe and the United States and the markets in these countries are significantly larger than those of African countries. Then, we could expect Ghanaian manufacturers to be able to charge a higher markup in African export markets than in the much larger markets of industrial countries.

A major advantage of the detailed nature of the Ghana survey is that it asks firms to report what percentage of their exports is sold in African countries and what percentage is sold in other countries. This gives at least a more detailed level of disaggregation of exports by destination than most establishment survey datasets. The information on export destination allows us to separate the foreign markups of exporters in the sample even further, to test whether Ghanaian exporters charge different markups within and outside of Africa.

Given the endogeneity issues discussed earlier, only the IV and GMM estimates are shown in Table 5.9 and the corresponding Wald and heteroskedasticity tests in Table 5.10. The sample for these regressions includes only the observations for the period between 1993 and 2002 since 1993 (Wave 3) is when firms begin to report export percentages by destination. The instruments used in these regressions are the same as those used in the IV and GMM regressions in Table 5.7.

Table 5.9: Distinguishing foreign markups by export destination

ESTIMATES	IV (1)	GMM (2)
μ^{NX}	1.325***	1.297***
	(0.0528)	(0.0485)
μ^{X} **(domestic market)**	0.549**	0.463***
	(0.234)	(0.175)
μ^{X} **(export markets within Africa)**	-0.257	-0.0401
	(0.211)	(0.113)
μ^{X} **(export markets outside Africa)**	-0.448**	-0.341**
	(0.210)	(0.156)
λ	1.004***	1.016***
	(0.0560)	(0.0453)
Export status dummy	-0.0267	-0.0284
	(0.0316)	(0.0223)
Constant	-0.101***	-0.103***
	(0.0295)	(0.0243)
Observations	1,125	1,125
Centered R^2	0.424	0.428
Uncentered R^2	0.427	0.431
Underidentification test [/a]	63.91***	63.91***
Hansen J statistic [/b]	15.53	15.53
Endogeneity test [/c]	20.94***	20.94***

Notes: IV regressions with clustered standard errors; GMM regressions with HAC consistent clustered standard errors. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.
Instrument set: labor, capital at *t-2*; raw materials at *t*, *t-1*, *t-2* (all in levels and log deviations from sector medians). For models (3)-(6), the instruments were combined with the additional interaction terms in the regressions.
[a/] Kleibergen-Paap rk LM statistic. Null hypothesis: estimating equation is underidentified.
[b/] Null hypothesis: instruments are uncorrelated with the error term and instrument set is correctly excluded from the estimating equation.
[c/] Test statistic: Difference in Sargan-Hansen statistics. Null hypothesis: all independent variables can be treated as exogenous.

The results confirm once again that exporters have a higher domestic markup than non-exporters, although the estimated markup premium for exporters is now much higher. The results in Table 5.9 suggest that exporters charge a domestic price markup of 76 to 87.4 percent above marginal cost (compared to 38-40 percent in the results in Table 5.7) and the Wald tests in Table 5.10 indicate these markups are significantly different from one.

The estimates also suggest that Ghanaian exporters charge a lower markup in African export markets than they do at home. The estimated markup premium for exports within Africa in the IV results implies a markup ratio of 1.047 and the corresponding Wald tests in Table 5.10 indicates this ratio is not significantly different from one. On the other hand, the GMM results imply a markup ratio for exporters of 1.26 for their sales within Africa and the corresponding Wald tests suggest that this ratio is significantly different from one. In other words, the IV results suggest that the markup for Ghanaian exporters in African export markets is close to zero, while the GMM results imply these exporters do have the ability to charge a positive price markup over marginal cost of around 26 percent.

Table 5.10: Wald and heteroskedasticity tests for estimated coefficients in Table 5.9

Null hypothesis	(1)	(2)
$\mu^{NX} = 1$	37.92***	37.60***
$\mu^{NX} + \mu^{X}$ (domestic market) = 1	11.75***	14.93***
$\mu^{NX} + \mu^{X}$ (within Africa) = 1	0.11	5.35**
$\mu^{NX} + \mu^{X}$ (outside Africa) = 1	0.39	0.09
μ^{X} (domestic) = μ^{X} (Africa)	6.05**	6.19**
μ^{X} (domestic) = μ^{X} (Other)	5.18**	6.09***
Scale parameter, $\gamma = 1$	0.00	0.13
No Heteroskedasticity[/a]	30.905	30.492

Notes: Wald test statistics, except heteroskedasticity test. μ^{NX}, markup ratio for non-exporters; μ^{X}, markup ratio for exporters; λ, returns to scale parameter. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.
[a/] Pagan-Hall heteroskedasticity test statistic.

On the other hand, the foreign markup for Ghanaian exporters in markets outside of Africa is much lower than all other estimated markups. The estimated markup premiums in these other markets are negative (between -34.1 and -44.8 percent for the IV and GMM results, respectively) and significantly different from zero. In fact, the implied markup ratios would suggest that Ghanaian exporters charge a price below marginal cost in markets outside of Africa, with markup ratios of 0.963 and 0.848 in the IV and GMM estimates, respectively. However, the Wald tests in Table 5.10 indicate that the implied markup ratios in both sets of results is not significantly different from one, suggesting marginal cost pricing for Ghanaian firms in markets outside Africa. Whether exporters are indeed charging a price below marginal cost or not, the results do suggest that Ghanaian exporters face fierce competition in export markets outside Africa and this level of competition is tougher than in African markets.

Compared to the previous IV/GMM results, the estimated scale coefficients in Table 5.9 are now higher and slightly above one (between 1.004 and 1.016, compared to 0.945 and 0.964 in Table 5.7). Nonetheless, the corresponding Wald tests in Table 5.10 indicate again that this scale parameter is not significantly different from one and confirm the previous results, which suggest Ghanaian firms operate under constant returns to scale.

6. Conclusions

Building on a simple model of Cournot competition, this paper finds that the prediction in previous studies that exporters are able to charge a higher domestic markup than non-exporters holds whether firms are capacity constrained or not. This prediction is then tested empirically with a panel of Ghanaian manufacturing firms and the results confirm that exporters have a domestic markup premium of around 7-10 percentage points over non-exporters.

In the analytical section, the cases of three types of firms are analyzed: non-exporters, partial exporters (firms that both export and produce for their domestic market) and full-time exporters. In the absence of capacity constraints, all three types of firms are found to treat the decision of how much to produce for the domestic and foreign markets as separate. For non-exporters, exporting is not profitable because marginal revenue abroad is lower than the sum of marginal, transportation and fixed exporting costs. Partial exporters, on the other hand, have a sufficiently low marginal cost, which allows them to cover all export-related costs and still compete in export markets even if they have little or no market power abroad. As a result of this marginal cost advantage, exporters are able to charge a higher markup at home than non-exporters, given that all firms charge the same price in equilibrium. At the same time, since firms do not have limits on production, exporters are predicted to have a higher domestic output share than non-exporters. However, in reality—and in particular for manufacturing firms in developing countries—we observe exporters who produce very little for the domestic market, even though their overall output is several times bigger than what most non-exporters produce.

The paper therefore explores the case of capacity constrained firms and finds that under those circumstances, both exporters and partial exporters face the decision of producing more for one market at the expense of producing less for the other. Hence, as exporters sell more of their product abroad, their domestic output shares decrease and may even become smaller than those of non-exporters. The capacity constraints model fits the Ghanaian data better, where we observe big exporting firms with a large number of employees producing the same amount of output or less for the domestic market as much smaller non-exporters with overall production levels that are several times lower. Nonetheless, even if firms are capacity constrained, exporters are found again to charge a higher *domestic* markup than non-exporters.

The results from the capacity constraints model also have some interesting policy implications. As exporters allocate higher amounts of output to exports, total output at home declines. If non-exporters are also capacity constrained, they will not be able to produce more and prices will increase. In that case, markups for all firms will increase, with a corresponding loss in consumer welfare. Therefore, trade promotion policies that aim to encourage firms to enter export markets may need to be accompanied by efforts to aide firms in overcoming the limits to how much they can produce in the short-run. Better access to credit, for example, may help those firms who cannot increase production because they lack the necessary capital or because they cannot finance the additional inputs needed.

In the empirical section, the prediction that exporters have a higher domestic markup than non-exporters was tested using a panel of Ghanaian manufacturing firms. The method used to recover markups is the production function approach based on Hall (1988) and extended by Klette (1994, 1999) to avoid the need of firm-specific output and input deflators. The paper also studies the effect on the estimated markups and scale coefficients of adding time dummies to capture economy-wide shocks that may affect all firms in the economy, as well as the effect of firms with unusually high input cost shares. The results suggest that time fixed-effects and cost shares above 100 percent for some firms tend to lower the size of the estimated coefficients. The paper also provides instrumental variables (IV) and general method of moments (GMM) estimates to correct for the endogeneity between random productivity shocks and variables included in the RHS of the estimating equation; namely input changes and output prices.

The results confirm the theoretical prediction that domestic markups are higher for exporters. The domestic markup premium for Ghanaian exporters is found to be between 7 and 10 percentage points. The results also suggest that the markup ratio for Ghanaian exporters in international markets is much lower than their domestic markup. In fact, in some of the results, the markup ratio is indistinguishable from one, implying marginal cost pricing for these firms in export markets. This is an important result and differs from previous empirical studies in which the foreign markup for exporters is not separated into its domestic and foreign components. Given that Ghanaian exporters' markup abroad is small or even close to zero the *average* markup for these firms is lower than their domestic markup. The IV/GMM results, for example, suggest the average markup for exporters is between 1.2 and 1.9 percentage points higher than the markup for non-exporters, which is much lower than the 7-10 percentage points domestic markup premium obtained after separating exporters' foreign and domestic markups. The average markup thus underestimates the true markup difference between exporters and non-exporters at home.

The detailed nature of the Ghana dataset also allows us to further separate the foreign markup for exporters according to the destination of their exports. The results suggest the price-cost margin for Ghanaian exporters may be slightly positive for sales within Africa, but it is closer to zero for exports to other countries. Since most of Ghana's trade outside of Africa is with industrialized countries, these results suggest that Ghanaian exporters face stronger competition there than in African export markets.

The estimates for the returns to scale coefficient in the regressions that do not correct for endogeneity imply that firms in Ghana operate under decreasing returns to scale (i.e., the estimated scale parameter is less than and significantly different from one). After correcting for endogeneity, the scale parameter increases in size and the null hypothesis that it is equal to one can no longer be rejected, implying firms actually operate under constant returns to scale.

Finally, it is important to note that the theoretical model in this paper does not consider the effect of market size or imports on markups and output shares. Therefore, the model could be extended in future research to study these effects under the scenario of capacity constrained firms. In particular, it may be the case that the output allocation decisions by partial exporters are different with foreign markets of varying sizes. In addition, competition from imports could of course have the effect of lowering markups for all firms participating in the domestic market, but it would be important to determine whether firms with the capacity to export shift their output allocation towards export markets or decide to compete at home and attempt to retain their domestic market share.

On the empirical side, recent studies on panels of firms from European countries have extended the production function approach to allow for imperfections in input markets and in particular, the labor market. Therefore, further research could extend the empirical framework employed in this paper to study whether labor market imperfections have an impact on the estimated markups and scale parameters for Ghana. This is particularly interesting since Ghana is a developing country with potentially more significant distortions in labor markets than the European countries in the recent studies where the extended production function approach has been applied.

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Data Appendix

The RPED-GMES panel covers the period between 1991 and 2002 (Waves 1 through 7) and is unbalanced, with some of the original 200 firms in Wave 1 exiting the survey and some firms added in subsequent waves. Given the relatively small number of observations and particularly the small number of exporters, all sectors are used in the regressions. This means that the estimated markups are interpreted averages for all of Ghana's manufacturing sectors represented in the sample.[22]

Firm managers interviewed in the survey are asked to report on production and input values (among many other things) for the period of time they are more comfortable with. This means values can be from weekly to annual. To make them comparable, output and input variables were annualized when the reporting period was not on an annual basis. This heterogeneity in reporting could be one source of measurement error if, for example, reporting periods of less than a year happen to be different from the rest of the year because of unusually high/low demand or because of seasonal factors.

As mentioned in Section 3, the econometric framework used in this paper calls for transforming the core output and input variables into their log deviations from some reference point in order to estimate a transformed production function which allows us to jointly recover markups and the returns to scale coefficient. The core variables used to construct the independent variables for the empirical models in Equations (3.11), (3.13) and (3.14) and their corresponding definitions are shown in Table A.1.[23]

For the value of the capital stock, the imputed series for the replacement value of machinery and equipment constructed by CSAE is used.[24] This series relies mainly on the reported value of machinery and equipment, but where missing, the responses to other to investment questions in the survey are used to impute values. Nonetheless, the imputing procedure drops the replacement value of machinery and equipment for a significant number of firms in some years. Therefore, for missing values on the imputed series and when the original replacement value of machinery and equipment series is complete for the firm, I use the latter entire series instead. This avoids losing a significant number of observations and in

[22] Early attempts were made to estimate markups separately for two of the sectors with the largest number of firms (the garments and wood furniture sectors), but it resulted impossible to estimate separate markups for exporters and non-exporters in those industries with the number of exporters ranging between 2 and 5 per year (out of 29 to 39 firms per year) in the garments sector and between 2 and 4 per year (out of 16 to 30 firms per year) in the wood furniture sector.

[23] For a more detailed explanation of these variables, as well as the corresponding questions in the survey questionnaires used to elicit the values, see CSAE (2011).

[24] The details of how this variable was constructed are outlined in CSAE (2011).

my view, it does not introduce additional noise since, as mentioned before, CSAE's imputed capital series is based primarily on the replacement value of machinery and equipment.[25]

Table A.1: Core variables and definitions

Variable	Definition
Output	Annual value of manufactured output (in millions of current *cedis*)
Wage bill	Annual total cost of labor, including wages and allowances (in millions of current *cedis)*
Raw materials	Annual value of all raw materials used in production (in millions of current *cedis*)
Capital stock	Replacement value of all plant and equipment (in millions of current *cedis*)
Employees	Total number of full-time permanent, full-time casual and part-time workers
Labor share	Wage bill divided by the value of output
Materials share	Value of raw materials divided by the value of output

The reference point for taking log deviations of the core variables is taken to be the median value for each major manufacturing sector in the sample. To construct the medians, the sample was first divided into 7 sectors: (1) Food and Beverages; (2) Textiles; (3) Garments; (4) Wood and Wood Products (except Wood Furniture); (5) Wood Furniture; (6) Chemicals and (7) Metal Products. Ideally, industries should have been defined at the most detailed level of disaggregation to get closer to a definition of relevant markets where firms in any given sector actually compete with each other. This could have been done by dividing firms into their International Standard Industrial Classification (ISIC), 4-digit code industry group. However, at this level of disaggregation a large number of industries would have had only one or two firms per year.

Another factor that limits the number of firms in each sector is that for some firms and some years, there is missing data on output and inputs. These observations were excluded from the final sample used in the regressions, but they were used to construct the industry medians. Thus, for example, the median level of output for the textiles sector in 1991 is calculated on the basis of all firms who report positive values of output and, of course, excluding missing values. After computing the industry medians, the sample was narrowed down to firms with two or more consecutive years of data on all

[25] The imputed series actually matches exactly the replacement value of machinery and equipment for some firms in some years and in others, at least the percent change in the two series is exactly the same.

output and inputs variables to avoid gaps in the panels. This meant dropping firms with missing or zero values of output, the wage bill, number of workers, the cost of raw materials and the value of the capital stock. Some firms were missing only one year of data to complete a consecutive run. For these firms, the longest part of the series was kept (e.g. a firm with data for 1991-1997, but missing 1992 is kept as 1993-1997). Where the consecutive runs were of equal length (e.g. a firm with data for 1991-1993 and 1995-1997, with a gap in 1994) I kept the most recent one, given that the more recent waves of the survey seem to contain better quality data (CSAE, 2011).

There are also some firms missing wage bill data. Where this is the case, the wage bill is imputed using the change in average monthly earnings per employee in the private sector, from IMF (2000, 2003 and 2005). For each firm, the implied average wage per employee is first obtained from dividing the wage bill by the total number of employees for the years in which wage bill data is available. The percent change in average monthly earnings series from the IMF is then applied to fill in the gaps in the implied wage series. Finally, the imputed average wage is multiplied by the number of employees to obtain the wage bill in missing years.

As discussed in Section 3, the labor and materials input shares ($\bar{s}_{it}^{L}$ and $\bar{s}_{it}^{M}$, respectively) in Equations (3.11), (3.13) and (3.14) are evaluated at some internal point between the observed point of operation of the firm and the median value for the industry in any given year. To construct these shares, each firm's actual input cost shares were first computed (defined in Table A.1). The median share for each sector was then calculated and the final shares used in the estimation were constructed as the mid-point between the actual and median shares.