Competition, Markups, and the Gains from International Trade*

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Abstract

We study product-level data for Taiwanese manufacturing establishments through the lens of a model with endogenously variable markups. We find that the gains from international trade can be large: in our benchmark model, moving from autarky to a 10% import share implies an increase in welfare equivalent to a 27% permanent increase in consumption. By contrast, a standard trade model with constant markups implies a smaller gain, around a 4% increase in consumption. By increasing competition, trade reduces markups and so reduces distortions in labor and investment choices. Greater competition also induces a more efficient allocation of factors of production across establishments, thereby directly raising TFP. These channels can be an order of magnitude more important than the love-of-variety effects in standard trade models. Our model predicts that industries that are more open are characterized by lower revenue productivity and lower dispersion in revenue productivity across producers. We find strong support for these predictions of the model in the Taiwanese data. In our model, micro details such as as the dispersion of industry-level import shares determine how the *Armington elasticity* endogenously responds to a change in trade policy. Consequently, these micro details also matter for determining the size of the gains from standard love-of-variety effects.

Keywords: market shares, productivity, misallocation, welfare, Armington elasticity.

JEL classifications: F1, O4.

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1 Introduction

How large are the welfare gains from international trade? We answer this question using a quantitative model with endogenously variable markups. Our main finding is that the welfare gains from trade can be large and, in particular, can be an order of magnitude larger than those implied by standard models with markups that do not change in response to trade.

In our model, opening an economy to trade exposes domestic firms to a *pro-competitive* mechanism which reduces market shares and increases demand elasticity. As a consequence, firms charge smaller markups over marginal cost. The impact of increased competition on markups leads to gains from trade both by reducing average markups and by reducing dispersion in markups. The former effect directly reduces distortions in labor and investment decisions. The latter effect promotes a more efficient allocation of factors across establishments and so increases total factor productivity (TFP). We quantify the model using product-level data for Taiwanese manufacturing establishments and find that both markup effects can be substantial. Combined, the model predicts that moving from autarky to a 10% import share implies an increase in welfare equivalent to a 27% permanent increase in consumption. By contrast, a standard trade model that does not account for the effects of increased competition on markups would predict a 4% increase in consumption.

We are far from the first to argue that the pro-competitive effects of trade may increase productivity and welfare. Instead, our main contribution is to carefully *quantify* the pro-competitive mechanism. To conduct this exercise we use a model developed by Devereux and Lee (2001) and Atkeson and Burstein (2008). The model features a nested pair of constant elasticity demand systems. Within a country, there is a continuum of imperfectly substitutable industries. Within any given industry, there is a small number of firms who engage in oligopolistic competition and whose products are more substitutable for one another than they are substitutable for products from other industries. The demand elasticity for any given firm depends on both these margins of substitution *and on that firm's market share in its industry*. A firm that is a monopolist in its industry faces no competition from close substitutes and so faces a less elastic demand curve than a firm that has a low market share. In this model, the market shares of firms, and hence their demand elasticities and markups, are determined in equilibrium. Heterogeneity in market shares is driven by exogenous firm-level productivity differences.

We consider a world with two perfectly symmetric countries.[1] A firm in either country can sell into its industry abroad, thereby exposing firms in that industry abroad to more

[1]By considering perfectly symmetric countries — and thus abstracting from aggregate differences in factor endowments or technologies — we isolate the gains from trade that are exclusively due to intraindustry trade, as in Krugman (1979, 1980).

competition, but to do so incurs an iceberg trade cost. Our main interest is the welfare gains from increased exposure to trade that result from reductions in tariffs on importers.[2] For intuition, consider an industry consisting of one large firm that has a high market share and charges a high markup plus a small number of less productive firms that have low market shares and charge low markups. This industry will have a high (revenue-weighted) average markup but also a considerable amount of markup dispersion between the large firm and the small firms. Now imagine confronting this industry with competition from symmetric firms in the same industry abroad. The increased competition will reduce market power across the board, driving down the market share of the large firm (in each country) and thereby increasing demand elasticities and reducing markups. This increase in competition brought about by opening to trade both reduces the average markup and, by shifting the large firms out of the tails of the markup distribution, also reduces dispersion in markups.

To quantify the effect of more competition on markups, we use product-level (7-digit) Taiwanese manufacturing data. We combine this with import data from the WTO to obtain disaggregated import shares for each product category. We use this data to discipline three key factors governing the size of the gains from trade in our model: (i) the equilibrium distribution of firm-level market shares, (ii) the extent to which substitution across industries is a good alternative to substitution within an industry, and (iii) the equilibrium magnitude of the *Armington elasticity*, i.e., the sensitivity of trade flows to changes in trade costs. In particular, we pin down the parameters governing the firm-level distribution of productivity and fixed costs of operating and exporting by requiring the model to reproduce the distribution of market shares and industry concentration statistics in the Taiwanese data. We choose the elasticity of substitution within industries so that our model matches standard estimates of the Armington elasticity. We choose the elasticity of substitution between industries so that our model fits the cross-sectional relationship between labor shares and market shares that we observe in the Taiwanese data. All other parameters are assigned values consistent with those used in existing work.

Our benchmark model predicts large gains from trade through the effect that increased competition has on the distribution of markups. First, holding fixed a given level of aggregate TFP, increased trade reduces the aggregate markup and so reduces distortions in labor and investment decisions. Second, holding fixed a given level of the aggregate markup, increased trade reduces the dispersion in markups and so endogenously increases the level of aggregate TFP as factors of production are more efficiently allocated. We find that both these effects are large. For example, going from our benchmark economy to the first-best (i.e., eliminating

[2]We interpret the trade costs in our model as being essentially technological, at least in the sense of their being difficult to change with policy. Accordingly, we find it more natural to compute the welfare implications of changes in the level of taxes/subsidies on importers.

both the level and dispersion in markups) gives a welfare gain equivalent to a 17% permanent rise in consumption. Of this, a 6.5% welfare gain can be obtained by eliminating the dispersion in markups while leaving the aggregate markup unchanged at its benchmark level. Thus in this case both effects play a substantial role in delivering the overall welfare gains.

Increasing TFP by reducing markup dispersion is an effect familiar from the work on "misallocation" of factors of production by Restuccia and Rogerson (2008), Hsieh and Klenow (2009) and others. We find that international trade can play a powerful role in reducing misallocation and so increase productivity both at home and abroad. In short, the size of the welfare gains from trade and the extent to which misallocation suppresses the level of TFP are closely related concerns. From a policy point of view, our model suggests that obtaining large welfare gains from an improved allocation may not require the detailed, perhaps impractical, scheme of cross-subsidies/taxes that implement the first-best. Instead, simply opening an economy to trade may provide an excellent practical alternative that substantially improves welfare even if it does not go all the way to the first-best.

Beginning with Eaton and Kortum (2002) and Melitz (2003), a large recent literature on trade with heterogeneous firms has emphasized two conceptually distinct but related channels by which trade may lead to welfare gains. The first channel is a *selection effect*. Exposure to trade forces less productive firms to exit and the resulting reallocation of resources increases measured productivity, as in the empirical work of Aw, Chung and Roberts (2000), Pavcnik (2002) and others. Selection is driven by the need to cover fixed costs of operating and/or exporting. In other words, this channel of reallocation operates at the *extensive margin*. Without the exit of less productive firms, there would be no increase in aggregate productivity. And as emphasized by Arkolakis, Costinot and Rodríguez-Clare (2011), the quantitative gains from trade in any reasonably calibrated version of a model of this kind are small. The second channel is the *pro-competitive effect* that we focus on. Reallocation in our model occurs primarily at the *intensive margin* and there are quantitatively significant gains from trade even if there is no exit by less productive firms.[3] Almost all the gains from trade in our model come from reallocation due to changes in the distribution of markups.[4]

In models such as Melitz (2003), trade has only a selection effect and has no pro-competitive effect because markups are constant. In other trade models, the absence of pro-competitive effects occurs for more subtle reasons. For example, in Bernard, Eaton, Jensen and Kortum (2003) — BEJK hereafter — heterogeneous firms compete in Bertrand fashion to be the sole producer in their industry, and this indeed gives rise to an endogenous

[3] In our model, trade acts like the competitive pressure effects surveyed in Holmes and Schmitz (2010).

[4] Our model includes fixed costs of operating and exporting and so also features reallocation due to selection, but these effects are quantitatively small. We include fixed costs only to ensure that the model can better match the micro-data we use to determine our key parameters.

markup distribution. The properties of this distribution depend on whether the lowest cost and second-lowest cost firms are domestic or foreign and, in principle, the effects of increased trade depend on how (if at all) trade leads to a new configuration of lowest and second-lowest cost firms. But owing to special properties of the Fréchet distribution, which BEJK use to model firm-level productivity draws, it can be shown that the markup distribution is *invariant* to a trade liberalization. Increased trade reduces prices but also proportionately reduces costs so that markups are unchanged. Consequently, this analysis misses the effect of trade-induced changes in competition on markups and TFP.

A pro-competitive effect in a model of imperfect competition can be obtained by departing from the assumption of a large number of firms facing constant elasticity demand. Brander (1981) and Brander and Krugman (1983) provide examples of this using models of Cournot competition in partial equilibrium settings. More recently, Devereux and Lee (2001) and Atkeson and Burstein (2008) have considered dynamic general equilibrium trade models featuring competition between a *small* number of firms facing constant elasticity demand. Melitz and Ottaviano (2008) consider monopolistic competition by a large number of firms that face *linear* demand curves and hence a variable elasticity of demand. Both of these frameworks predict that more productive firms will have larger market shares and charge larger markups. In both frameworks, an increase in international trade has the effect of increasing competition and reducing markups.[5] Other departures from constant elasticity demand, such as the translog demand systems considered by Feenstra and Weinstein (2010) and Novy (2010) can give similar effects.[6] In addition to its theoretical appeal, this pro-competitive effect is widely documented in empirical work. Examples from the trade literature include Harrison (1994), Levinsohn (1993), Krishna and Mitra (1998), and Bottasso and Sembenelli (2001). Campbell and Hopenhayn (2005) document a similar effect in U.S. establishment data. Relative to this empirical work, our main contribution is to embed the pro-competitive mechanism in a tightly grounded model that can be used for welfare analysis and counterfactual experiments.

Several recent theoretical papers on variable markups also highlight the importance of changes in markup dispersion for aggregate productivity and the gains from trade. Epifani and Gancia (2011) provide conditions under which falls in markup dispersion increase

[5]In Devereux and Lee (2001), as in the original Dixit and Stiglitz (1977) model, the markup is endogenous to the number of producers but the distribution of market shares is uniform. Atkeson and Burstein (2008) extend this model by considering firm-level heterogeneity in productivity which then determines, in equilibrium, the distribution of market shares.

[6]Arkolakis, Costinot and Rodríguez-Clare (2010) show, however, that if firm-level productivity has a Pareto distribution then the translog demand system will still give small gains from trade. The intuition for this is that with free-entry, the markup is pinned down by the fixed cost of entry and the threat of further entry already provides enough competition that competition from international firms has little extra effect.

aggregate productivity, but in their analysis the markup distribution is exogenous. Peters (2011) provides a related analysis of a closed-economy model where the markup distribution is endogenous because of entry/exit decisions by firms and discusses the implications of the markup distribution for aggregate productivity. Like us, he emphasizes that only the aggregate markup matters for factor prices, and hence for labor and investment decisions, and that it is markup dispersion that inefficiently reduces aggregate productivity. De Blas and Russ (2010) have extended BEJK so that the distribution of markups is endogenous to trade costs. Holmes, Hsu and Lee (2011) make a related theoretical contribution and construct a model that nests both a standard constant elasticity framework and BEJK framework as special cases. Though they differ in details, both Holmes et al. (2011) and De Blas and Russ (2010) have a selection effect and a pro-competitive effect and both can account, qualitatively, for a trade-induced fall in markup dispersion and the resulting increase in productivity. Relative to these papers, our main contribution is quantifying the pro-competitive mechanism.

To further evaluate the pro-competitive mechanism, we examine several other predictions of the model. For example, the model predicts that industries with higher import shares are more competitive and have both lower levels of measured revenue (labor) productivity and lower dispersion in revenue productivity. Encouragingly for our mechanism, we find strong support for both predictions in the Taiwanese data. We find that industries with high import shares have substantially lower average revenue productivity and substantially lower dispersion in revenue productivity. Both relationships hold even when we control for differences in capital intensity at the industry level. Moreover, we find that most of the reduction in dispersion comes from reducing the revenue productivity of the largest firms. This is consistent with the model's prediction that most of the reduction in markup dispersion comes from exposing large firms to more effective competition.

The remainder of the paper proceeds as follows. Section 2 presents the model and shows how the distribution of markups, aggregate TFP and the Armington elasticity are determined in equilibrium. Section 3 gives an overview of the Taiwanese manufacturing data and Section 4 explains how we use that data to quantify the model. Section 5 contains our main results on the welfare gains from international trade. Section 6 presents extensions of our benchmark model and discusses the robustness of our main results. Section 7 provides evidence showing that our model's predictions for the cross-industry relationship between import shares and the distribution of revenue productivity are supported by the Taiwanese data. Section 8 concludes.

2 Model

The world consists of two symmetric countries, Home and Foreign. We focus on describing the problem of Home agents in detail. We indicate Foreign variables with an asterisk.

2.1 Consumers and final good producers

Each country consists of consumers and perfectly competitive firms that produces a single final good from a continuum of industries, with each industry consisting of a finite number of domestic and foreign intermediate inputs.

Consumers. The problem of home consumers is to choose aggregate consumption C_t, labor supply L_t, and investment in physical capital X_t, to maximize:

$$\sum_{t=0}^{\infty} \beta^t U\left(C_t, L_t\right)$$

subject to:

$$P_t(C_t + X_t) \leq W_t L_t + \Pi_t + T_t + R_t K_t,$$

where P_t is the price of the final good, W_t is the wage rate, Π_t is firm profits, T_t is lump-sum net taxes, and R_t is the rental rate of physical capital K_t, which satisfies:

$$K_{t+1} = (1-\delta)K_t + X_t.$$

The solution to the consumers' problem is characterized by standard first order conditions. The marginal rate of substitution between labor and consumption is equated to the real wage:

$$-\frac{U_{l,t}}{U_{c,t}} = \frac{W_t}{P_t}$$

while the return on capital satisfies the intertemporal condition:

$$1 = \beta \frac{U_{c,t+1}}{U_{c,t}} \left(\frac{R_{t+1}}{P_{t+1}} + (1-\delta) \right).$$

We assume identical initial capital stocks and technologies in the two countries. Absent aggregate uncertainty, this implies that trade is balanced in each period, and, in addition, that:

$$\frac{P_t^*}{P_t} = \frac{U_{c,t}^*}{U_{c,t}}.$$

Final good producers. The producers of the final good are perfectly competitive. The technology with which they operate is:

$$Y_t = \left(\int_0^1 y_{j,t}^{\frac{\theta-1}{\theta}} \, dj \right)^{\frac{\theta}{\theta-1}},$$

where $\theta > 1$ is the elasticity of substitution *between* industries $j \in [0,1]$ and where industry output draws on N domestic goods and N imported goods:

$$y_{j,t} = \left(\frac{1}{N} \sum_{i=1}^{N} \left(y_{ij,t}^{H}\right)^{\frac{\gamma-1}{\gamma}} + \frac{1}{N} \sum_{i=1}^{N} \left(y_{ij,t}^{F}\right)^{\frac{\gamma-1}{\gamma}} \right)^{\frac{\gamma}{\gamma-1}}, \tag{1}$$

where $\gamma > \theta$ is the elasticity of substitution across goods i *within* a particular industry j.

2.2 Intermediate inputs

Intermediate producer i in industry j uses the technology:

$$y_{ij,t} = a_{ij} k_{ij,t}^{\alpha} l_{ij,t}^{1-\alpha},$$

where a_{ij} is the producer's idiosyncratic productivity (which for simplicity we assume is *time-invariant*), $k_{ij,t}$ is the amount of capital hired by the producer, and $l_{ij,t}$ is the amount of labor hired. We discuss the assumptions we make on the distribution of firm-level productivity in Section 4 below. To conserve notation, for the remainder of the paper we suppress time subscripts whenever there is no possibility of confusion.

Trade costs. An intermediate goods producer sells output to final goods producers located in both countries. Let y_{ij}^{H} be the amount sold to home final goods producers and similarly let y_{ij}^{*H} be the amount sold to foreign final goods producers. The resource constraint for home intermediates is:

$$y_{ij} = y_{ij}^{H} + (1+\tau) y_{ij}^{*H},$$

where $\tau > 0$ is an iceberg trade cost, i.e., $(1+\tau)y_{ij}^{*H}$ must be shipped for y_{ij}^{*H} to arrive abroad.

We describe an intermediate producer's problem below, after describing the demand for their good. Due to fixed costs of operating, not all intermediate firms will be selling. Let the indicator function $\phi_{ij}^{H} \in \{0,1\}$ denote the decision to operate or not in the home market and let $\phi_{ij}^{*H} \in \{0,1\}$ denote the decision to operate or not in the foreign market.

Foreign intermediate goods producers face an identical problem. We let y_{ij}^{*} denote their output and note that the resource constraint for foreign intermediates is:

$$y_{ij}^{*} = (1+\tau) y_{ij}^{F} + y_{ij}^{*F},$$

where y_{ij}^{*F} is the amount sold by foreign intermediates to foreign final goods producers and y_{ij}^{F} is the amount shipped to home final goods producers.

Demand for intermediate inputs. Final good producers buy intermediate goods from Home producers at prices p_{ij}^{H} and from Foreign producers with prices p_{ij}^{F} and sell the final good to consumers with price P. The problem of a final goods producer is to choose y_{ij}^{H} and y_{ij}^{F} to maximize:

$$PY - \int_0^1 \left(\frac{1}{N} \sum_{i=1}^{N} p_{ij}^{H} y_{ij}^{H} + (1+\tau) \frac{1}{N} \sum_{i=1}^{N} p_{ij}^{F} y_{ij}^{F} \right) dj.$$

The optimal choices are given by:

$$y_{ij}^{H} = \left(\frac{p_{ij}^{H}}{p_j} \right)^{-\gamma} \left(\frac{p_j}{P} \right)^{-\theta} Y, \tag{2}$$

and

$$y_{ij}^{F} = \left(\frac{(1+\tau)\, p_{ij}^{F}}{p_j} \right)^{-\gamma} \left(\frac{p_j}{P} \right)^{-\theta} Y, \tag{3}$$

where the aggregate and industry price indexes are:

$$P = \left(\int_0^1 p_j^{1-\theta}\, dj \right)^{\frac{1}{1-\theta}}, \tag{4}$$

and

$$p_j = \left(\frac{1}{N} \sum_{i=1}^{N} \phi_{ij}^{H} \left(p_{ij}^{H} \right)^{1-\gamma} + (1+\tau)^{1-\gamma} \frac{1}{N} \sum_{i=1}^{N} \phi_{ij}^{F} \left(p_{ij}^{F} \right)^{1-\gamma} \right)^{\frac{1}{1-\gamma}}. \tag{5}$$

Market structure. An intermediate good producer faces the demand given by (2)-(3) and engages in *Cournot competition* within its industry, i.e., setting quantities.[7] Due to constant returns, the problem of a firm in its domestic market and its export market can be considered separately.

[7] In Section 6 below we solve our model under the alternative assumption of *Bertrand competition*.

Fixed costs. A fixed cost F_d, denominated in units of labor, must be paid in order to operate in the domestic market and a fixed cost F_f must be paid in order to export. We think of these as fixed costs of selling the good, not of producing the good. The firm may choose to sell zero units of output in any given period to avoid paying the fixed cost F_d.

Home market. A home firm's problem in the home market is given by:

$$\pi_{ij}^H \equiv \max_{y_{ij}^H, k_{ij}^H, l_{ij}^H, \phi_{ij}^H} \left[p_{ij}^H y_{ij}^H - R k_{ij}^H - W l_{ij}^H - W F_d \right] \phi_{ij}^H.$$

Conditional on selling, $\phi_{ij}^H = 1$, the demand for labor and capital satisfy the standard first order conditions:

$$\alpha v_{ij} \frac{y_{ij}^H}{k_{ij}^H} = R \tag{6}$$

$$(1-\alpha) v_{ij} \frac{y_{ij}^H}{l_{ij}^H} = W, \tag{7}$$

where v_{ij} is the intermediate's marginal cost (which, by symmetry, is common to both the domestic and export market), and is given by:

$$v_{ij} = \frac{V}{a_{ij}}, \qquad \text{where} \qquad V \equiv \alpha^{-\alpha} (1-\alpha)^{-(1-\alpha)} R^{\alpha} W^{1-\alpha}. \tag{8}$$

Using this notation, we can rewrite the profits of the intermediate producer as:

$$\pi_{ij}^H = \max_{y_{ij}^H, \phi_{ij}^H} \left[\left(p_{ij}^H - v_{ij} \right) y_{ij}^H - W F_d \right] \phi_{ij}^H,$$

subject to the demand function (2) above. As usual, the solution to this problem is characterized by a price that is a markup over marginal cost:

$$p_{ij}^H = \frac{\varepsilon_{ij}^H}{\varepsilon_{ij}^H - 1} v_{ij}.$$

Here ε_{ij}^H is the demand elasticity in the home market, which satisfies:

$$\varepsilon_{ij}^H = \left(\omega_{ij}^H \frac{1}{\theta} + \left(1 - \omega_{ij}^H \right) \frac{1}{\gamma} \right)^{-1}, \tag{9}$$

where ω_{ij}^H is the market share of producer i in industry j in the home market:

$$\omega_{ij}^H = \frac{p_{ij}^H y_{ij}^H}{\sum_{i=1}^N p_{ij}^H y_{ij}^H + (1+\tau)\sum_{i=1}^N p_{ij}^F y_{ij}^F} = \frac{1}{N}\left(\frac{p_{ij}^H}{p_j}\right)^{1-\gamma}, \tag{10}$$

with $\sum_{i=1}^N \omega_{ij}^H = 1$ for each industry j.[8]

Market shares and demand elasticity. As in Devereux and Lee (2001) and Atkeson and Burstein (2008), the demand elasticity is endogenous and given by a weighted harmonic average of the between-industry elasticity θ and the within-industry elasticity $\gamma > \theta$. Firms with a large share of an industry's revenue face an endogenously lower demand elasticity and charge high markups. These firms compete more with producers in other industries and so face a demand elasticity closer to θ than they compete with other smaller producers in their own industry. Quantitatively, the extent of markup dispersion across firms depends both on the (endogenous) dispersion in market shares within industries and on the size of the *gap* between γ and θ. If γ and θ are the same, then the demand elasticity will also equal that common constant irrespective of the dispersion in market shares. Alternatively, if γ is substantially larger than θ, then the demand elasticity is very convex and a modest change in market shares can have a large effect on demand elasticity.

Market shares and labor shares. The model implies a simple negative relationship between a firm's market share and it's labor share. To see this, observe from (7), that profit maximization by firms implies that marginal cost can be written:

$$v_{ij} = \frac{W l_{ij}^H}{(1-\alpha) y_{ij}^H}.$$

Given this, a firm's revenue productivity is proportional to its markup:

$$\frac{p_{ij}^H y_{ij}^H}{W l_{ij}^H} = \frac{1}{1-\alpha}\frac{\varepsilon_{ij}^H}{\varepsilon_{ij}^H - 1}. \tag{11}$$

Using (9) to substitute out the demand elasticity ε_{ij}^H in terms of the market share ω_{ij}^H, we

[8]To simplify formulas such as equation (10) we adopt the convention that $p_{ij}^H = y_{ij}^H = 0$ for any producer that does not operate (i.e., those with $\phi_{ij}^H = 0$) whenever there is no possibility of confusion.

find that the model implies a *linear* relationship[9] between market shares and labor shares:

$$\frac{Wl_{ij}^{H}}{p_{ij}^{H}y_{ij}^{H}} = (1-\alpha)\left(1-\frac{1}{\gamma}\right) - (1-\alpha)\left(\frac{1}{\theta}-\frac{1}{\gamma}\right)\omega_{ij}^{H}. \tag{12}$$

Since $\gamma \geq \theta$, the coefficient on market share ω_{ij}^{H} is negative. As discussed in Section 4 below, since we observe both market shares and labor shares in our microdata, this negative relationship plays a crucial role in our identification of the key elasticity parameters.

Foreign market and tariffs. A home firm's problem in the foreign market is essentially identical except that (i) to export, they pay a fixed cost F_f rather than F_d, and (ii) the sales of their good in the foreign market are subject to an *ad valorem* tariff $\xi \in [0,1]$ (which for simplicity we take to be the same for all goods). Their problem can be written:

$$\pi_{ij}^{*H} = \max_{y_{ij}^{*H},\phi_{ij}^{*H}} \left[\left((1-\xi)p_{ij}^{*H} - v_{ij}\right)y_{ij}^{*H} - WF_f\right]\phi_{ij}^{*H}$$

subject to the demand function for their good in the foreign market, analogous to (2) above. We assume that the revenue from tariffs is redistributed lump-sum to consumers in the importing country.

Prices in the foreign market are then given by:

$$p_{ij}^{*H} = \frac{1}{1-\xi}\frac{\varepsilon_{ij}^{*H}}{\varepsilon_{ij}^{*H}-1}v_{ij},$$

where ε_{ij}^{*H} is the demand elasticity in the foreign market:

$$\varepsilon_{ij}^{*H} = \left(\omega_{ij}^{*H}\frac{1}{\theta} + \left(1-\omega_{ij}^{*H}\right)\frac{1}{\gamma}\right)^{-1}, \tag{13}$$

and where ω_{ij}^{*H} is the market share of producer i in industry j in the foreign market:

$$\omega_{ij}^{*H} = \frac{(1+\tau)p_{ij}^{*H}y_{ij}^{*H}}{\sum_{i=1}^{N}p_{ij}^{*F}y_{ij}^{*F} + (1+\tau)\sum_{i=1}^{N}p_{ij}^{*H}y_{ij}^{*H}}. \tag{14}$$

[9] The linear decreasing relationship between market shares and labor shares is driven by our assumption of Cournot competition. As discussed in Section 6 below, with Bertrand competition, the relationship is decreasing but strictly concave.

Entry and exit. Each period a firm must pay a fixed cost F_d to sell in its home market. The firm sells in the home market as long as:

$$(p_{ij}^H - v_{ij})y_{ij}^H \geq WF_d.$$

Similarly, the firm must pay another fixed cost F_f to operate in its foreign market. The firm exports as long as:

$$((1-\xi)p_{ij}^{*H} - v_{ij})y_{ij}^{*H} \geq WF_f.$$

There are multiple equilibria in any given industry. Different combinations of intermediate firms may choose to operate, given that the others do not. As in Atkeson and Burstein (2008), we place intermediate firms in the order of their productivity a_{ij} and focus on equilibria in which firms sequentially decide on whether to operate or not: the most productive decides first (given no other firm enters), the second most productive decides second (given that no other less productive firm enters), etc.

2.3 Equilibrium

In equilibrium, consumers and firms optimize and the markets for labor and physical capital clear:

$$\begin{aligned} L_t &= \int_0^1 \frac{1}{N} \sum_{i=1}^{N} \left[\left(l_{ij,t}^H + F_d \right) \phi_{ij,t}^H + \left(l_{ij,t}^{*H} + F_f \right) \phi_{ij,t}^{*H} \right] \, dj \\ K_{t-1} &= \int_0^1 \frac{1}{N} \sum_{i=1}^{N} \left[k_{ij,t}^H \phi_{ij,t}^H + k_{ij,t}^{*H} \phi_{ij,t}^{*H} \right] \, dj, \end{aligned}$$

(here we present the Home market clearing conditions, the Foreign conditions are identical). The market clearing condition for the final good in each country is:

$$Y_t = C_t + X_t.$$

Recall that we assume initial capital stocks for each country, so that due to symmetry and the lack of aggregate uncertainty, trade is balanced in each period.

2.4 Aggregation

This model aggregates to a two-country representative agent economy which is standard except that TFP, the aggregate markup, and the Armington elasticity are all endogenous.

Each of these key variables is determined by underlying productivity differences a_{ij}, the elasticity of substitution parameters θ and γ, as well as the trade cost and tariff parameters τ, ξ that govern the amount of trade.

Aggregate productivity. The quantity of final output in each economy can be written:

$$Y = AK^{\alpha}\tilde{L}^{1-\alpha},$$

where A is the endogenous level of TFP, K is the aggregate stock of physical capital and $\tilde{L}$ is the aggregate amount of labor used *net of fixed costs*. To obtain this, we begin with the market clearing conditions for capital:

$$K = \int_0^1 \frac{1}{N}\sum_{i=1}^{N} k_{ij}^{H}\, dj + \int_0^1 \frac{1}{N}\sum_{i=1}^{N} k_{ij}^{*H}\, dj,$$

and for labor net of fixed costs:

$$\tilde{L} = \int_0^1 \frac{1}{N}\sum_{i=1}^{N} l_{ij}^{H}\, dj + \int_0^1 \frac{1}{N}\sum_{i=1}^{N} l_{ij}^{*H}\, dj.$$

We can then use the firms' first order conditions (6)-(8) to write:

$$K = \alpha\frac{V}{R}\left(\int_0^1 \frac{1}{N}\sum_{i=1}^{N} \frac{1}{a_{ij}} y_{ij}^{H}\, dj + (1+\tau)\int_0^1 \frac{1}{N}\sum_{i=1}^{N} \frac{1}{a_{ij}} y_{ij}^{*H}\, dj\right), \tag{15}$$

and similarly for labor,

$$\tilde{L} = (1-\alpha)\frac{V}{W}\left(\int_0^1 \frac{1}{N}\sum_{i=1}^{N} \frac{1}{a_{ij}} y_{ij}^{H}\, dj + (1+\tau)\int_0^1 \frac{1}{N}\sum_{i=1}^{N} \frac{1}{a_{ij}} y_{ij}^{*H}\, dj\right). \tag{16}$$

Observe that because of the trade cost τ, a unit sold abroad requires proportionately more capital and labor input than a unit produced for the domestic market. Raising both sides of (15) to the power α and both sides of (16) to the power $1-\alpha$ and then using $V = \alpha^{-\alpha}(1-\alpha)^{-(1-\alpha)} R^{\alpha}W^{1-\alpha}$ from (8) allows us to write $Y = AK^{\alpha}\tilde{L}^{1-\alpha}$ where aggregate productivity A is:

$$A = \left(\int_0^1 \frac{1}{N}\sum_{i=1}^{N} \frac{1}{a_{ij}} \frac{y_{ij}^{H}}{Y}\, dj + (1+\tau)\int_0^1 \frac{1}{N}\sum_{i=1}^{N} \frac{1}{a_{ij}} \frac{y_{ij}^{*H}}{Y}\, dj\right)^{-1}. \tag{17}$$

That is, aggregate productivity is a *quantity-weighted* harmonic mean of firm-level productivity.

Aggregate markup. Define the aggregate (economy-wide) markup by:

$$M \equiv \frac{P}{V/A},$$

that is, aggregate price divided by aggregate marginal cost. From (16) we can write $W\tilde{L}/Y = (1-\alpha)V/(W/A)$, or equivalently:

$$\frac{W\tilde{L}}{PY} = (1-\alpha)\frac{1}{M}.$$

The aggregate labor share is reduced in proportion to the aggregate markup. Proceeding analogously to the derivation of (17) we obtain:

$$M = \left(\int_0^1 \frac{1}{N}\sum_{i=1}^{N}\frac{1}{m_{ij}^H}\frac{p_{ij}^H y_{ij}^H}{PY}\,dj + (1+\tau)\int_0^1 \frac{1}{N}\sum_{i=1}^{N}\frac{1-\xi}{m_{ij}^{*H}}\frac{p_{ij}^{*H}y_{ij}^{*H}}{PY}\,dj\right)^{-1}. \tag{18}$$

The aggregate markup is a *revenue-weighted* harmonic mean of firm-level markups. Observe that revenues from abroad are reduced in proportion to the tariff rate ξ.

Two source of distortions due to markups. The presence of market power provides two conceptually distinct channels by which equilibrium allocations are distorted relative to an efficient level. First, consider some particular level of the aggregate markup $M_t > 1$. The level of the aggregate markup distorts aggregate labor and investment decisions *for any fixed level of aggregate productivity* A_t. From the first order conditions for the consumers' problem and the expressions for labor and capital demand above, we have:

$$-\frac{U_{l,t}}{U_{c,t}} = \frac{W_t}{P_t} = \frac{1}{M_t}(1-\alpha)\frac{Y_t}{\tilde{L}_t},$$

and

$$U_{c,t} = \beta U_{c,t+1}\left(\frac{R_{t+1}}{P_{t+1}} + (1-\delta)\right) = \beta U_{c,t+1}\left(\frac{1}{M_{t+1}}\alpha\frac{Y_{t+1}}{K_{t+1}} + (1-\delta)\right).$$

High aggregate markups thus act like distortionary labor and capital income taxes and reduce output relative to its efficient level. Second, dispersion in markups endogenously reduces the level of aggregate TFP, as in the work of Restuccia and Rogerson (2008) and Hsieh and Klenow (2009). To understand this effect, consider the case where there is no markup dispersion so that all producer markups are equal to M. Then without markup dispersion, TFP is at its efficient level but output is too low relative to its efficient level because of the common aggregate markup M. Put differently, in this economy prices are too high relative to marginal cost and firms are producing too little. But *relative* producer prices are properly aligned (all equal to the reciprocal of relative productivities) and producers are operating at the proper relative scales of output. With markup dispersion, however, relative producer prices also become distorted so that aggregate TFP falls. Worse, since markups and productivity (output) are positively correlated, those firms with high productivity that should be employing a greater share of the economy's stock of capital and labor are exactly those that fail to do so.

Armington elasticity. The Armington elasticity is a key statistic governing the gains from trade in standard trade models. In those models, a high Armington elasticity, of the size inferred from micro trade data, implies small gains from trade since Home and Foreign goods are closely substitutable. We show below that with endogenously varying markups the gains from trade can be large *despite a high Armington elasticity.* Here we briefly describe how we compute the Armington elasticity in our model.

The Armington elasticity is defined as the *partial* elasticity of trade flows to changes in trade costs, and in particular,

$$1-\sigma = -\frac{\partial \log \frac{1-\lambda}{\lambda}}{\partial \tau},$$

where λ is the share of spending on domestically produced goods. In our model λ is:

$$\lambda = \frac{\int_0^1 \sum_{i=1}^N p_{ij}^H y_{ij}^H \, dj}{\int_0^1 \left(\sum_{i=1}^N p_{ij}^H y_{ij}^H + (1+\tau) \sum_{i=1}^N p_{ij}^F y_{ij}^F \right) dj} = \int_0^1 \lambda_j \left(\frac{p_j}{P} \right)^{1-\theta} dj = \int_0^1 \lambda_j s_j \, dj,$$

where the λ_j denotes the industry-level share of spending on domestically produced goods and where $s_j \equiv (p_j/P)^{1-\theta}$ is each industry's share in total spending.

Some algebra shows that the Armington elasticity is related to the two key underlying elasticity of substitution parameters γ and θ, according to the weighted average:

$$\sigma = \gamma \left(\int_0^1 s_j \frac{\lambda_j}{\lambda} \frac{1-\lambda_j}{1-\lambda} \, dj \right) + \theta \left(1 - \int_0^1 s_j \frac{\lambda_j}{\lambda} \frac{1-\lambda_j}{1-\lambda} \, dj \right). \tag{19}$$

To understand this expression, note that a reduction in trade costs in this model changes import shares through two channels: (i) by increasing the import shares in each industry j, an effect governed by the within-industry elasticity γ, and (ii) by reallocating expenditure towards industries with lower import shares, an effect governed by the between-industry elasticity θ. The weight on the within-industry elasticity γ is a measure of the dispersion in industry-level import shares. For example, if all industries have identical import shares $\lambda_j = \lambda$ for all j, then changes in trade costs imply no between-industry reallocation of resources and $\sigma = \gamma$. In this case, all the effects from a reduction in trade costs come through channel (i), i.e., through a uniform increase in import shares. At the other extreme, if some industries have import shares of $\lambda_j = 0$ while all others have import shares of $\lambda_j = 1$, then changes in trade costs imply that all reallocation is between industries and $\sigma = \theta$. In this case, all the effects from a reduction in trade costs come through channel (ii), i.e., by reallocation towards industries with low import shares. More generally, the Armington elasticity depends on the dispersion in import shares across industries.[10]

3 Data

The data we use is from the Taiwan Annual Manufacturing Survey conducted by the Ministry of Economic Affairs of Taiwan. The survey's purpose is to record the opening, relocation, and closing of manufacturing plants. It reports data for the universe of establishments which *engage in production activities*.[11] Our sample covers the years 2000 and 2002–2004. The year 2001 is missing because in that year a separate census was conducted.

3.1 Measurement

Product classification. The dataset we use has two parts. First, a plant-level part collects detailed information on operations, such as employment, expenditure on labor, materials and energy, and total revenue. Second, a product-level part collects further information on revenues for each of the products produced at a given plant. Each product is categorized into a 7-digit Standard Industrial Classification created by the Taiwanese Statistical Bureau. This classification at 7 digits is comparable to the detailed 5-digit SIC product definition collected for U.S. manufacturing plants as described by Bernard, Redding and Schott (2010). Panel A of Table 1 gives an example of this classification, while Panel B reports the distribution of 7-digit products and 4-digit industries within 2-digit sectors. Most of the products are concentrated in the Chemical Materials, Industrial Machinery, Computer/Electronics and Electrical Machinery industries.

[10]See Imbs and Méjean (2011) for a related model where an endogenous Armington elasticity is derived by aggregating over heterogeneous goods each with their own elasticity of substitution.

[11]The survey is however a sub-sample of the manufacturing census, because it excludes any plants which do not engage in production activities and only participate in sales.

Import shares. We supplement the survey with detailed import data at the HS6 product level. We obtain the import data from the WTO and then match HS6 codes with the 7-digit product codes used in the Annual Manufacturing Survey. This match gives us disaggregated import penetration ratios for each product category.

3.2 Key facts

Two key facts from the Taiwanese manufacturing data are crucial for our model's quantitative implications: (i) there is very strong concentration among producers, and (ii) there is a pronounced negative correlation between producer labor shares and market shares, i.e., large firms have low measured labor shares.

Strong concentration at product level. Panel A of Table 2 shows that the mean and median inverse Herfhindhals (among domestic producers) in an industry are 7.3 and 4.0. Recall that the inverse Herfhindhal would be equal to the number of producers in an industry if all those producers had equal market shares. The next few rows report the distribution of market shares across domestic producers. These statistics reflect sales by both domestic producers and imports. The average market share of a domestic producer is 2.9%, while the median producer has a share of slightly below 0.5%. The distribution of shares is heavily *fat-tailed*: the 95th percentile of this distribution is about 14% and the 99th percentile is about 46%. The pattern that emerges is thus one of very strong concentration. Although many producers operate in any given industry, most of them are small and a few large producers account for the bulk of an industry's revenue.

Labor share negatively correlated with market share. We measure the labor share of producer i as $w_i l_i / p_i y_i$ where $w_i l_i$ is the producer's wage bill and $p_i y_i$ their revenue. (Here and below we suppress industry-level subscripts and country-level subscripts whenever there is no possibility of confusion).

The *average* labor share in the Taiwanese data is 0.61. However, the *aggregate* labor share

$$\frac{WL}{PY} = \sum_i \frac{w_i l_i}{p_i y_i} \frac{p_i y_i}{\sum_{i'} p_{i'} y_{i'}},$$

is much lower, only 0.43. This pronounced difference between the average and aggregate labor share emerges because, just as in the model, firms in the data that have high market shares are also firms with low labor shares.

Is this correlation due to differences in capital intensities? One concern with this interpretation is that differences in labor shares might really be due to firm-level differences in capital intensity rather than markups. To examine this, we suppose that firms have the technology $y_i = a_i k_i^{\alpha_i} l_i^{1-\alpha_i}$ and back out capital intensities α_i from the firms' profit maximization condition:

$$\frac{\alpha_i}{1-\alpha_i} = \frac{Rk_i}{w_i l_i}$$

where Rk_i is the producer's expenditure on capital costs. We choose $R = 0.17$ so that the mean α_i is 0.33. We can then calculate the weighted and unweighted mean of

$$\frac{1}{1-\alpha_i}\frac{w_i l_i}{p_i y_i}$$

which corresponds to the inverse markup. We find that the aggregate markup is 40% larger than the average markup. Thus differences in capital intensities do not account for the relationship between labor shares and market shares. Underlying this result is that in our data the correlation between capital/labor ratios and firm size is *negative*, so it is simply not the case that large firms in our data are more capital intensive.

4 Quantifying the model

We use the Taiwanese data to pin down the key parameters of our model and then quantify the welfare gains from international trade.

Calibration strategy. In the model, three key factors determine the size of the gains from trade: (i) the equilibrium distribution of firm-level market shares, (ii) the size of the gap between γ and θ, which governs the impact that the distribution of market shares has on markups, and (iii) the equilibrium magnitude of the Armington elasticity. We discipline our model along these dimensions as follows. We pin down the parameters governing the distribution of firm-level market shares — namely, the distribution of firm-level productivity and the size of the fixed costs — by requiring the model to match the distribution of market shares and industry concentration statistics in our data. We similarly choose the elasticity of substitution between industries, θ, so that our model reproduces the negative correlation between labor shares and market shares we observe in the Taiwanese data. Finally, we choose the elasticity of substitution within industries, γ, so that our model reproduces standard estimates of the Armington elasticity used in the trade literature. All other parameters are assigned values consistent with those used in existing work.

4.1 Assigned parameters

We assume a utility function:

$$U(C, L) = \log C + \psi \log (1 - L) .$$

We choose a value for ψ to ensure $L = 0.3$ in the steady-state, implying a Frisch elasticity of labor supply equal to 2.33, in line with the findings of Rogerson and Wallenius (2009).

The period length is one year. We assume a time discount factor of $\beta = 0.96$ and a capital depreciation rate of $\delta = 0.10$. The elasticity of output with respect to physical capital is $\alpha = 1/3$. Because of the markups, this does not correspond to capital's share in aggregate income. We set the tariff rate ξ to 6.4%, which is the OECD estimate for Taiwanese manufacturing.

4.2 Calibrated parameters

Productivity distribution and fixed costs. The amount of market concentration in the model is determined by the parameters of the productivity distribution as well as the fixed costs of selling in the domestic and foreign markets, F_d and F_f, and the number of potential producers within an industry, N. We assume that productivity a is distributed according to:

$$a \sim \begin{cases} \frac{1-a^{-\mu}}{1-H^{-\mu}} & \text{with prob. } 1 - p_H \\ = H & \text{with prob. } p_H \end{cases} . \tag{20}$$

That is, a fraction $(1 - p_H)$ of firms draw a from a *bounded Pareto* on $[1, H)$ with shape parameter μ and the remaining p_H firms have productivity exactly H. We found that imposing a mass-point at the upper bound is critical in allowing the model to match the high concentration in market shares in the data. We choose the parameters (μ, H, p_H, N, F_d) to match various concentration statistics, detailed below, and choose F_f to match the fraction of Taiwanese producers that export.

Estimating θ. We use the pronounced negative correlation between market shares and labor shares in the data to estimate the elasticity of substitution θ between industries. Our implementation of this begins with the decreasing linear relationship between market shares and labor shares implied by the model, equation (12). In that expression, the measure of labor share is for variable labor costs. Our empirical measures of labor share include fixed labor costs, in which case (12) generalizes to:

$$\frac{w_i l_i}{p_i y_i} = (1-\alpha)\left(1-\frac{1}{\gamma}\right) - (1-\alpha)\left(\frac{1}{\theta}-\frac{1}{\gamma}\right)\omega_i + \frac{F}{p_i y_i}, \tag{21}$$

where $w_i l_i$ is the wage bill for producer i, $p_i y_i$ their revenue and F a (common) fixed cost. Then given a value for the within-industry elasticity γ, the intercept in a regression of labor shares $Wl_i/p_i y_i$ on market shares ω_i and inverse revenue $1/p_i y_i$ determines α and with this in hand the slope coefficient then determines θ.

To make full use of our data, we also generalize (21) to cover (i) multi-product firms, (ii) to include exporters who have potentially different market shares at home and abroad, and (iii) variable capital shares.[12] Including multi-product firms is fairly straightforward. For these firms, equation (21) holds for each firm-product pair and we can aggregate up to get a version of (21) that holds between a multi-product firm and an appropriately weighted-average of product-level market shares. Although we do not observe exporting firms' market shares in their export markets, we are able to recover a version of equation (21) for these firms if we assume their home and export market shares are correlated. This leads to a similar generalization as for multi-product firms but where the weighted average of market shares now also covers home and export markets and depends on the extent to which the two market shares are correlated.

Armington elasticity and trade costs. We choose the elasticity of substitution within an industry γ to ensure that the model reproduces an Armington elasticity of $1-\sigma=-8$, a typical number used in trade studies.[13] We choose the size of the iceberg trade cost τ so that the model reproduces the Taiwanese manufacturing import share of 26%.

Calibration results. Panel A of Table 2 reports the moments we use to pin down our parameter values, both in the data and in the model. Panel B reports the parameter values that achieve this fit. Our model successfully reproduces the amount of concentration in the data. The largest 7-digit producer accounts for an average of 40-45% of that product's domestic sales (40-50% in the model). Including importers, the model reproduces well the heavy concentration in the tails of the distribution, with the 95th percentile share about 14% in data and model and similarly the 99th percentile share about 46% in both.

In the data 25% of producers export. To match this, the model requires an export fixed cost F_f equal to 3.6% of steady state labor. The fixed cost to operate domestically F_d is

[12] Full details of each of these cases available on request.

[13] See, for example, Anderson and van Wincoop (2004), Broda and Weinstein (2006) or Feenstra, Obstfeld and Russ (2010).

2.3% of steady state labor. Since the fixed costs are a smaller share of the wage bill for larger producers, the relationship between labor productivity (inclusive of fixed costs) and firm size pins down the size of the fixed costs.

To reproduce an Armington elasticity of 8, we have the within-industry elasticity of substitution $\gamma = 8.5$. To reproduce an import share of 26%, we have a trade cost of $\tau = 0.22$. These estimates are obtained for a between-industry elasticity of substitution $\theta = 1.25$. This contrasts with Atkeson and Burstein (2008) who assume $\theta = 1.01$ (so that industry level expenditure shares are almost constant). It is significantly lower than the $\theta = 3.79$ used in Bernard et al. (2003), but it should be remembered that they assume $\gamma = \infty$ and so have, like us, a large gap between the within- and between-industry elasticities — and for many purposes, it is the magnitude of this gap that is most important for determining the effects of increased competition on markups.

To justify our choice of $\theta = 1.25$ number, Panel A of Table 3 reports the implied estimate of θ using single and multi-product firms and standard errors computed using the delta method. These calculation use the assigned capital intensity $\alpha = 1/3$ and the within-industry elasticity $\gamma = 8.25$. We find an estimate of 1.38 using all observations and a slightly lower 1.23 if we restrict observations to only those with market shares $\omega_i \leq 0.90$. There are not many firms with such large market shares, but since most firms in the sample are small, these large firms have a substantial impact on the estimate. We also control for outliers by reporting quantile regressions for the median. This gives estimates of θ of 1.35 or 1.2 with slightly higher standard errors. In Panel B of Table 3 we make use of our generalization of equation (21) to cover exporters. This adds a substantial number of observations. We find in general slightly lower estimates of θ, but the results do not change substantially.

Finally, in Panel C of Table 3, we compute measures of "labor and capital" shares and regress these on market shares. This captures the concern that firm-level differences in capital intensity bias our estimates of θ. We find that our estimates for θ drop a little, to 1.28 or 1.13, but the basic picture of a low elasticity of substitution between industries remains. The modest variation here is due to the fact that labor shares and "labor and capital" shares are quite positively correlated, about 0.84. Overall, we find that a robust estimate of θ is a number close to 1.25. In our robustness experiments below, we report results for $\theta = 3$ which is closer to the $\theta = 3.79$ used in BEJK but much larger than any θ estimated from our micro-data.

Additional implications. Table 4 reports several additional micro implications of the model. We note that the model implies a mean markup of 1.17, a median markup of 1.14 and a rather small standard deviation of markups across producers, of 0.11. But, as is clear from equation (18), what really matters for the model's aggregate implications are the *revenue-weighted* markups and markup dispersion. And indeed, the large producers in the model do have very high markups: the 95th percentile markup is 1.27, while the 99th percentile is 1.76.

5 Welfare gains from trade

We proceed first by discussing the efficiency losses due to markups in our economy. We then study how trade subsidies or tariffs affect the extent of these losses and compute the welfare gains from international trade.

5.1 Efficiency losses in the benchmark model

We quantify the efficiency losses from markups in our benchmark economy calibrated to the Taiwanese manufacturing data. To do so, we use the following policy experiment. We subsidize/tax each producer in the economy in order to induce them to charge the same markup. We assume that such subsidies are financed via lump-sum taxes levied on consumers and hence can fully restore efficiency.

Let $\bar{m}$ be the markup that this policy is designed to implement. We choose producer-specific subsidies/taxes, τ_{ij}, to ensure that each producer charges a markup equal to $\bar{m}$. That is, we choose τ_{ij} to ensure that the solution to the producer's problem,

$$\max_{y_{ij}} \left[\left(\left(1+\tau_{ij} \right) p_{ij} - v_{ij} \right) y_{ij} \right],$$

subject to the demand function (2), implies a choice of prices equal to:

$$p_{ij} = \bar{m} v_{ij}.$$

That is, we choose:

$$\tau_{ij} = \frac{\varepsilon_{ij}}{\varepsilon_{ij}-1} \frac{1}{\bar{m}} - 1,$$

where the demand elasticity ε_{ij} satisfies the formula given in equation (9) above but is now determined by the market shares ω_{ij} under the new policy.

We consider two experiments that are reported in Table 5. In the first, labeled first-best, we set $\bar{m} = 1$ and so eliminate both the dispersion and the level of markups. In the second experiment, we set $\bar{m} = 1.47$, thus eliminating all the markup dispersion but keeping the aggregate markup unchanged from its benchmark value. In all our experiments we compute statistics inclusive of the *transition path* from the initial steady state to the final steady state. The welfare numbers including the transition path are smaller than would be obtained from a static comparison across steady states. There are two reasons for this. Along the transition path consumers both forgo consumption to invest in physical capital and, in addition, employment temporarily overshoots its new steady state level.

Losses relative to first-best. That said, Panel A of Table 5 shows that the efficiency losses due to markups are large. Taking the benchmark economy to the first best by eliminating markups altogether leads to welfare gains equivalent to a permanent 17% increase in consumption. This increase in welfare is due to a 5% increase in TFP and due to the fact that employment increases by 31%, leading to a 57% increase in output.

Losses from markup dispersion. The last column of Panel A of Table 5 shows that eliminating markup dispersion alone would generate significant welfare gains (equivalent to a 6.5% permanent increase in consumption) due to the 5% increase in TFP. Observe that because of our assumption of log utility, with its offsetting income and substitution effects, the 5% increase in TFP here leads to no change in employment. The additional welfare gains from eliminating markups altogether come from eliminating the implied distortions in labor and investment decisions relative to the first best.

5.2 Efficiency losses in autarky

How does international trade affect the efficiency losses from markups and misallocation? To see this, consider a perturbation of our model in which we increase the import tariff ξ to levels that make trade prohibitively expensive in both countries and thus reduce the import share from 26% in the benchmark model to zero.

Panel B of Table 5 shows that, absent trade, domestic firms would charge somewhat greater markups: the aggregate markup would increase from 1.47 to 1.69. Moreover, the dispersion in markups would greatly increase as well. Eliminating markups altogether would lead to welfare gains of about 49%. Again, eliminating markup dispersion alone would generate significant welfare gains (32%) due to the 23% increase in TFP that results from reallocating factors of production efficiently across producers.

Trade in this model is a powerful mechanism that reduces the extent of misallocation of factors of production and distortions to investment and employment decisions. Opening to international trade is a simple way for an economy to reap the majority of the gains from an improved allocation of factors. In this sense, merely opening an economy to trade provides an excellent substitute for the complicated scheme of product-specific subsidies τ_{ij} that, for

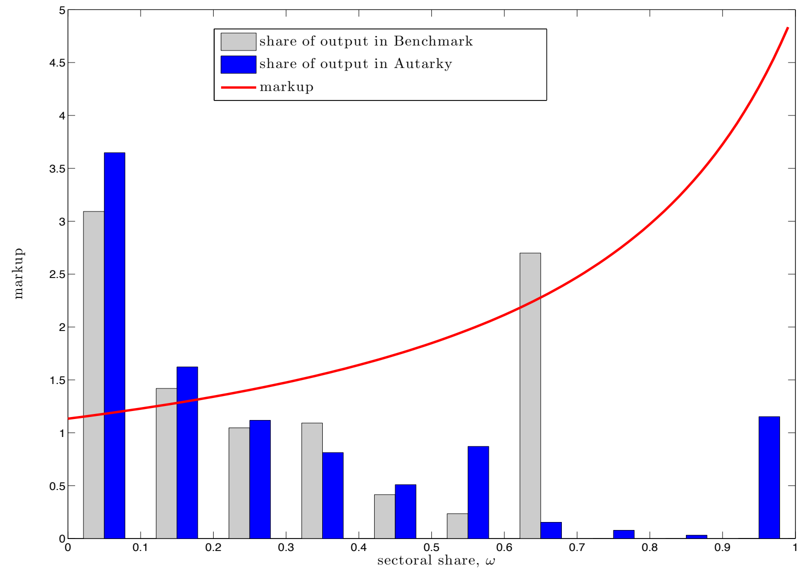

Figure 1: Convex relationship between markups and market shares.

International trade exposes high market share firms to more competition, reducing their market share and markups. The movement out of the tail of the distribution implies that both the level and dispersion in markups fall, with both effects leading to significant welfare gains.

a host of technical, administrative and political economy reasons, would surely be difficult to implement in practice. Moving from autarky to the level of trade observed in Taiwan (the benchmark economy) reduces the TFP losses from misallocation by more than three-quarters, from 23% to 5%.

The mechanism through which trade increases efficiency and lowers markups is straightforward, and can be seen in the expressions for the demand elasticity and market shares in (9) and (10). An increase in import shares lowers the market shares of individual producers and therefore raises their demand elasticity (i.e., there is more competition within an industry) and reduces markups. For our benchmark parameters, the relationship between markups and market shares is highly convex, as shown in Figure 1, so even small increases in import shares, generate a decrease in the market shares of the largest producers and therefore substantially lower their markups, thus increasing TFP as more resources are allocated to the highest-productivity producers.

Figure 1 also illustrates this insight, showing how the distribution of shares changes as we move from autarky to free trade (we report the share of output accounted for by firms with shares between 0 and 0.1, 0.1 and 0.2, etc). Under autarky, the distribution of output is very distorted. About 10% of the output is accounted for by producers that have a market share greater than 90% and hence are effectively monopolists in their industry. Reducing tariffs exposes these firms to more competition and lowers their market shares to about 60% forcing them to halve their markups.

5.3 Trade policy: the importance of micro detail

We next explore the welfare gains from trade in more detail, and show how allocations and efficiency change as we change the tariffs levied on importers from complete autarky to subsidies on imports that increase the import share to 50% (the largest import shares can be in this symmetric two country world). To illustrate how the gains from trade depend on the micro details in the data, we also compute similar statistics for a *standard trade model* with $\theta = \gamma = \sigma$ and hence no markup dispersion irrespective of the amount of productivity or market share dispersion.

Lowering tariffs. Figure 2 shows the relationship between import shares and the welfare gains from trade as we vary the subsidies/tariffs on importers (recall that these are assumed to be symmetric in both countries). The welfare gains from trade increase to more than 35% as the import share increases from autarky to 0.50. By contrast, in a standard trade model, the gains from trade are much smaller. Moving from autarky to free trade leads to welfare gains of only about 5%. In the standard trade model, markups are little affected by trade policies since there is little concentration even in autarky. But in our model markups decline by about 25% as the import share increases from autarky to 0.50. The greater welfare gains from trade in our model, relative to a standard model are not driven by endogenously generating a substantially lower Armington elasticity. The lower-right panel of Figure 2 shows that the Armington elasticity in our model varies from 8.5 to 7.4 as we vary the import share from zero to 40% and is thus not substantially different from that in the standard trade model (which is constant at 8.1).

Marginal gains from trade. Our model predicts a nonlinear relationship between openness and welfare (or TFP). Near autarky, the marginal gain from trade is huge. This is driven by the very convex relationship between markups and market shares in the model. Even a small increase in the amount of competition faced by domestic firms is enough to reduce their markups significantly. Panel A Table 6 reports that moving from autarky to a 0.10 import share gives a welfare gain of 27% in the benchmark economy as opposed to 4% in the standard trade model. But there are diminishing marginal gains from trade. At higher import shares, the same increase in openness leads to smaller gains. Moving from an import share of about 0.20 (similar to that of benchmark economy) to 0.30 produces a gain of 3% in the benchmark economy. While this is smaller than the marginal gain obtained on first

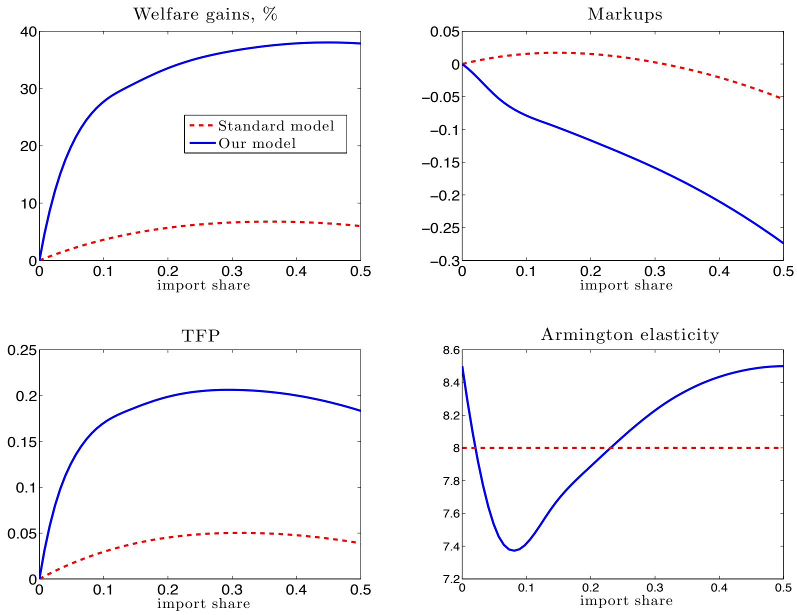

Figure 2: Effect of lowering tariffs.

The marginal gains from trade are highest when opening an economy from autarky. Even when the economy is already substantially open, as in our benchmark economy, the marginal gains from trade with variable markups are still about three times as large as those in the standard trade model with no markup dispersion.

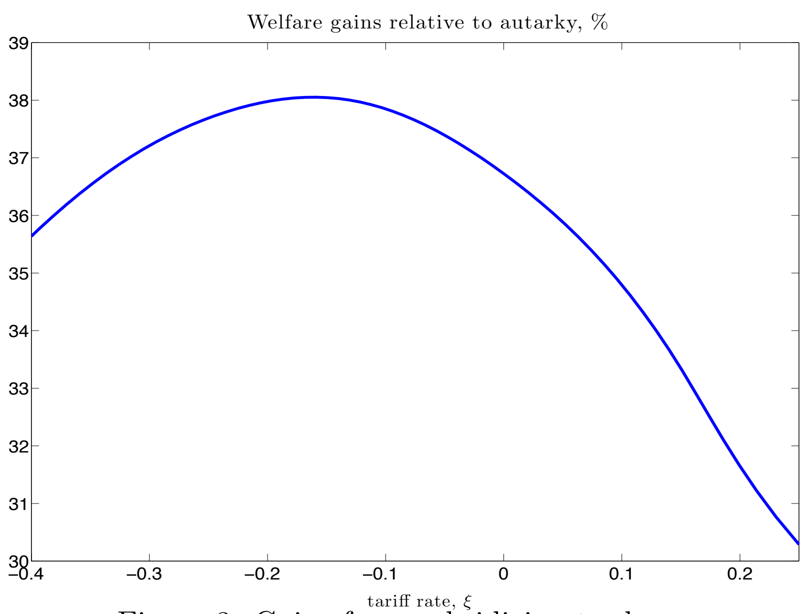

Figure 3: Gains from subsidizing trade.

Welfare gains relative to autarky for various tariff rates ξ holding other parameters fixed at their benchmark values. The welfare gains are maximized with about a 15% subsidy for imported goods.

opening an autarkic economy to trade, it is still significantly larger than the 1% marginal gain for the standard model in the same region (Panel B of Table 6). Thus, it would be wrong to conclude that our model produces very large gains from trade only on initially opening an economy from autarky. Our benchmark model produces gains from trade more than double that of a standard model even when, say, increasing the import share from 0.20 to 0.30.

Gains from subsidizing trade. The pro-competitive effects of trade in our model are sufficiently strong that a policy of *subsidizing* trade can increase welfare. As in Brander and Krugman (1983), there is a tension between the gains from subsidizing trade and the losses from inefficient "cross-hauling" that incurs the iceberg trade cost. Brander and Krugman provide qualitative results showing that either effect can dominate, depending on the magnitude of the trade cost. For our benchmark model we find that the pro-competitive effect dominates so that it is indeed welfare-increasing to subsidize trade. Figure 3 shows the welfare gains from trade relative to autarky as we vary the uniform tariff rate ξ holding other parameters fixed at their benchmark values. Starting from our benchmark value of $\xi = 0.064$ the gains from trade increase as we reduce tariffs, they continue to increase even after ξ becomes negative, reaching a maximum at about $\xi = -0.15$, i.e., a 15% subsidy for imported goods. The welfare gains then begin to fall again for more negative value of ξ as the trade cost losses begin to dominate the effect of enhanced competition.[14]

Changes in trade costs. In an important recent paper, Arkolakis, Costinot and Rodríguez-Clare (2011) have shown that, in a large class of models of international trade, the welfare gains of changes in trade costs that lead to a change in the share of spending on domestic goods equal to $\Delta \ln \lambda$ are given by:

$$\Delta \ln \mathrm{TFP} = \frac{1}{1-\sigma} \Delta \ln \lambda \tag{22}$$

Although the class of models they study does not nest our economy with the pro-competitive effect on markups, we find it instructive to evaluate how TFP and welfare change in our model economy in response to changes in trade costs. This calculation allows us to isolate the role of TFP gains due to standard *love-of-variety* effects (as captured by the above formula) from those induced by a trade-induced decline in misallocation.

Table 7 shows how welfare and TFP change in our benchmark model as well as in a standard trade model with no markup dispersion (i.e., $\theta = \gamma = \sigma$) as we vary the trade

[14] Roughly speaking, in our model the trade distortions ξ have a second-order effect on TFP but a first-order effect on markups. The latter effect dominates so it is optimal to provide some subsidy to trade (so long as the extent of the subsidy is not too large).

cost to achieve different import shares. Since Arkolakis et al. (2011) abstract from capital accumulation and assume inelastic labor supply, their welfare calculations apply to the level of TFP. We therefore also report how TFP varies with changes in trade costs in the class of standard trade models they consider.

Once again our model predicts substantial gains from trade. Raising the import share from zero ($\tau = \infty$) to 0.10 raises welfare by 24% in our model, compared to about 2.7% in the standard trade model. Such a change in import shares raises TFP by about 13% in our model and by about 2% in the standard trade model. Note that a 2% gain for this reduction in trade costs is slightly larger than the gain from the Arkolakis et al. formula, equation (22), which gives a gain of 1.48%. This slight difference arises because, in addition to trade costs, the standard model we use also has tariffs which give rise to distortions (i.e., markups) that depend on how much is traded. This is also why in Figure 2 the aggregate markup is initially increasing in import shares for the standard model.

6 Robustness

We now consider several variations on our model, each designed to examine the sensitivity of our results to parameter choices or other assumptions.

6.1 5-digit industries

Are our results driven by the focus on 7-digit industries? To examine this, we keep the key parameters θ and γ unchanged at their benchmark values $\theta = 1.25$ and $\gamma = 8.5$ and recalibrate all other parameters to 5-digit data. These parameters and the moments they are used to match are reported in Table 8. Of course at this higher level of aggregation there is less concentration in market shares than there is at the 7-digit level, but the concentration in the tails of the distribution is still pronounced, the 99th percentile of the distribution still has a market share of 17%.

Table 9 reports our key results for 5-digit industries. We find that increasing the level of aggregation to 5-digits makes almost no difference for the model's predictions. Going from autarky to an import share of 0.10 gives a gain of 27% in the benchmark 7-digit economy and a slightly higher gain of 28% in the 5-digit economy. In either case, the gains from trade are much larger than the 4% in a standard trade mode.

6.2 Small gap between γ and θ

If the gap between the within-industry elasticity of substitution γ and the between industry elasticity θ is reduced, then any trade-induced variation in market shares has a smaller effect on markups and the gains from trade in our model will tend to be smaller. Table 10 bears this out, showing that if we increase θ from its benchmark value of 1.25 to 3, then a tariff reduction that raises the import share from zero to 0.10 raises welfare by 8% rather than the 27% in our benchmark. Moreover, while the level of the gains from trade is reduced, the relative size of the gains compared to a standard trade model also fall. For an increase in the import share from 0.10 to 0.20 or from 0.20 to 0.30, the gains in our model are larger than in a standard model but only barely. Thus, in this setting, more of the difference in the gains from trade comes from the effect of initially opening an economy from autarky.

Given that our quantitative results are somewhat sensitive to θ, it is worth considering how plausible $\theta = 3$ is for our data. A value of $\theta = 3$ is twice as large as any of the values we estimated (see Table 3), let alone the value of $\theta = 1.01$ used in Atkeson and Burstein (2008). It is close to the $\theta = 3.79$ used in Bernard et al. (2003), but they effectively have $\gamma = \infty$ and so retain a large gap between the within- and between-industry elasticities rather than the narrower gap that is being considered in this experiment.

6.3 Bertrand competition

In our benchmark model we assume that firms compete in Cournot fashion, i.e., choosing quantities. If we instead assume that firms compete in Bertrand competition, choosing prices, then the model changes in only one respect. The demand elasticity facing producer i in industry j is no longer a weighted harmonic average of θ and γ, as in equation (9), but is now just a simple average:

$$\varepsilon_{ij} = \omega_{ij}\theta + (1 - \omega_{ij})\,\gamma. \tag{23}$$

Qualitatively, the intuition for this demand elasticity is the same as in the Cournot case. If a producer is a near-monopolist in its own industry, then the relevant competition is from firms in other industries so the demand elasticity is the lower value θ. But if a producer has very little market share its own industry, the elasticity is the higher value γ.

To examine the quantitative implications of Bertrand competition in our model, we keep the elasticities $\theta = 1.25$ and $\gamma = 8.5$ as in the benchmark but recalibrate the other model parameters to match the same moments as before. Table 10 shows that when we do this, the gains from trade increase slightly relative to the Cournot benchmark. In particular, going from autarky to an import share of 0.10 gives a gain of 34% with Bertrand competition as against 27% with Cournot. The marginal gains from trade diminish a little more rapidly with Bertrand competition, going from an import share of 0.10 to 0.20 gives an additional gain of 2.9% with Bertrand instead of the 6.2% with Cournot. However, as with the high θ case, with Bertrand competition the relative size of the gains compared to a standard trade model also fall. For an increase in the import share from 0.10 to 0.20 or from 0.20 to 0.30, the gains in our model are larger than in a standard model but not by much.

Bertrand vs. Cournot. The Cournot and Bertrand specifications have broadly similar aggregate productivity and overall welfare implications. We chose the Cournot specification for the benchmark case because it allows us to better match the micro data on labor shares and market shares. As in equation (12), the Cournot case implies a linear decreasing relationship between labor shares and market shares. Bertrand competition implies a decreasing but strictly concave relationship. If anything, the data gives a slightly *convex* relationship which the linear Cournot case is better able to match.

6.4 Uncorrelated productivity

In our benchmark model, firm-level productivity draws at home a_{ij} and abroad a_{ij}^* are perfectly correlated. Thus, if under autarky a given industry contains a large, dominant firm that charges a high markup and produces relatively too little, opening up to trade confronts that firm with a similarly productive firm that can compete effectively (though hampered by trade costs and any remaining tariff barriers). If, however, that large domestic firm was not systematically likely to face competition from a similarly productive firm, then the pro-competitive effects of trade will be diminished. To assess the quantitative significance of our assumption that productivity is perfectly correlated, we solve our model assuming a_{ij} and a_{ij}^* are uncorrelated draws from (20). We choose uncorrelated draws rather than some degree of partial correlation so as to make the comparison as stark as possible.

Similar overall gains from trade. For this exercise, we again keep $\theta = 1.25$ and $\gamma = 8.5$ but recalibrate the other model parameters to match the same moments as before. The results are shown in Table 10. With uncorrelated productivity, moving from autarky to a 0.10 import share leads to a gain of 14% as opposed to 27% in the benchmark model with correlated productivity. This is still considerably larger than in the standard trade model where the gain is about 9% when productivity is uncorrelated. However, with uncorrelated productivity, the diminishing marginal gains from trade does not set in so quickly. Indeed, going from a 0.10 to 0.20 import share gives an additional gain of 19% as opposed to an additional gain of 6% in the benchmark. Adding these up, going from autarky to a 0.20

import share gives a gain of 33.5% in the benchmark model with correlated productivity and an almost identical 33.3% with uncorrelated productivity.

Different composition of gains from trade. Why are the overall gains from trade so similar despite the lack of correlation? The short answer is that the composition of the gains from trade changes greatly; with uncorrelated productivity the aggregate markup is essentially unchanged, but the gains from the standard love-of-variety channel are now much larger. The love-of-variety effect is larger because, endogenously, *the Armington elasticity falls substantially* as the economy becomes open to trade. The uncorrelated productivity translates to greater industry-level dispersion in import shares, which, via equation (19), reduces the Armington elasticity. In this exercise, increasing the import share from autarky to 0.20 reduces the Armington elasticity from 8.5 to 2.8. This implies larger misallocation losses in autarky and hence larger gains from trade. Indeed, even a standard trade model would produce fairly substantial gains from trade if given an Armington elasticity as low as 2.8. This increase in the gains from love-of-variety completely offsets the decreased gains from the pro-competitive effect.

Why correlated productivity matters. In essence, having perfectly correlated productivity is akin to *assuming* that more trade brings more competition (though the significance of that extra competition is a quantitative question). We view the assumption of correlated productivity draws as being reasonable for a small economy like Taiwan; it is presumably less reasonable for a country like the U.S. with a large domestic market and many producers that will not face more productive rivals even if trade barriers are lowered.

However, since all heterogeneity in goods in this model is captured by productivity differences (e.g., there are no product- or industry-level differences in consumer expenditure shares), even for large countries like the U.S. it would be perhaps more realistic to have some partial correlation across products to capture these attributes.

Again, micro details matter. This exercise highlights that, when calculating the welfare gains from trade in our model, it is important to properly account for the micro details even when the competitive effects of trade turn out to be weak. Although the model with uncorrelated productivity results in lower gains from the pro-competitive effect, in order to correctly calculate these gains it is essential to determine how the Armington elasticity changes with policy. Micro details such as as the dispersion of industry-level import shares are endogenous to policy and determine the magnitude of the the induced changes in the Armington elasticity and therefore the size of the gains from the standard love-of-variety effect (this is true with a common tariff ξ, it is likely to be only more true if we had good-specific trade barriers). Put differently, in this model correctly calculating the gains from trade requires knowing the magnitude of the Armington elasticity after the policy change, but that magnitude cannot be determined independently of the micro details. By contrast, in the large class of trade models covered by the Arkolakis et al. (2011) formula, the Armington elasticity is constant and these micro details are irrelevant for welfare.

7 Evidence for the pro-competitive mechanism

Our model predicts that industries with higher import shares are characterized by more competition, and therefore both lower revenue (labor) productivity and lower dispersion in revenue productivity. We next describe the evidence from the Taiwanese manufacturing data on these predictions of the model.

Revenue productivity and import shares. Panel A of Table 11 reports regressions of log revenue productivity in industry j on log import shares in industry j for the Taiwanese manufacturing data. Consistent with the theory, we find that industries with higher import shares have substantially lower labor productivity. The elasticity of labor productivity with respect to import share ranges from -0.13 (unweighted regression) to -0.26, with standard errors in the range of 0.02 or 0.03. This is an economically substantial effect. For the unweighted regression, for example, increasing the import share from zero (autarky) to 0.50 leads to a 6.5% drop in revenue productivity (i.e., $-0.13 \times 0.5 = -0.065$).

Controlling for variation in capital intensities α_i. One concern with these regressions is that revenue productivity variation across industries might be driven by variation in capital intensities or other inputs rather than variation in markups. In particular, more tradable goods may be more capital intensive. To examine this, we observe from (11) that if a firm has capital intensity α_i then its markup is:

$$m_i = \frac{\varepsilon_i}{\varepsilon_i - 1} = (1 - \alpha_i)\frac{p_i y_i}{w_i l_i}.$$

That is, if we have two firms with different capital intensities but the same labor productivity, the firm with the higher α_i will have a lower measured markup m_i. For each industry we compute the weighted average of m_i and regress it on industry-level import shares. We find, if anything, that the reduction in productivity in higher import share industries is even larger than for just labor productivity. The elasticity of productivity with respect to import share now varies from -0.21 (unweighted regression) to -0.45 (weighted regression). Thus cross-sectional variation in capital intensity does not drive our finding that higher import share industries have lower productivity.

Dispersion in labor productivity. Panel B of Table 11 shows that the dispersion in labor productivity across producers within an industry is also negatively related to the industry import share. In the model, most of the change in markup dispersion induced by changes in trade come from changes in the tails of the distribution. Given this, in the table we report industry-level productivity dispersion as the gap between the 95th and 50th percentiles of the distribution. This gives elasticities varying from -0.13 (unweighted) to -0.20 with standard errors around 0.03. We obtain similar results when controlling for variation in capital intensities.

Pro-competitive effects in the empirical trade literature. A large literature studies the links between markups and import competition. A key challenge in this literature is that measuring markups is difficult because neither prices nor marginal cost are typically observable at the firm/plant level. Two common methods exist for addressing this difficulty are the use of price/cost margin (PCM) regressions[15] or the generalized Solow residual approach developed by Hall (1988). Tybout (2003) systematically reviews the evidence from both methods for many countries. For example, when PCM regressions implemented with plant-level panel data, the "results for Mexico (1985-90), Colombia (1977-85), Chile (1979-86), and Morocco (1984-89) all reveal the same basic pattern: in *every* country studied, relatively high industry-wide exposure to foreign competition is associated with lower price-cost margins, and the effect is concentrated in *larger* plants." Grether (1996) explores alternative measures of import competition and find these patterns robust for Mexico. Various studies have also investigated trade liberalization episodes using Hall's framework. Comparing pre- and post-liberalization estimates, Levinsohn (1993), Harrison (1994), and Krishna and Mitra (1998) find evidence that, an increase in foreign competition, *over time*, drives down domestic firm markups in Turkey, Cote d'Ivoire, and India respectively. Several other studies have used more highly aggregated industry-level data but with longer time series to document the pro-competitive effects of trade. For example, recently Chen, Imbs and Scott (2009) have estimated a version of the Melitz and Ottaviano model using EU manufacturing data covering 1989-1999. They find short-run evidence that trade openness exerts a competitive effect with prices and markups falling.

[15] PCMs are the ratio of revenue less variables costs to variable costs. Under the assumption of constant marginal costs, this ratio is a monotonic transformation of the markup.

8 Conclusions

We calculate the gains from international trade in a quantitative model with endogenously variable markups. We find that the welfare gains from trade can be large and, in particular, can be an order of magnitude larger that those implied by standard trade models with constant markups.

In our model, a trade-induced fall in markups increases welfare through two distinct channels: by reducing average markups, and by reducing dispersion in markups. The first effect directly reduces distortions in labor and investment decisions. The second effect reduces relative producer price distortions, thereby promoting a more efficient allocation of resources across firms and increasing aggregate TFP. We quantify the model using product-level data for Taiwanese manufacturing establishments and find that both effects can be substantial. This pro-competitive mechanism implies that industries with high exposure to international competition have substantially lower average revenue productivity and lower dispersion in revenue productivity than in industries that face little such competition. We find direct evidence in support of these predictions in the Taiwanese micro data.

The main message of our paper, however, is not that the gains from trade are "always and everywhere" large. Rather, our conclusion is that to quantify the welfare gains from trade requires *getting the micro details right*. In our benchmark model, the gains from trade are large and operate through a pro-competitive mechanism that is not emphasized in standard models with constant markups. And while we find smaller effects from the pro-competitive mechanism in some of our robustness experiments, even then we find that the micro details matter. Irrespective of the size of the pro-competitive effects, to correctly calculate the gains from trade in our model requires correctly determining how the Armington elasticity changes with the change in trade policy. Micro details such as as the dispersion of industry-level import shares determine the change in the Armington elasticity and therefore also determine the size of the gains from standard love-of-variety effects, not just pro-competitive effects.

To keep our paper focussed we have made a number of important simplifying assumptions. For example, we have focussed exclusively on intraindustry trade and, in the tradition of such models, have abstracted from aggregate differences in technologies or factor endowments. It would be interesting to understand the between-country relative gains from the pro-competitive effects trade when two countries of different sizes and/or different aggregate technologies become more integrated. Similarly, in our experiments we have always considered symmetric changes in trade policy. It would be interesting to consider the gains from trade in our model from unilateral changes in trade policy. Finally, by adopting a representative consumer framework, we have abstracted from all issues of the distribution of the within-country gains from trade. We consider all these issues to be important directions for future research.

Table 1: Data Description

Panel A: *An example of product classification*

3-digit	314 - computers and storage equipment
5-digit	31410 - computers
7-digit	3141000 - mini-computer
	3141010 - work-station
	3141021 - desktop computer
	3141022 - laptop computer
	3141023 - notebook computer
	3141024 - palmtop computer
	3141025 - pen-based computer
	3141026 - hand held computer
	3141027 - electronic dictionary

Panel B: *Distribution of products and industries*

2-digit (sector)	4-digit (industry)	7-digit (products)
textile	16	76
apparel	10	39
leather	4	33
lumber	6	15
furniture	4	12
paper	6	23
printing	3	4
chemical materials	7	152
chemical products	9	83
petroleum	2	12
rubber	3	16
plastics	7	34
clay/glass/stone	18	47
primary metal	14	99
fabricated metal	14	65
industrial machinery	29	163
computer/electronics	11	136
electronic parts	6	72
electrical machinery	11	125
transportation	12	99
instruments	7	70

Table 2: Parameterization

Panel A: *Moments*

	Data	Model
Concentration statistics excl. importers		
mean inv HH	7.25	5.41
median inv HH	3.95	4.42
mean highest share	0.45	0.50
median highest share	0.39	0.39
Concentration statistics incl. importers		
mean share	0.029	0.029
s.d. share	0.087	0.077
median share	0.0036	0.0049
75th p.c. share	0.016	0.016
95th p.c share	0.141	0.141
99th p.c. share	0.461	0.474
Additional statistics		
mean industry import share	0.26	0.26
fraction export	0.25	0.25
Armington elasticity	8	8

Panel B: *Parameters*

	Calibrated
N, number competitors	80
μ, Pareto distribution shape	4.2
H, upper bound	80
p_H, mass at upper bound	0.0035
F_f, fixed cost export, % S.S. labor	3.6
F_d, fixed cost, % S.S. labor	2.3
γ, elasticity within industry	8.50
τ, iceberg trade cost	0.22
	Assigned
θ, elasticity between industries	1.25
β, discount factor	0.96
δ, capital depreciation	0.10
α, capital intensity	0.33
ξ, tariff rate	0.064

Table 3: Estimates of θ

Panel A: *Exclude exporters*

	Drop if share > 0.9	All observations
OLS	1.23	1.38
	(0.039)	(0.046)
median regression	1.20	1.35
	(0.046)	(0.053)
# observations	58895	58920

Panel B: *Include exporters*

	Drop if share > 0.9	All observations
OLS	1.20	1.33
	(0.036)	(0.041)
median regression	1.18	1.30
	(0.039)	(0.045)
# observations	64677	64705

Panel C: *Labor and capital shares*

	Drop if share > 0.9	All observations
OLS	1.13	1.28
	(0.032)	(0.033)
median regression	1.04	1.13
	(0.033)	(0.032)
# observations	26498	26509

(Assumed 15% user cost in Panel C)

Table 4: Additional Micro Implications

	Data	Model
mean markup		1.17
s.d. markup		0.11
median markup		1.14
75th p.c. markup		1.15
95th p.c. markup		1.27
99th p.c. markup		1.79
s.d. labor product.	0.68	0.10
mean labor share	0.61	0.62
median labor share	0.65	0.62
aggregate labor share	0.43	0.45

Table 5: Losses Due to Markups

Panel A: *Benchmark model*

	Benchmark	First-Best	No markup dispersion
markup	1.47	1	1.47
$\Delta \ln$ TFP	–	0.05	0.05
$\Delta \ln Y$	–	0.57	0.07
$\Delta \ln C$	–	0.48	0.07
$\Delta \ln L$	–	0.31	0
welfare gains, %	–	16.7	6.5

Panel B: *Autarky*

	Benchmark	First-Best	No markup dispersion
markup	1.69	1	1.69
$\Delta \ln$ TFP	–	0.23	0.23
$\Delta \ln Y$	–	1.01	0.35
$\Delta \ln C$	–	0.89	0.35
$\Delta \ln L$	–	0.41	0
welfare gains, %	–	48.9	31.6

Table 6: Gains from Trade due to Reductions in Tariffs

Panel A: *Benchmark model*

Δ import share	0 to 10%	10 to 20%	20 to 30%
welfare gains, %	27.3	6.2	3.0
$\Delta \ln$ markup	−0.08	−0.04	−0.04
$\Delta \ln$ TFP	0.17	0.03	0.01
$\Delta \ln Y$	0.35	0.10	0.07
$\Delta \ln C$	0.34	0.09	0.06
$\Delta \ln L$	0.06	0.03	0.03
Armington elasticity	8.5 to 7.5	7.5 to 7.9	7.9 to 8.2

Panel B: *Standard trade model*

Δ import share	0 to 10%	10 to 20%	20 to 30%
welfare gains, %	4.3	2.3	1.3
$\Delta \ln$ markup	0.02	0.00	−0.01
$\Delta \ln$ TFP	0.04	0.02	0.01
$\Delta \ln Y$	0.03	0.02	0.03
$\Delta \ln C$	0.03	0.02	0.02
$\Delta \ln L$	−0.02	0.00	0.01
Armington elasticity	8.1	8.1	8.1

Table 7: Gains from Trade due to Reductions in Trade Costs

Panel A: *Benchmark model*

Δ import share	0 to 10%	10 to 20%	20 to 30%
welfare gains, %	23.7	8.0	6.4
$\Delta \ln$ markup	-0.12	-0.02	-0.01
$\Delta \ln$ TFP	0.13	0.05	0.04
$\Delta \ln Y$	0.34	0.10	0.07
$\Delta \ln C$	0.32	0.10	0.07
$\Delta \ln L$	0.09	0.02	0.00
Armington elasticity	8.5 to 7.5	7.5 to 7.9	7.9 to 8.2

Panel B: *Standard trade model*

Δ import share	0 to 10%	10 to 20%	20 to 30%
welfare gains, %	2.7	2.9	3.2
$\Delta \ln$ markup	0.01	0.01	0.01
$\Delta \ln$ TFP	0.02	0.02	0.03
$\Delta \ln Y$	0.02	0.03	0.03
$\Delta \ln C$	0.03	0.03	0.03
$\Delta \ln L$	-0.01	-0.01	-0.01
Armington elasticity	8	8	8

Table 8: Parameterization of Economy Calibrated to 5-Digit Industries

Panel A: *Moments*

	Data	Model
Concentration statistics excl. importers		
mean inv HH	14.90	12.23
median inv HH	7.97	10.40
mean highest share	0.30	0.41
median highest share	0.25	0.24
Concentration statistics incl. importers		
mean share	0.011	0.010
s.d. share	0.040	0.040
median share	0.0014	0.0026
75th p.c. share	0.006	0.006
95th p.c share	0.044	0.033
99th p.c. share	0.173	0.156
Additional statistics		
mean industry import share	0.26	0.26
fraction export	0.25	0.25
Armington elasticity	8	8

Panel B: *Parameters*

	Calibrated
N, number competitors	100
μ, Pareto distribution shape	6.56
H, upper bound	31
p_H, mass at upper bound	0.0035
F_f, fixed cost export, % S.S. labor	2.4
F_d, fixed cost, % S.S. labor	0.5
γ, elasticity within industry	8.50
τ, iceberg trade cost	0.15
	Assigned
θ, elasticity between industries	1.25
β, discount factor	0.96
δ, capital depreciation	0.10
α, capital intensity	0.33
ξ, tariff rate	0.064

Table 9: Gains from Trade due to Reductions in Tariffs

Economies calibrated to 7- and 5-digit industries

	Standard	7-digit	5-digit
0 to 10%	4.3	27.3	27.8
10 to 20%	2.3	6.2	5.9
20 to 30%	1.3	3.0	2.8

Table 10: Gains from Trade due to Reductions in Tariffs

Additional robustness experiments

	Benchmark	Armington = 5	$\theta = 3$	Bertrand	Uncorrelated
0 to 10%	27.3 (4.3)	22.6 (6.6)	8.2 (4.3)	34.0 (4.3)	14.2 (8.8)
10 to 20%	6.2 (2.3)	7.6 (3.7)	2.7 (2.3)	2.9 (2.3)	19.1 (8.5)
20 to 30%	3.0 (1.3)	4.3 (2.0)	1.4 (1.3)	1.4 (1.3)	15.8 (5.3)
Armington	8	5	8	8	8.5, 3.8, 2.8, 4.2

Note: This table reports the consumption-equivalent change in welfare (including transitions) We report (in brackets) the welfare gains of the corresponding standard model (i.e., the model with the same Armington elasticity) For all models, except the Uncorrelated Shocks, we report the Armington elasticity for Taiwan's import share For the model with Uncorrelated Shocks, we report the Armington elasticity at 0%, 10%, 20% and 30% import shares For the model with Uncorrelated Shocks, we report the welfare gains of the standard model with an Armington elasticity of 3.8, 2.8 and 2.8, respectively, i.e., the lowest elasticity in that range of trade shares in the model with endogenous markups

Table 11: Trade and Productivity in Taiwanese Manufacturing

Panel A: *Industry productivity vs. industry import share*

	Unweighted	Weighted
labor productivity	−0.125	−0.260
	(0.023)	(0.029)
(labor + capital) productivity	−0.214	−0.452
	(0.046)	(0.047)

Panel B: *Industry productivity dispersion vs. import share*

	Unweighted	Weighted
labor productivity	−0.130	−0.198
	(0.032)	(0.036)
(labor + capital) productivity	−0.127	−0.285
	(0.029)	(0.040)

Statistics are computed for non-exporting plants We measure dispersion in productivity as the 95th minus 50th percentile

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