Commodity Booms, Markup Dispersion, and Misallocation *

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Abstract

I develop an open economy model with variable markups to analyze the effect of commodity booms on misallocation. Commodity booms create a real exchange rate appreciation that reallocates resources across firms within the tradable sector. This reallocation occurs through two channels. First, there is tougher foreign competition on domestic producers (*competition channel*), which pushes large firms to reduce their markups and small firms to exit. Second, a reduction in the relative cost of imported materials (*cost channel*) induces large firms, who use them more intensively, to increase their markups. I calibrate the model to Chile and replicate the increase in the price of copper, its main export product, during the early 2000s. I find that there is a substantial reallocation within the tradable sector, which decreases misallocation. Both channels matter quantitatively. Markup dispersion falls more in industries that experience a higher increase in foreign competition. Furthermore, without heterogeneity in the share of imported materials, the decrease in misallocation would be halved. Finally, I estimate markups using Chilean firm-level data and show that the broad patterns are qualitatively consistent with the model predictions.

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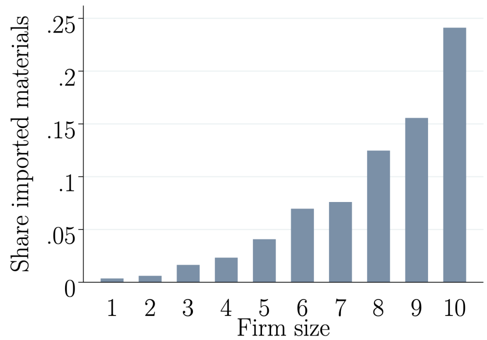
1 Introduction

Commodity price fluctuations are a key driver of economic activity for many emerging market economies (Fernández et al., 2018; Drechsel & Tenreyro, 2018). Booms in commodity prices increase domestic income and boost consumer demand for domestic goods, increasing their relative price and appreciating the real exchange rate. This appreciation can induce the reallocation of resources away from the non-commodity tradable sector, as has been highlighted by the early literature (Corden & Neary, 1982). However, less is known about how commodity booms impact the allocation of production across firms within the tradable sector. Recent literature has found that real exchange appreciations can have heterogeneous impact on firms depending on their size (Amiti et al., 2019). I build on this result to study how commodity booms induce reallocation within the tradable sector.

This paper studies the effect of commodity booms on reallocation across firms in the tradable sector. I analyze two channels by which the appreciations that follow a commodity boom can affect firms in the tradable sector differently, triggering reallocation. First, there is a *competition channel* by which domestic producers face tougher competition from foreign producers. Small unproductive firms exit, while large and more productive firms reduce their markups to retain market share. Second, there is a *cost channel* by which the cost of imported materials falls relative to domestic materials. This affects large firms more because they tend to import a higher share of the materials they use in production, reducing their marginal cost and allowing them to increase markups.

I analyze whether the reallocation generated by a commodity boom is efficient in the presence of imperfect competition in product markets. When an economy is distorted, reallocation is efficient if it moves resources from inefficiently large firms to inefficiently small firms. When distortions are due to market power, an efficient reallocation reduces markup dispersion, which is inefficient because it implies a misalignment between relative prices and relative marginal costs. To study this I extend a standard two-country model to include in the domestic economy a commodity sector, a non-tradable sector, and a tradable

Figure 1: Imported materials and firm size



Note: Average share of imported materials over total materials by deciles of the within-industry revenue share distribution for the year 2002. Computed using data from the *Encuesta Nacional Industrial Anual* (ENIA) for Chile, collected by the Instituto Nacional de Estadística.

sector in which I embed the variable markup framework of Atkeson & Burstein (2008). I calibrate the model to Chile, a country that has experienced strong commodity booms in recent decades, and quantify their effect on markup dispersion and misallocation.

To speak to the competition channel, the model features domestic and foreign firms that are heterogeneous in their productivity. They engage in Cournot competition within industries in the tradable sector, where entry is endogenous. As in the Atkeson & Burstein (2008) framework, I use a nested constant elasticity of substitution (CES) demand system that generates variable markups. The demand elasticity that each firm faces is decreasing in its market share, and therefore endogenous markups are increasing in firm size. This relationship holds for estimated markups with firm-level data for Chile. Additionally, I assume that the share of imported materials that firms use in production is an increasing function of their productivity, which is key for the cost channel to generate reallocation. This mechanism is present in Amiti et al. (2019) and motivated by the Chilean data, where large firms import a higher share of the materials they use in production (Figure 1).

I discipline the model using firm-level data from Chile's survey of the manufacturing sector (*Encuesta Nacional Industrial Anual*, ENIA). Importantly, the model matches moments of the distribution of market shares within and across industries and the pattern of intensity in the use of imported materials. The model also matches the relative size of the tradable, non-tradable, and commodity sectors in the domestic economy and the relative size of the domestic and foreign economies. The foreign economy represents the relevant rest of the world for Chile, defined as the ten most important destinations for Chilean exports.

I first characterize the extent of misallocation in the calibrated economy by comparing the distorted market equilibrium with the first-best allocation obtained by a social planner. In the domestic economy market power distortions result in welfare losses of 5% in consumption equivalent terms[1]. These distortions operate on three margins. First, there is a size distortion: the most productive firms are smaller than they should be, while less productive firms are larger. Second, the level of foreign competition is distorted: foreign producers hold too much market share at home. Finally, there is inefficient entry of both domestic and foreign firms: the least productive firms that operate in the market equilibrium are not active in the first-best allocation.

Next, I simulate a commodity boom of the size observed for copper between 2002 and 2007 and study its effect on misallocation. The observed increase in commodity prices (262%) leads to a strong real exchange appreciation in the model (16.4%), increasing foreign competition and making imported materials cheaper than domestic ones. There is substantial exit of small domestic firms, which is efficient, and all firms except the most productive ones get closer to their efficient size. However, the appreciation also triggers substantial entry of foreign firms and the incumbent foreign firms expand. Considering all firms in the tradable domestic sector, I find that markup dispersion within industries falls by 8% on average. The decrease in markup dispersion in the domestic economy suggests a reduction in distortions. Comparing the market equilibrium with the first best allocation, I find that welfare losses from misallocation fall by 3.3 percentage points (p.p.) after the commodity boom.

I decompose the effect of the two channels and find that they both play an important role in generating a reduction in markup dispersion. First, I look at a counterfactual scenario

[1] This means that consumers are willing to give up 5% of consumption to move from the distorted market equilibrium to the first-best allocation

where there is no heterogeneity in import shares. This allows me to quantify the importance of the cost channel, which only generates reallocation because larger firms import a higher share of the materials they use in production. In the counterfactual scenario, all domestic firms import the same share of the materials they use in production, so the appreciation affects their costs equally. I find that import share heterogeneity accounts for approximately half of the reduction in markup dispersion. This channel reduces the entry of foreign firms and the increase in foreign competition because it represents an advantage for large domestic firms. However, it allows large domestic firms to adjust their markups less and therefore generates an increase in markup dispersion among the subset of home firms in the domestic market. Second, to gain understanding of the importance of the competition channel, I compare the fall in markup dispersion across industries that experienced different changes in foreign competition. I find substantial heterogeneity in industry-level effects: dispersion falls more in industries with higher increases in foreign competition.

Finally, I turn to the firm-level data for Chile in search of supportive evidence of the model predictions. Given the lack of data for foreign firms that sell to the Chilean market, I contrast the results of the model relating to domestic firms. In the model, if we look only at the subset of domestic firms, we see that markup dispersion increases with the boom. There is a composition effect, by which the average markup of large firms increases because large firms are, on average, larger. To contrast with the data, I estimate markups using the firm-level data for Chilean firms following the De Loecker & Warzynski (2012) framework. I find that large firms increased their markups more than small firms during the commodity boom, and markup dispersion within industries increased by 26.5% on average. This is qualitatively consistent with the model predictions for domestic firms, where dispersion increases by 13.6% after the commodity boom.

Related literature. This paper is related to mainly two strands of literature. First, the paper relates to the literature on Dutch disease, starting with the seminal paper of Corden & Neary (1982) and with recent contributions by García-Cicco & Kawamura (2015), Alberola & Benigno (2017), and Esquivel (2024) among others. Corden & Neary (1982) mainly focus on the sectoral reallocation caused by the coexistence of booming (usually extractive) and lagging (usually manufacturing) tradable sectors. In extensions of this model, such as those that include externalities in the manufacturing sector, commodity booms can reduce aggregate productivity by reallocating resources away from the manufacturing sector. This paper complements the existing literature by focusing on an underexplored channel, which is the reallocation that occurs within the tradable sector.

This paper, however, is not the first to study reallocation across firms that result from commodity price cycles. Benguria et al. (2023) study firm-level responses to commodity booms in the Brazilian context. They highlight the role of labor market frictions in shaping the transmission of commodity price shocks, while instead, I emphasize the importance of market power distortions for allocative efficiency. Heresi (2023) studies reallocation across firms during a commodity boom in Chile, finding reallocation away from exporters due to currency appreciation and away from capital-intensive firms due to higher costs of capital. Since the economy is not distorted, the boom only has effects on aggregate productivity due to a composition effect. In contrast, in this paper reallocation resulting from the boom improves efficiency due to the reduction of market power distortions, reducing welfare losses due to misallocation.

Second, this paper relates to the literature that studies how firms' markups respond to changes in external conditions, like trade liberalizations or exchange rate fluctuations, and the implications for efficiency and welfare. Among papers that study gains from trade, Arkolakis et al. (2019) find that pro-competitive gains from trade are elusive in models of monopolistic competition and non-CES demand that generate variable markups, while Edmond et al. (2015) find important pro-competitive gains in a model of two symmetric countries with oligopolistic competition based on Atkeson & Burstein (2008). Impullitti et al. (2021) also find pro-competitive gains from trade in a model of oligopolistic heterogeneous firms where they add endogenous innovation choices. I adopt a framework close to Edmond et al. (2015) but apply it to asymmetric countries and an asymmetric shock. I also find pro-competitive effects, not from opening up to trade, but from an arguably more exogenous shock, which is the increase in global commodity prices.

Amiti et al. (2019) provide micro evidence of differential markup adjustment by Belgian firms of different sizes as a response to depreciations and argue that this shapes the aggregate exchange rate pass-through. I build on this result and focus on the effect that this differential markup adjustment has on misallocation and welfare in the context of real exchange appreciations that follow commodity booms. The closest paper in this literature is Weinberger (2020), who shows that real exchange rate changes can be important drivers of allocative efficiency. He analyzes a partial equilibrium framework, looking at a representative industry, whereas I consider a general equilibrium framework, allowing for reallocation across industries. Additionally, in his model only domestic firms operate, so the only effect of an appreciation is through the cost of imported materials. Instead, in my framework competition with foreign producers is a key channel that generates reallocation as a response to appreciations.

2 Model

I build a general equilibrium two-country model with firm heterogeneity and endogenous variable markups, based on Atkeson & Burstein (2008). The domestic economy is comprised of three sectors: commodities, non-tradables, and tradables. In the tradable sector there is oligopolistic competition between domestic and foreign firms, which are heterogeneous in productivity and in the use of imported materials. This market structure plus nested-CES demand generates variable markups endogenously. Figure 12 in the Appendix provides an illustration of the structure of the two-country model. The purpose of the model is to study the effects of an increase in the price of the commodity good on markup dispersion and misallocation in the tradable sector.

2.1 Households

At home there is a representative household that enjoys consumption of tradable (C^T) and non-tradable goods (C^N):

$$U(C^T, C^N) = \chi \ln C^T + (1-\chi) \ln C^N \tag{2.1}$$

where χ denotes the share of expenditure dedicated to tradable goods. Households supply L units of labor to domestic firms and are the owners of the commodity endowment and the domestic firms, so their budget constraint is:

$$P^T C^T + P^N C^N = WL + P^{Co}\bar{Y}^{Co} + \Pi \tag{2.2}$$

where W is the wage rate, $P^{Co}\bar{Y}^{Co}$ are total revenues from the commodity sector, and Π are aggregate profits of all domestic producers, which will be described below. Using the first order conditions (FOCs) of the household problem we get the price index of the consumption basket as:

$$P = \left(\frac{P^T}{\chi}\right)^{\chi} \left(\frac{P^N}{1-\chi}\right)^{1-\chi} \tag{2.3}$$

In the foreign economy there is also a representative consumer that consumes the final foreign good (C^*). This consumer maximizes

$$U(C^*) = \ln C^* \tag{2.4}$$

subject to resource constraint

$$P^* C^* = W^* L^* + \Pi^* \tag{2.5}$$

where $W^* L^*$ is labor income and Π^* is the sum of profits of all foreign firms.

2.2 Production Technology

There are three sectors in the domestic economy. First, the commodity sector consists on a fixed endowment of the commodity good, which is entirely exported to a third country. Second, a representative firm produces a non-tradable good and sells it to households in a perfectly competitive market. Third, the tradable sector aggregates output of different industries, whose output is a CES aggregate of the output of heterogeneous domestic and foreign firms, that engage in Cournot competition. For simplicity, in the foreign economy there is only a tradable sector analogous to the tradable sector in the domestic economy.

Commodity sector. I assume that the commodity sector consists of a fixed endowment $\bar{Y}^{Co}$ with exogenous price P^{Co}[2]. For simplicity, I assume that the commodity endowment is entirely exported to a third country, whose demand for the commodity good is taken as given. As a consequence, the price P^{Co} is determined by this exogenous demand.

Non-tradable sector. The non-tradable good is produced by a competitive representative firm using a technology that is linear in labor:

$$Y^N = L^N \tag{2.6}$$

Taking FOCs in the representative firm's problem, we obtain that the price of the non-tradable good is equal to the wage rate $(P^N = W)$.

Tradable sector. In each economy there is an final good Y^T that is produced by a perfectly competitive firm using as inputs the output from a continuum of industries (y_j), subject to a CES production function:

$$Y^T = \left(\int_0^1 y_j^{\frac{\theta-1}{\theta}} dj \right)^{\frac{\theta}{\theta-1}} \tag{2.7}$$

[2]This is as in Medina & Soto (2007) for the case of Chile.

where y_j is the output of industry $j \in [0,1]$, and θ is the elasticity of substitution across industries. In each industry, output is produced using inputs from a finite number of domestic and foreign intermediate producers, again subject to CES technology:

$$y_j = \left(\sum_{i=1}^{N_j} (y_{ij}^H)^{\frac{\gamma-1}{\gamma}} + \sum_{i=1}^{N_j} (y_{ij}^F)^{\frac{\gamma-1}{\gamma}} \right)^{\frac{\gamma}{\gamma-1}} \tag{2.8}$$

where y_{ij}^H is the output of domestic producer i in industry j, y_{ij}^F is the output of foreign producer i in industry j, N_j is the number of potential producers in industry j, and γ is the elasticity of substitution within industries. As is standard, I assume that $\gamma > \theta$, that is that goods are closer substitutes within industries than across industries.

Domestic firms. In each industry there is a finite number of domestic firms that produce intermediate goods using labor and materials with Cobb-Douglas technology:

$$y_{ij} = a_{ij} l_{ij}^{1-\alpha} m_{ij}^{\alpha} \tag{2.9}$$

where a_{ij} is the firm-specific productivity level, l_{ij} is firm i's labor demand, and m_{ij} is its demand for materials, which is a CES composite of domestic and imported materials:

$$m_{ij} = \left[\phi_{ij}^{\frac{1}{\rho}} x_{ij}^{\frac{\rho-1}{\rho}} + (1-\phi_{ij})^{\frac{1}{\rho}} v_{ij}^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}} \tag{2.10}$$

I denote with x_{ij} the imported materials, which are the final tradable good of the foreign country, and with v_{ij} the domestic materials, which are the final good of the domestic country. The parameter ϕ_{ij} is firm-specific and it determines the share of imported materials relative to domestic ones, and ρ is the elasticity of substitution between them.

Domestic intermediate firms sell their output to final good producers in both countries:

$$y_{ij} = y_{ij}^H + \tau y_{ij}^{*H} \tag{2.11}$$

where y_{ij}^H is the amount sold at home, y_{ij}^{*H} is the amount sold abroad, and τ is the iceberg trade cost associated to exports.

Foreign firms. In each industry there is a finite number of foreign firms that produce using only labor:

$$y_{ij}^* = \bar{A}^* a_{ij}^* l_{ij}^* \tag{2.12}$$

where $\bar{A}^* a_{ij}^*$ is firm i's productivity and l_{ij}^* its labor demand. The parameter $\bar{A}^*$ shifts the level of productivity of all foreign firms, so it represents the relative productivity of foreign to domestic firms. They sell an amount y_{ij}^F to home final good producers (paying trade cost τ) and y_{ij}^{*F} to foreign producers:

$$y_{ij}^* = \tau y_{ij}^F + y_{ij}^{*F} \tag{2.13}$$

2.3 Firms and Markup Dispersion

Final good producers' problem. The producers of the final good choose domestic and foreign intermediate inputs, with prices p_{ij}^H and p_{ij}^F respectively, to maximize their profits:

$$P^T Y^T - \int_0^1 \left(\sum_{i=1}^{N_j} p_{ij}^H y_{ij}^H + \tau \sum_{i=1}^{N_j} p_{ij}^F y_{ij}^F \right) dj$$

subject to (2.7) and (2.8)

The solution of this problem results in the following demand functions:

$$y_{ij}^H = \left(\frac{p_{ij}^H}{p_j} \right)^{-\gamma} \left(\frac{p_j}{P^T} \right)^{-\theta} Y^T \tag{2.14}$$

$$y_{ij}^F = \left(\frac{\tau p_{ij}^F}{p_j} \right)^{-\gamma} \left(\frac{p_j}{P^T} \right)^{-\theta} Y^T \tag{2.15}$$

where p_j is the industry-level price index and P^T is the price of the final good in the tradable sector. These indexes are defined as:

$$p_j = \left(\sum_{i=1}^{N_j} \psi_{ij}^H (p_{ij}^H)^{1-\gamma} + \tau^{1-\gamma} \sum_{i=1}^{N_j} \psi_{ij}^F (p_{ij}^F)^{1-\gamma} \right)^{\frac{1}{1-\gamma}} \tag{2.16}$$

$$P^T = \left(\int_0^1 p_j^{1-\theta} dj \right)^{\frac{1}{1-\theta}} \tag{2.17}$$

where ψ_{ij}^H and ψ_{ij}^F are indicator functions that equal one when domestic and foreign producers, respectively, operate in the domestic market.

Intermediate good producers' problem. Intermediate good producers face the demand system given by equations (2.14)-(2.17) at home and equivalent ones abroad. In each market firms engage in Cournot competition within their industry, that is, they choose their quantity taking as given the quantities produced by their competitors. Because of constant returns to scale, we can consider the problem of firms in the domestic and export markets separately. Starting with the problem of a home firm in the domestic market, firms maximize:

$$\pi_{ij}^H := \max_{y_{ij}^H, \psi_{ij}^H} \left[\left(p_{ij}^H - MC_{ij} \right) y_{ij}^H - W f_d \right] \psi_{ij}^H$$

subject to the demand system above, where f_d is the fixed labor cost of participating in the domestic market and MC_{ij} is the marginal cost, obtained by solving the cost minimization problem (detailed in Appendix section A.3.2). It can be expressed as:

$$MC_{ij} = \left(\frac{W_t}{1-\alpha} \right)^{1-\alpha} \left(\frac{P_{ij}^m}{\alpha} \right)^{\alpha} \frac{1}{a_{ij}} \tag{2.18}$$

where $P_{ij}^m = \left[\phi_{ij} (P_t^*)^{1-\rho} + (1-\phi_{ij})(P_t^T)^{1-\rho} \right]^{\frac{1}{1-\rho}}$ is the price index of materials, which depends on P_t^T, the price of domestic materials, and P_t^*, the price of imported materials. This price index is firm-specific as it depends on the share of imported materials ϕ_{ij}.

The solution to this maximization problem (detailed in Appendix section A.3.1) is characterized by a price that is a markup μ_{ij}^H over the marginal cost:

$$p_{ij}^H = \frac{\varepsilon_{ij}^H}{\varepsilon_{ij}^H - 1} MC_{ij} \tag{2.19}$$

where $\varepsilon_{ij}^H > 1$ is the firm-specific demand elasticity in the domestic market:

$$\varepsilon_{ij}^H = \left(\omega_{ij}^H \frac{1}{\theta} + (1 - \omega_{ij}^H) \frac{1}{\gamma} \right)^{-1} \tag{2.20}$$

This demand elasticity is a weighted harmonic average of underlying elasticities θ and γ, with weights given by shares in industry-level revenues ω_{ij}^H, defined as:

$$\omega_{ij}^H := \frac{p_{ij}^H y_{ij}^H}{\sum_{i=1}^{N_j} p_{ij}^H y_{ij}^H + \tau \sum_{i=1}^{N_j} p_{ij}^F y_{ij}^F} = \left(\frac{p_{ij}^H}{p_j} \right)^{1-\gamma} \tag{2.21}$$

In the Atkeson & Burstein (2008) model variable markups emerge because firms face different, endogenously determined, demand elasticities. Small firms compete mostly with firms in their industry so they face a high demand elasticity (close to within-industry elasticity $\gamma > \theta$) and they set a low markup. Large firms face relatively more competition from firms in other industries, so they have a low demand elasticity (close to across-industry elasticity $\theta < \gamma$) and set a high markup. The extent of markup dispersion across firms then depends both on the *gap* between the two elasticities θ and γ and the *dispersion* in market shares.

The problem of firm i in its export market can be defined analogously, taking into account the iceberg trade cost τ and using the fixed cost of operating on export markets (f_x) instead of the fixed cost of domestic (f_d). Finally, firms decide to operate in each market if they make non-negative profits:

$$\psi_{ij}^H = 1 \iff \left(p_{ij}^H - MC_{ij} \right) y_{ij}^H \geq W f_d \tag{2.22}$$

$$\psi_{ij}^{*H} = 1 \iff \left(p_{ij}^{*H} - MC_{ij} \right) y_{ij}^{*H} \geq W f_x \tag{2.23}$$

Let us denote by Π the sum of profits of all domestic intermediate firms:

$$\Pi = \int_0^1 \left(\sum_{i=1}^{N_j} \pi_{ij}^H \psi_{ij}^H + \sum_{i=1}^{N_j} \pi_{ij}^{*H} \psi_{ij}^{*H} \right) dj \tag{2.24}$$

Similarly, we can define the problem of foreign firms in the home market (the export market from the perspective of foreign producers) as:

$$\pi_{ij}^F := \max_{y_{ij}^F, \psi_{ij}^F} \left[\left(p_{ij}^F - MC_{ij}^* \right) y_{ij}^F - W f_x \right] \psi_{ij}^F$$

subject to the demand system above, where the marginal cost is:

$$MC_{ij}^* = \frac{W^*}{\bar{A}^* a_{ij}^*} \tag{2.25}$$

where W^* is the wage in the foreign economy, which I normalize to one. The price solution is analogous to equation (2.19) and the operating decisions to equations (2.22)-(2.23).

2.4 Equilibrium

Given a potential number of firms in each industry N_j, a distribution of firm productivities for each country, a_{ij} and a_{ij}^*, and a fixed level of labor supply in each country L and L^*, an equilibrium is: (i) a set of prices (p_{ij}^H, p_{ij}^F, p_{ij}^{*F}, p_{ij}^{*H}), allocations (y_{ij}^H, y_{ij}^F, y_{ij}^{*F}, y_{ij}^{*H}), and participation decision (ψ_{ij}^H, ψ_{ij}^F, ψ_{ij}^{*F}, ψ_{ij}^{*H}), (ii) aggregate output in the tradable and non-tradable sectors at home (Y^T and Y^N), and abroad (Y^*), consumption (C^T, C^N, C^*), aggregate materials V (domestic) and X (imported), and a wage rate W, such that firms and consumers optimize and markets clear. In particular:

$$L = L^N + \int_0^1 \left(\sum_{i=1}^{N_j} (l_{ij}^H + f_d)\psi_{ij}^H + \sum_{i=1}^{N_j} (l_{ij}^{*H} + f_x)\psi_{ij}^{*H} \right) dj \tag{2.26}$$

$$L^* = \int_0^1 \left(\sum_{i=1}^{N_j} (l_{ij}^F + f_x)\psi_{ij}^F + \sum_{i=1}^{N_j} (l_{ij}^{*F} + f_d)\psi_{ij}^{*F} \right) dj \tag{2.27}$$

$$Y^T = C^T + V \tag{2.28}$$

$$Y^* = C^* + X \tag{2.29}$$

$$Y^N = C^N \tag{2.30}$$

where V is the total amount of domestic materials demanded by domestic firms in the tradable sector,

$$V = \int_0^1 \left(\sum_{i=1}^{N_j} v_{ij}^H \psi_{ij}^H + \sum_{i=1}^{N_j} v_{ij}^{*H} \psi_{ij}^{*H} \right) dj$$

and X is the total amount of imported materials demanded by domestic firms,

$$X = \int_0^1 \left(\sum_{i=1}^{N_j} x_{ij}^H \psi_{ij}^H + \sum_{i=1}^{N_j} x_{ij}^{*H} \psi_{ij}^{*H} \right) dj$$

2.5 Misallocation

In this model, dispersion in firms' markups represents misallocation in the sense of Hsieh & Klenow (2009) because it means that relative prices are not aligned with relative marginal costs. In this subsection I solve the problem of a global planner that maximizes the utility of home and foreign consumers subject to the same trade and fixed costs. By comparing the market equilibrium with the efficient allocation in terms of welfare and output I can quantify in the next section the effect of the boom on misallocation.

The global social planner solves, for given weights Ω and Ω^*:

$$\mathcal{W} = \max \Omega \left(\chi \ln C^T + (1-\chi) \ln C^N\right) + \Omega^* \left(\ln C^*\right) \tag{2.31}$$

subject to the C.E.S. aggregators in equations (2.7) and (2.8), firm's technologies (equations (2.13) to (2.13)[3]) and market clearing conditions (equations (2.26) to (2.30)). The detailed problem and the solution can be found in Appendix section A.4. The weights Ω and Ω^* are chosen so that there are no transfers between the two countries when the efficient allocation is implemented as a market equilibrium with taxes or subsidies that depend on firms' market shares within industries. The details of the implementation can be found in Appendix section A.5.

Finally, to quantify misallocation I compute welfare losses in consumption equivalent terms. A detailed definition can be found in Appendix section A.6.

3 Quantifying the Model

I calibrate the model to Chile, a country that has experienced strong commodity booms in recent decades. Its main export product, which is copper, saw its international price more than triple between 2002 and 2007. I calibrate the model to match some features of the data for Chile in 2002, before the start of the boom. In this section I first describe the micro data used to discipline the model, and then present the calibration. Finally, I characterize the market equilibrium explaining how the market power distortions lead to markup dispersion and how this affects the allocation of resources and welfare in the domestic economy.

[3]Notice that this takes into account trade costs τ.

Table 1: Parameterization

Parameter	Value	Description
Literature/Data		
θ	1.24	Across-industry elasticity of substitution (Edmond et al., 2015)
γ	10.5	Within-industry elasticity of substitution (Edmond et al., 2015)
ρ	4	Elasticity of substitution btw imported/domestic materials (Kasahara & Rodrigue, 2008; Halpern et al., 2015)
α	0.60	Share of materials in gross output (OECD input-output tables)
Internally Calibrated		
ζ	0.0012	Geometric parameter for number of producers per industry
ξ_z	1.20	Pareto shape parameter for industry productivity
ξ_q	8.75	Pareto shape parameter for idiosyncratic productivity
σ_{jj^*}	0.95	Cross-country industry correlation
f_d	0.05	Fixed cost of domestic operations
λ	1.069	Slope of ϕ_i (share of imported materials)
χ	0.31	Share of tradables in consumption expenditure
P^{Co}	0.09	Initial price of commodity good
L^*	55.39	Labor supply in Foreign
$\bar{A}^*$	2.89	Relative productivity of foreign producers
τ	1.71	Gross trade cost
f_x	0.03	Fixed cost of export operations

3.1 Firm-level Data for Chile

To discipline the model I use the *Encuesta Nacional Industrial Anual* (ENIA), a survey of the manufacturing sector in Chile conducted by the Instituto Nacional de Estadística. This data consists on an unbalanced panel covering all establishments in the manufacturing sector with at least ten employees. The panel is available for the period 1996-2009, with approximately 5,000 observations per year. It includes data on value added, the wage bill, physical assets, exports, materials used in production (including the share of them that are imported), among other variables. Firms in the data are classified into three-digit ISIC industries, which I use for my definition of industries in the model.

3.2 Parameterization

A first group of parameters is taken from the literature and directly from the data. I set the elasticities of substitution within and across industries, γ and θ, to 10.5 and 1.24, following Edmond et al. (2015). I set the share of materials in gross output α to be 0.6, computed for the manufacturing sector with the OECD's input-output tables. The elasticity of substitu-

Table 2: Targeted Moments

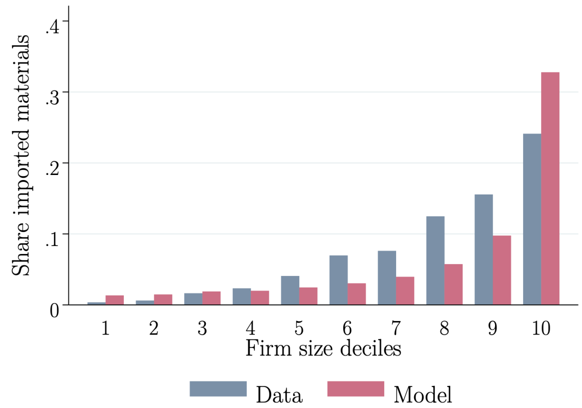
	Data	Model	Data	Model
Panel A. Market share distribution				
	Within industries		Across industries	
Mean	0.05	0.05	0.02	0.02
Median	0.03	0.03	0.01	0.02
SD	0.07	0.07	0.04	0.02
p75	0.05	0.05	0.03	0.02
p95	0.18	0.19	0.09	0.03
p99	0.26	0.3	0.19	0.13
Panel B. Other moments				
Producers per industry (median)	53	30.5		
Mean share imported materials	0.08	0.08		
Share tradables in GDP	0.31	0.36		
Share commodities in GDP	0.06	0.06		
Share commodities in exports	0.3	0.3		
GDP foreign over home	48	45		
Export penetration	0.004	0.004		
Foreign competition (weighted mean)	0.26	0.26		
Foreign competition (std dev)	0.3	0.18		
Fraction exporters	0.2	0.09		

tion between domestic and imported materials ρ is set to 4, following Kasahara & Rodrigue (2008) and Halpern et al. (2015). I then simultaneously choose a vector of twelve parameters (ζ, ξ_z, ξ_q, σ_{jj^*}, f_d, λ, χ, P^{Co}, L^*, $\bar{A}^*$, τ, f_x) to match features of the micro and macro data for the year 2002, when copper prices started increasing. The parameter values are reported in Table 1 and the model fit in Table 2.

Market share distributions within and across industries. First, I target moments of the market share distributions within and across industries, which I obtain from the ENIA data. This mainly depends on the distribution of firm productivities, which I characterize following Edmond et al. (2015). In each industry the number of producers actively operating is drawn i.i.d. from a geometric distribution with parameter ζ. Within industries, I assume that firm productivity a_{ij} is the product of an industry-specific component z_j and an idiosyncratic component q_{ij}:

$$a_{ij} = z_j q_{ij} \tag{3.1}$$

Figure 2: Share of Imported Materials



Note: Average share of imported materials over total materials by deciles of the within-industry revenue share distribution. Data moment computed for the year 2002 with data from the *Encuesta Nacional Industrial Anual* (ENIA) for Chile.

where z_j is drawn i.i.d. from a Pareto distribution $F_Z(z)$ with shape parameter $\xi_z > 0$, and q_{ij} is drawn i.i.d. from a Pareto distribution $F_Q(q)$ with shape parameter $\xi_q > 0$. I allow for cross-country correlation in industry productivities. The cross-country joint distribution of industry productivities is:

$$H_Z(z, z^*) = \mathcal{C}(F_Z(z), F_Z(z^*)) \tag{3.2}$$

where the copula $\mathcal{C}$ is the joint distribution of a pair of uniform random variables u, u^* on $[0, 1]$. I assume that the marginal distributions are linked by a Gumbel copula with parameter σ_{jj^*}:

$$\mathcal{C}(u, u^*) = \exp\left(- \left[(-\log u)^{\frac{1}{1-\sigma_{jj^*}}} + (-\log u^*)^{\frac{1}{1-\sigma_{jj^*}}} \right]^{1-\sigma_{jj^*}} \right) \tag{3.3}$$

The shape parameters of the distributions $F_Z(z)$ and $F_Q(q)$ target moments of the distributions of market shares within and across industries (mean, median, standard deviation, and the 75th, 95th, and 99th percentiles) and the parameter ζ targets the median number of producers across industries, which I report in Table 2. The parameter f_d, the fixed cost of domestic operations, also helps to control the median size of producers within industries.

Use of imported materials. I then target the patterns seen in the ENIA data in terms of the use of imported materials. I define the firm-specific parameter ϕ_{ij} for the share of imported materials as a function of firm's productivity:

$$\phi_{ij} = \min\{\lambda \frac{a_{ij}^{\gamma-1}}{\sum a_{ij}^{\gamma-1}}, \phi_{\max}\}$$

where $\frac{a_{ij}^{\gamma-1}}{\sum_{i=1}^{N_j} a_{ij}^{\gamma-1}}$ is a measure of relative productivity. The parameter λ is calibrated to match the average share of imported materials (7.6%). Although it is not explicitly a target in the calibration, the model matches well the pattern of import shares across the firm size distribution, as can be seen in Figure 2.

Sector and aggregate moments. I also target the relative size of the tradable, non-tradable and commodity sectors, which accounted for 31.4%, 62.3% and 6.3% of Chilean GDP in 2002. The parameter χ controls the relative size of the tradable and non-tradable sectors, while the initial value for the price P^{Co} (for $\bar{Y}^{Co}$ normalized to one) determines the size of the commodity sector, as well as the share of commodity exports in total exports, which is 29.8% and I also target.

Another moment that I target is the ratio of foreign GDP to Chilean GDP. To compute this moment in the data I first define the rest of the world that is relevant for Chile as the ten most important destinations for Chilean manufacturing exports in 2002[4]. The GDP of the foreign country is the weighted average of GDP of these 10 countries, with weights given by the share of exports to each country:

$$\text{GDP}_{\text{ROW}} = \sum_{d=1}^{10} \left(\frac{X_{\text{Chile},d}}{\sum_{d=1}^{10} X_{\text{Chile},d}} \right) \text{GDP}_d \tag{3.4}$$

where $X_{\text{Chile},d}$ are exports from Chile to country d. In the model, I normalize the labor

[4]These countries are (in order of importance): United States of America, Mexico, Brazil, Peru, Colombia, Ecuador, Netherlands, Argentina, Bolivia, and Spain. They accounted for 72% of Chilean manufacturing exports in 2002 according to the United Nations Comtrade database.

supply at home to be one, so the relative size of foreign to home is governed by the supply of labor in the foreign country, L^*, plus the relative productivity of foreign to domestic producers, $\bar{A}^*$.

Trade moments. Importantly, to reflect the fact that Chile is small with respect to the rest of the world, I target Chile's "export penetration" in the rest of the world. I compute this as the weighted average of each destinations' ratio of Chilean exports ($X_{\text{Chile},d}$) to total manufacturing GDP[5] (GDP_d^{M}):

$$\text{Export penetration} = \sum_{d=1}^{10} \left(\frac{X_{\text{Chile},d}}{\sum_{d=1}^{10} X_{\text{Chile},d}} \right) \frac{X_{\text{Chile},d}}{\text{GDP}_d^{\text{M}}} \tag{3.5}$$

In the domestic economy, I target the level and dispersion in foreign competition across industries. For each industry j, I compute foreign competition as:

$$\text{Foreign competition}_j = \frac{Q_j^{\text{Imported}}}{Q_j^{\text{Domestic}} + Q_j^{\text{Imported}}} \tag{3.6}$$

where Q_j^{Imported} is the value of total imports in industry j and Q_j^{Domestic} is the value of domestic production in industry j, which I obtain from Use and Supply Tables for 2003 from CEPALSTAT (ECLAC). I target the weighted mean of foreign competition across industries (0.26, weighted by industries' revenue shares) as well as the standard deviation (0.3), to reflect the heterogeneity across industries. Finally, I target the fraction of total producers that export to the foreign economy, which is 0.2 according to the ENIA survey.

These moments are controlled by the trade cost parameters: the iceberg trade cost τ and the fixed cost of exporting f_x. The standard deviation of foreign competition is governed by the copula parameter σ_{jj^*}, which controls the degree of cross-country correlation in industry-level productivities.

[5] Manufacturing GDP is constructed using National Accounts data from the UN and the World Bank for all countries except Peru, for which I use data from the Instituto Nacional de Estadística e Informática.

Table 3: Markups and Misallocation

Panel a. Weighted Average Markups	All	Large	Small
All	1.20	1.23	1.11
Home	1.21	1.25	1.12
Foreign	1.15	1.18	1.11
Panel b. Markup Dispersion (S.D.)	Within	Across	
All	0.05	0.07	
Home	0.05	0.09	
Foreign	0.02	0.05	
Panel c. Losses			
Welfare losses (C.E.)	4.99		
Output losses	45.95		

Note: Panel (a) of Table 3 reports cost-weighted harmonic average markups for different groups of firms. Large firms are those in the top 25% of industry revenue shares (ω_{ij}), while small firms are those in the remaining 75%. Panel (b) reports markup dispersion within (simple average of within industry standard deviation) and across (standard deviation of industry-level average markups). Panel (c) reports welfare losses in consumption equivalent terms (defined in equation A.58) and output losses, which are the percentage gap between tradable output in the fist-best allocation and the market equilibrium.

3.3 Characterizing the Market Equilibrium

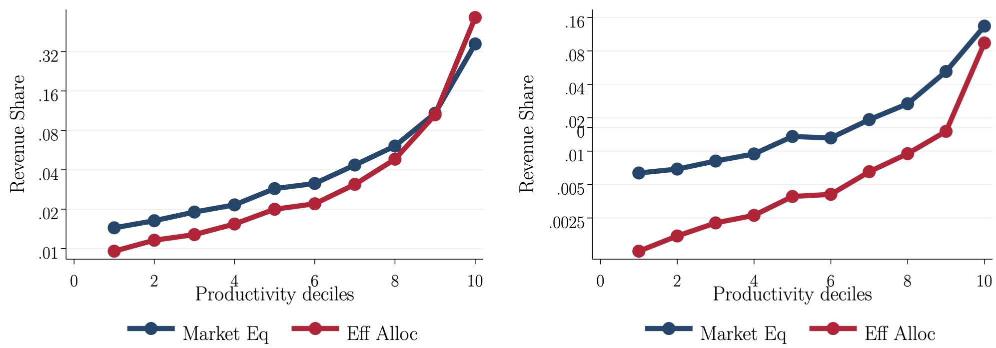
I now use the calibrated the model to characterize the market equilibrium, describing the distribution of markups, the (mis)allocation of resources and its effects on welfare in the domestic economy.

Average markups and dispersion. Table 3 reports moments of the markup distribution at home. First, in panel (a) I report the cost-weighted average markup of different groups of firms.[6] I separate firms by origin (home and foreign) as well as size (large and small). I classify firms as large if they are in the top 25% of the revenue share distribution within their industry, and small if they are in the remaining 75%. The average markup of all firms operating in the domestic tradable sector is 1.20. The average markup of large firms is higher than the average for small firms, a result that follows from equations (2.19) and (2.20). The average markup is also higher for home than for foreign firms, consistent with

[6] I use cost-weighted average markups following Edmond et al. (2023). In Table 8 of the Appendix I compare the cost-weighted and revenue-weighted averages.

Figure 3: Market Share Distributions: Market Equilibrium vs Efficient Allocation

(**a**) Home firms (**b**) Foreign firms



Note: This figure plots the total market share held by firms in each decile of the productivity distribution. Blue lines show the distribution in the market equilibrium, while red lines show the distribution in the efficient allocation. The y-axis is on a log scale.

the fact that home firms hold more market share in the domestic economy.

Second, in panel (b) I report markup dispersion within and across industries, reflecting misallocation of resources both across firms within industries and across industries. Markup dispersion within industries (the simple average of industries' standard deviation of markups) is 0.05 in the model. On the other hand, dispersion across industries (the standard deviation of industry-level cost-weighted harmonic average markups) is 0.07, meaning that markups are more dispersed across industries than within industries.

Losses from misallocation. In the last panel of Table 3, I compute the welfare losses that result from market power distortions. Welfare losses in consumption equivalent terms are 5%, meaning that domestic consumers would be willing to forgo 5% of their consumption to move from the market equilibrium to the efficient allocation. The table also reports output losses in the tradable sector, defined as the percentage gap between tradable output in the first-best allocation and the market equilibrium, which are almost 46%.

Figure 3 compares the distribution of market shares (ω_{ij}) by productivity deciles in the market equilibrium and the efficient allocation. I plot the total market share held by firms in each decile of the productivity distribution. Panel (a) shows, for home firms, how the distortion generated by market power operates. The most productive firms are too small in the market equilibrium compared with the efficient allocation. On the contrary, less productive firms are larger than what would be efficient. Instead, for foreign firms, we see in panel (b) that firms in all productivity deciles are too large: they hold more market share in the market equilibrium than in the efficient allocation.[7] Nonetheless, the less productive foreign firms are further away from their optimal size than the most productive: the 10% least productive firms are five times larger than optimal, while the 10% most productive are only 43% larger. Finally, apart from the size distortion of active firms, more firms (domestic and foreign) are active in the market equilibrium than in the efficient allocation, revealing excessive entry.[8]

4 Quantifying the Effects of a Commodity Boom

In this section I conduct a quantitative exercise where I simulate an increase in commodity prices and quantify the effect on markup dispersion, misallocation, and welfare. In this section I present the results for a 262% increase in commodity prices, which is the increase in the price of copper observed between 2002 and 2007.[9]

Aggregate effects. Table 4 reports some aggregates before and after the boom, as well as their percentage change. First, let me define real GDP of the domestic economy at time t as the sum of real GDP in the three sectors:

$$GDP_t = GDP_t^T + GDP_t^N + GDP_t^{Co} \tag{4.1}$$

[7]This can also be seen in Figure 7: the social planner chooses much less foreign competition in the domestic economy than in the market equilibrium.

[8]This is reported in table 6 in the Appendix, and can also be seen graphically in panel (a) of Figure 6.

[9]I also perform the quantitative exercise for a boom 50% smaller and a boom 50% larger than the benchmark. Results are approximately linear in the size of the boom, so they are relegated to Appendix section C.2.

Table 4: Effects on Aggregates

	Before	After	% change
Panel a. Shock			
P^{Co}	0.087	0.314	262
Panel b. Aggregates			
Real GDP	1.184	1.160	-2.0
Tradable	0.278	0.166	-40.3
Non-Tradable	0.819	0.907	10.8
Commodity	0.087	0.087	0.0
RER	0.081	0.067	-16.4
Panel c. Allocation of Labor			
Tradable (L^T)	0.185	0.100	-45.9
Non-tradable (L^N)	0.809	0.896	10.8

where

$$GDP_t^T = \int_0^1 \left(\sum_{i=1}^{N_j} (p_{ij,0}^H y_{ij,t}^H - p_{ij,0}^m m_{ij,t}^H) + \sum_{i=1}^{N_j} (p_{ij,0}^{*H} y_{ij,t}^{*H} - p_{ij,0}^m m_{ij,t}^{*H}) \right) dj \tag{4.2}$$

$$GDP_t^N = Y_t^N P_0^N \tag{4.3}$$

$$GDP_t^{Co} = Y_t^{Co} P_0^{Co} \tag{4.4}$$

where $t = 0$ is some base period, which I chose to be the moment before the boom. Real GDP in the tradable sector is the aggregate value added of domestic producers, computed as their revenues minus the value of materials used in production, all valued at base prices. For the non-tradable and commodity sectors, real GDP is the value of production at base prices. Second, the real exchange rate is defined as the ratio of the foreign consumer price index over the domestic consumer price index:

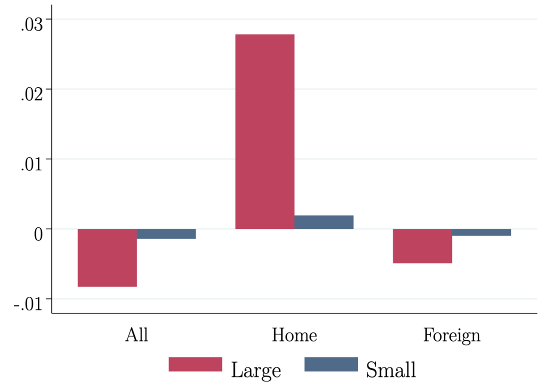
$$RER_t = \frac{P_t^*}{\left(\frac{P_t^T}{\chi}\right)^{\chi} \left(\frac{P_t^N}{1-\chi}\right)^{1-\chi}} \tag{4.5}$$

In panel (b) of the Table we see that a 262% in commodity prices results in the model in a 2% reduction in real GDP. This results from the strong contraction of real GDP in the trad-

Table 5: Effects on Markup Dispersion

	Before	After	% change
Panel a. Markup Dispersion within Industries			
All firms	0.047	0.044	-8.0
Home firms	0.053	0.061	13.6
Foreign firms	0.021	0.022	6.9
Panel b. Markup Dispersion across Industries			
All firms	0.075	0.073	-2.4
Home firms	0.095	0.128	35.9
Foreign firms	0.045	0.043	-4.9

Figure 4: Change in Average Markups



Note: Panel (a) of Table 5 reports the average standard deviation of markups within industries (simple average across industries). Panel (b) reports the standard deviation of industry-level average markups, where industry averages are computed as the harmonic cost-weighted average of markups. Figure 4 plots the change in cost-weighted harmonic average markups after the boom by firm size. Large firms are those in the top 25% of industry revenue shares (ω_{ij}), while small firms are those in the remaining 75%.

able sector (40.3%), too large to be compensated by the 10.8% growth in the non-tradable sector. Real GDP in the commodity sector is constant by assumption. The commodity boom also leads to a real exchange appreciation of 16.4%. The model captures a large fraction of the appreciation observed in Chile during the boom, which was 24.3%. Finally, panel (c) shows the reallocation of labor across sectors. There is a substantial reduction in the amount of labor used in production of tradables (45.9%), while the labor allocated to non-tradables increases by 10.8%.

Effects on markup dispersion. Table 5 shows the effects on markup dispersion within (panel a) and across (panel b) industries[10]. Considering all firms operating in the domestic economy, within industry dispersion falls from 0.047 to 0.044 and across industry dispersion falls from 0.075 to 0.073. However, if we look at domestic and foreign firms separately, dispersion increases for both groups and more so for domestic firms.

To understand this better, we can look at how the (cost-weighted harmonic) average markup of firms of different sizes reacts to the boom. Figure 4 displays the change in average

[10] I compute dispersion across industries as the standard deviation of cost-weighted average markups. Table 9 of the Appendix reports the changes in dispersion using revenue-weighted averages instead.

Table 6: Effects on Misallocation

	Before	After	Change
Panel a. Welfare Loss (C.E.)			
Home	4.99	1.68	-3.31
Foreign	2.14	1.79	-0.36
Panel b. Output Loss			
Y_t^T	45.95	40.55	-5.41
Y_t^*	2.40	2.04	-0.36

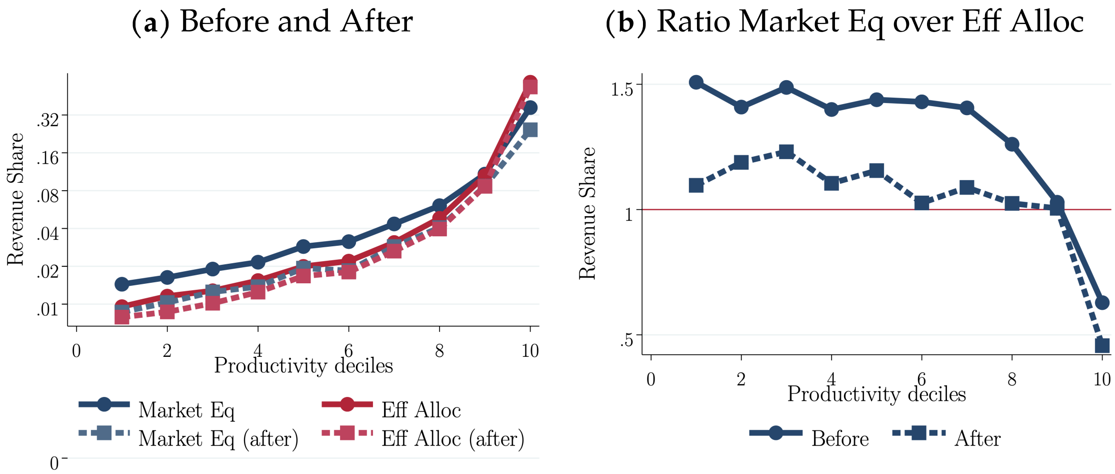
Note: This table reports the vales before and after, as well as the change in percentage points, of welfare and output losses in the domestic and foreign economy. Welfare losses are in consumption equivalent terms and output losses are the percentage gap between tradable output in the fist-best allocation and the market equilibrium.

markups[11] for different groups of firms, while the values before and after the boom can be found in Table 10 in the Appendix. First, we find that, while the average of all large firms in the domestic economy fell by almost 0.01 (from 1.23 to 1.22), the average for small firms almost did not change. As large firms have higher markups than small firms, this relates to the reduction in markup dispersion. Instead, if we look at the subset of domestic firms, the average for large firms increased by almost 0.03 (from 1.25 to 1.28) while that of small firms is constant at 1.12. Consequently, markup dispersion increased. Finally, for foreign firms the changes are smaller, with average markups of large firms decreasing by less than 0.005 (from 1.182 to 1.177).

The average markup of large firms falls because of reallocation of market shares towards foreign firms with lower markups. This reallocation happens both at the extensive and intensive margin. Figure 6 shows how the boom leads to substantial exit of home firms and entry of foreign firms into the domestic market. Approximately 42% of home firms exit after the boom, while the number of foreign firms almost doubles. On the intensive margin, Figure 7 shows how foreign consumption rises sharply with the commodity boom, increasing by approximately 73%.

[11] Here I also use cost-weighted harmonic averages, while revenue-weighted counterparts can be found in Figure 15 in the Appendix.

Figure 5: Reallocation for Home Firms

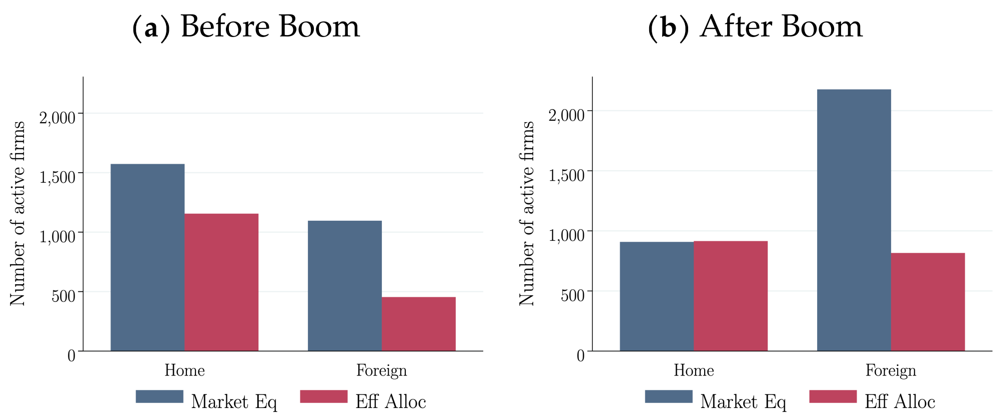


Note: Panel (a) plots the total market share held by firms in each decile of the productivity distribution. Blue lines show the distribution in the market equilibrium, while red lines show the distribution in the efficient allocation. Solid lines are for the time before the boom and dashed lines for the time after the boom. The y-axis is on a log scale. Panel (b) reports the ratio of of the revenue share in the market equilibrium over the efficient allocation for each productivity decile (blue line over red line in panel (a)). Solid lines correspond to the time before the boom and dashed lines to the time after the boom.

Welfare effects. Table 6 reports the effect of the commodity boom on welfare and output losses. In the domestic economy the welfare loss in consumption equivalent terms falls by 3.3 p.p. after the boom. The domestic consumer was willing to forego 5% of consumption to move from the market equilibrium to the efficient allocation before the commodity boom, but only 1.68% after the boom. Welfare losses also fall for foreign consumers, but only by 0.36 p.p. (from 2.14% to 1.79%). The losses in tradable output at home fall by 5.4 p.p., from 45.9% to 40.5%, and fall slightly in the foreign economy (by 0.36 p.p.).

This result suggests that the boom led to an efficient reallocation of resources, reducing welfare losses from misallocation. To further analyze this reallocation, I plot in Figure 5 the distribution of market shares before and after the boom. Panel (a) plots the market share accumulated by each productivity decile for the market equilibrium (blue lines) and the efficient allocation (red lines), before (solid lines) and after (dashed lines) the boom. Panel (b) plots the ratio of the revenue share in the market equilibrium over the efficient allocation for each productivity decile. Values above one mean that firms are inefficiently large, while values below mean that they are inefficiently small. For home firms we see

Figure 6: Number of Active Firms

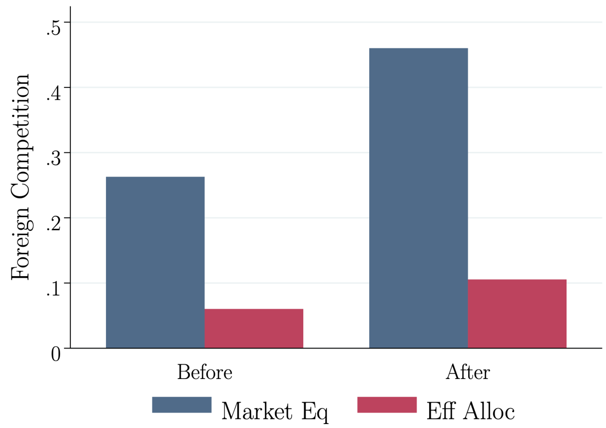


Note: This figure compares the number of active home and foreign firms operating in the domestic market in the market equilibrium (blue bars) and the efficient allocation (red bars). Panel (a) reports the numbers before the commodity boom and panel (b) reports the numbers after it.

in panel (a) that the red and blue lines are closer to each other after the boom for less productive firms. The least productive firms shrink and it is efficient for them to do so. On the contrary, the 10% most productive firms were too small to begin with, and shrink even further. This can be seen more clearly in panel (b): the ratio is closer to one after the boom for all productivity deciles except for the tenth. For foreign firms changes go in the same direction but are smaller: reallocation is efficient for the less productive firms but not for firms in the top decile. The corresponding plots can be found in Figure 17 in the Appendix.

In terms of the extensive margin, comparing the number of active firms before and after the boom, we see in Figure 6 that the substantial exit of home firms is efficient. The "excess" of active firms in the market equilibrium relative to the efficient allocation practically disappears after the commodity boom. Instead, the entry of foreign firms is too large: the excess of active foreign firms is exacerbated with the boom. Finally, in terms of foreign competition, Figure 7 reports how the share of revenues accounted for by foreign firms increases sharply with the boom. However, since the increase is similar in magnitude in the market equilibrium and the efficient allocation (approximately 73%), the gap between the two does not change.

Figure 7: Foreign Competition



Note: This figures compares the degree of foreign competition in the domestic economy in the market equilibrium (blue bars) and the efficient allocation (red bars), before and after the commodity boom. Foreign competition is the weighted average across industries of the share of the value of imports over the total value (domestic plus imported production).

5 Decomposing the Channels

In this section I explore the relative importance of the two channels at play in the model to explain the reallocation that results from the commodity boom. First, I compare the benchmark results with a counterfactual scenario where there is no heterogeneity in import shares. Second, I look at heterogeneous effects across industries with different changes in foreign competition.

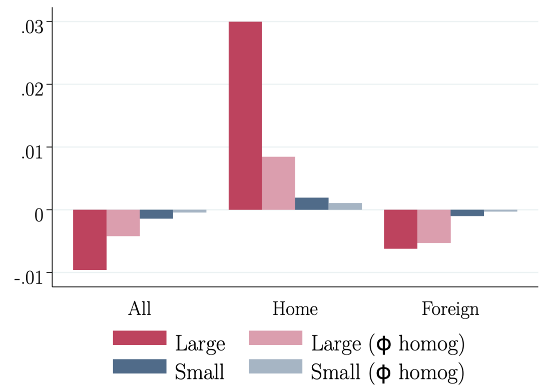
5.1 Heterogeneity in Import Shares

One key feature of the model is that larger firms import a higher fraction of the materials they use in production, consistently with the data. This represents an advantage for large domestic firms when there is an appreciation, since imported materials become cheaper relative to domestic ones. This advantage mitigates the effect of tougher foreign competition on large home firms. Instead, if all home firms imported the same share of materials, the change in the relative price of domestic and imported materials has no effect on the allocation of resources among firms in the domestic economy.

Table 7: No Heterogeneity in Import Shares

	Benchmark	$\phi_{ij} = \bar{\phi}$
Panel a. Change in Dispersion (within)		
All firms	-8.0	-3.5
Home firms	13.6	0.7
Foreign firms	6.9	15.5
Panel b. Change in Dispersion (across)		
All firms	-2.4	-1.5
Home firms	35.9	23.3
Foreign firms	-4.9	-4.4
Panel c. Entry, exit, foreign competition		
Exit home firms	42.3	40.6
Entry foreign firms	98.6	107.6
Change in foreign competition	72.7	94.4

Figure 8: Change in Markups

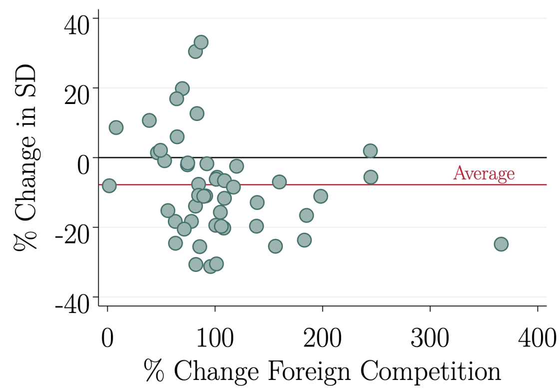


Note: Table 7 compares some model results in the benchmark with the results in a counterfactual scenario where there is no heterogeneity in import shares ($\phi_{ij} = 0.026\ \forall ij$). Panel (a) compares the change in the standard deviation of markups within industries (simple average across industries). Panel (b) compares the change in the standard deviation of industry-level average markups, where industry averages are computed as the harmonic cost-weighted average of markups. Panel (c) compares exit of home firms (percentage reduction in the number of active home firms), entry of foreign firms (percentage increase in the number of active foreign firms), and the percentage change in foreign competition, all for the domestic economy. Figure 8 plots the change in cost-weighted harmonic average markups after the boom by firm size. Large firms (red bars) are those in the top 25% of industry revenue shares (ω_{ij}), while small firms (blue bars) are those in the remaining 75%. Dark colors are changes in the benchmark, while light colors are the corresponding changes in the counterfactual without heterogeneity in import shares.

I then study a counterfactual scenario where all firms import the same share of materials. I set $\phi_{ij} = 0.026\ \forall ij$ to keep the average import share equal to 7.6% as in the data. Table 7 compares some of the results with and without heterogeneity in ϕ_{ij}. First, I find that heterogeneity in import shares accounts for over half of the fall in markup dispersion within industries and approximately one third of the reduction in across industry dispersion. Figure 8 compares the change in average markups of different groups of firms with and without heterogeneity. The average of all large firms falls less in the absence of import share heterogeneity, consistent with dispersion falling less.

On one hand, we see that heterogeneity in import shares explains virtually all the increase in dispersion within industries for the subset of domestic firms. As we can see in Figure 8, the average of large home firms would have increased much less in the absence of this

Figure 9: Heterogeneous effects across industries by change in foreign competition



Note: This figure shows the percentage change in markup dispersion for each industry, as a function of the percentage change in foreign competition experienced by that industry. The red line represent the simple average of changes in dispersion across industries.

channel. When all firms import the same share of materials, large firms lose the advantage they had and they reduce their markups more. This channel also explains a small fraction of the exit of (small) home firms because it represents an advantage for large firms.

On the other hand, heterogeneity in import shares reduces the dispersion in markups for foreign firms. In the absence of this channel, markup dispersion within industries would have increased more than twice as much for foreign firms. As we can see in Figure 8, the change in average markups of large foreign firms is very similar with or without import heterogeneity. However, as we can see in panel (c) of Table 7, in the absence of this channel there is more entry of foreign firms (107.6% vs 98.6%) and foreign competition increases substantially more (94.4% vs 72.7%).

5.2 Effect of Higher Foreign Competition

In the previous section I show that the commodity boom leads to a reduction in within-industry markup dispersion of 8% on average across industries. Figure 9 shows that this average (the red horizontal line in the figure) hides significant heterogeneity across industries. Each dot is an industry, showing on the horizontal axis the percentage change in foreign competition in that industry, and on the vertical axis the percentage change in within-industry markup dispersion. While in most industries dispersion falls, there is a non-negligible number of industries for which dispersion increases. Markup dispersion falls more in the industries where foreign competition increased the most, pointing to the importance of the competition channel. Figure 19 in the Appendix also reports how the change in dispersion by industry correlates with the initial level of foreign competition, the use of imported materials and industry size.

6 Supportive Evidence: Copper Boom and Markup Dispersion in Chile

In this section I provide some evidence supporting the predictions of the model, using the micro data for Chile used to calibrate the model. Like in the case of most commodities, the price of copper increased sharply in the first half of the 2000s, more than tripling between 2002 and 2007 (as can be seen in Figure 10). For Chile, the largest copper producer in the world, this led to a sizable increase in income and a real exchange appreciation of 24.3% (Figure 21). I estimate markups for domestic firms at the firm level and find that large firms increased markups more than small firms during the copper boom. Since large firms showed higher levels of markups to begin with, this differential adjustment implied an increase in markup dispersion, qualitatively consistent with the predictions of the model.

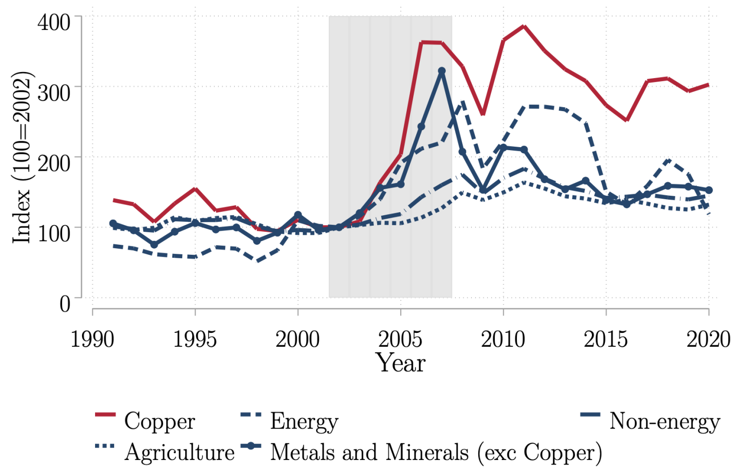
6.1 Markup Estimation

Using the manufacturing survey described in section 3.1, I estimate markups at the firm level applying the framework proposed by De De Loecker & Warzynski (2012). The markup of firm i at time t is estimated as:

$$\mu_{it} = \theta_{it}^{X} \left(\alpha_{it}^{X}\right)^{-1} \tag{6.1}$$

where θ_{it}^{X} is the output elasticity of a variable input and α_{it}^{X} is the input's expenditure share.

Figure 10: Commodity prices



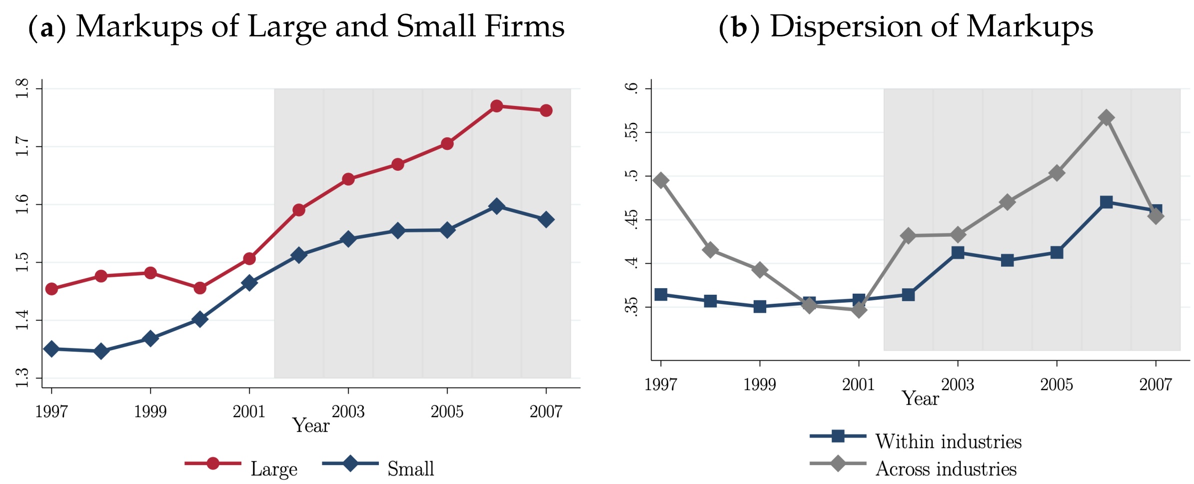
Note: World Bank Commodity Price Data (The Pink Sheet). Prices are in real US dollars, normalized to 100 in 2002.

I choose materials as the variable input, as it can be argued that it is almost free of adjustment costs (or at least more than labor, the other candidate variable input). Estimation details can be found in the Appendix section D.2.

6.2 Evidence of Differential Markup Adjustment During a Commodity Boom

The markup estimates reveal a differential adjustment by firms of different sizes during the commodity boom episode, as can be seen in Figure 11. Large firms, defined as those in the top 25% of industry revenue shares, increased their markups by 10.8%. Small firms, those in the remaining 75% of industry revenues, only increased them by 4.1%. Since large firms showed higher levels of markups to begin with, this differential adjustment implied an increase in markup dispersion within industries of 26.5% on average. On the other hand, dispersion across industries increases by 5.2%. These numbers are qualitatively consistent with the increases in markup dispersion of home firms found in the quantitative exercise of 13.6% (within) and 35.9% (across).

Figure 11: Estimated Markups for Domestic Firms



Note: own estimations using data from Chile's Encuesta Nacional Industrial Anual (INE). Panel (a) shows the mean over time for two groups: small firms (in the bottom 75% of industry revenue shares) and large firms (in the top 75% of industry revenue shares). Panel (b) shows markup dispersion within and across industries. Within industry dispersion is the simple mean of industries' standard deviation of markups and across industry dispersion is the standard deviation of industries' cost-weighted harmonic average markups.

7 Conclusions

I study the effects of commodity booms on reallocation of resources within the tradable sector in the presence of market power distortions. Using a two-country model with variable markups, I explore two channels that can lead to reallocation after a commodity boom. First, a commodity boom is associated with a strong real exchange appreciation that increases foreign competition on domestic producers. This forces many small domestic firms to exit and large firms to reduce their markups to retain market share. At the same time, it induces entry by foreign firms and a reallocation of production to foreign producers. Second, the appreciation reduces the relative price of imported materials relative to domestic ones, affecting mostly large domestic firms that import a higher share of the materials they use in production. This proves to be an advantage for large domestic firms, mitigating the reduction in markups and the reallocation of market shares to foreign producers.

I calibrate the model to Chile, a country that has experienced large commodity booms in recent decades, using firm-level data from a Survey of the manufacturing sector. I find substantial reallocation as a response to an increase in commodity prices of the size observed in the early 2000s for copper, Chile's main export product. As the real exchange appreciates, markup dispersion falls in the domestic economy and the welfare losses generated by misallocation decrease. I find that both channels play a role: heterogeneity in import shares accounts for approximately half of the reduction in markup dispersion. I also find that, while dispersion within industries falls on average, the effect is heterogeneous across industries. Dispersion falls more in industries that experienced larger increases in the level of foreign competition.

However, if we focus only on domestic firms, we see that markup dispersion increases with the boom. There is a composition effect, by which the average markup of large firms increases because large firms are, on average, larger. I estimate markups using the firm-level data for Chilean firms following the De Loecker & Warzynski (2012) framework, and find that this pattern is qualitatively consistent with the data. Markup dispersion among domestic firms increases by 26.5% during the boom in copper prices. The model can therefore explain approximately half the increase in markup dispersion observed in the data during this period.

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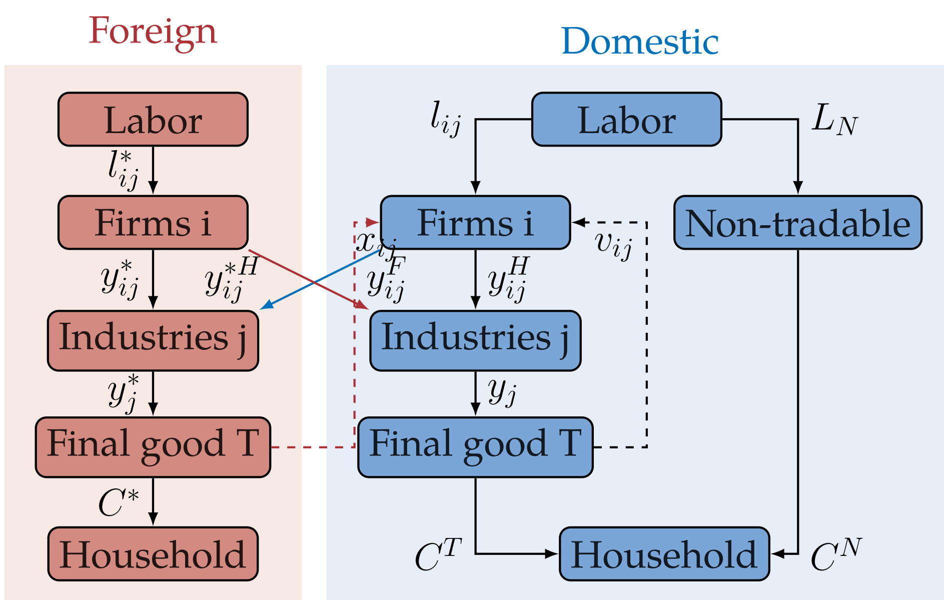
Appendix

A Model Details

A.1 Description of Economy

Figure 12: Schematic model structure



A.2 Final Good Producers' Problem

The producers of the tradable final good choose domestic and foreign intermediate inputs, with prices p^H_{ij} and p^F_{ij} respectively, to maximize their profits:

$$P^T Y^T - \int_0^1 \left(\sum_{i=1}^{N_j} p^H_{ij} y^H_{ij} + \tau \sum_{i=1}^{N_j} p^F_{ij} y^F_{ij} \right) dj \tag{A.1}$$

$$\text{subject to (2.7) and (2.8)} \tag{A.2}$$

We can split this problem in two stages. First, the producer chooses y_j to maximize:

$$P^T \left(\int_0^1 y_j^{\frac{\theta-1}{\theta}} dj \right)^{\frac{\theta}{\theta-1}} - \int_0^1 p_j y_j dj \tag{A.3}$$

where the F.O.C. leads to industry-level demand given by:

$$y_j = \left(\frac{p_j}{P^T}\right)^{-\theta} Y^T \tag{A.4}$$

Then, final good producers choose y_{ij}^H and y_{ij}^F to maximize:

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

where F.O.C.s lead to demands

$$y_{ij}^H = \left(\frac{p_{ij}^H}{p_j}\right)^{-\gamma} y_j \tag{A.6}$$

$$y_{ij}^F = \left(\frac{\tau p_{ij}^F}{p_j}\right)^{-\gamma} y_j \tag{A.7}$$

Combining these with (A.4) we get equations (2.14) and (2.15) in the main text.

A.3 Intermediate Firms' Problem

A.3.1 Price Setting

A home firm in the home market solves:

$$\begin{aligned}
\pi_{ij}^H := \max_{y_{ij}^H, \psi_{ij}^H} & \left[\left(p_{ij}^H - MC_{ij}\right) y_{ij}^H - W f_d\right] \psi_{ij}^H \\
\text{s.t.} & \\
p_{ij}^H &= \left(\frac{y_{ij}^H}{y_j}\right)^{-\frac{1}{\gamma}} \left(\frac{y_j}{Y_t^T}\right)^{-\frac{1}{\theta}} P^T \\
Y^T &= \left(\int_0^1 y_j^{\frac{\theta-1}{\theta}} dj\right)^{\frac{\theta}{\theta-1}} \\
y_j &= \left(\sum_{i=1}^{N_j} {y_{ij}^H}^{\frac{\gamma-1}{\gamma}} + \sum_{i=1}^{N_j} {y_{ij}^F}^{\frac{\gamma-1}{\gamma}}\right)^{\frac{\gamma}{\gamma-1}}
\end{aligned}$$

First we find the optimal y_{ij}^H if the firm decides to produce $\psi_{ij}^H = 1$, and then choose $\psi_{ij}^H = 1$

if this level of output makes non-negative profits and 0 otherwise. The FOC is:

$$\frac{\partial p_{ij}^H}{\partial y_{ij}^H} y_{ij}^H + \left(p_{ij}^H - MC_{ij}\right) = 0 \tag{A.8}$$

which results in

$$p_{ij}^H = \frac{\varepsilon_{ij}^H}{\varepsilon_{ij}^H - 1} MC_{ij} \tag{A.9}$$

where $\varepsilon_{ij}^H = -\frac{\partial y_{ij}^H}{\partial p_{ij}^H} \frac{p_{ij}^H}{y_{ij}^H}$. Taking derivatives:

$$\begin{aligned} \frac{\partial p_{ij}^H}{\partial y_{ij}^H} &= -\frac{1}{\gamma} \frac{p_{ij}^H}{y_{ij}^H} + \left(\frac{1}{\gamma} - \frac{1}{\theta}\right) \frac{p_{ij}^H}{y_j} \frac{\partial y_j}{\partial y_{ij}^H} & \text{(A.10)} \\ &= -\frac{p_{ij}^H}{y_{ij}^H} \left[\frac{1}{\gamma} - \left(\frac{1}{\gamma} - \frac{1}{\theta}\right) \left(\frac{y_{ij}^H}{y_j}\right)^{1-\frac{1}{\gamma}}\right] & \text{(A.11)} \\ &= -\frac{p_{ij}^H}{y_{ij}^H} \left[\frac{1}{\gamma} - \left(\frac{1}{\gamma} - \frac{1}{\theta}\right) \omega_{ij}^H\right] & \text{(A.12)} \end{aligned}$$

where I used $\frac{\partial y_j}{\partial y_{ij}^H} = \left(\frac{y_{ij}^H}{y_j}\right)^{-\frac{1}{\gamma}}$ and $\left(\frac{y_{ij}^H}{y_j}\right)^{1-\frac{1}{\gamma}} = \left(\frac{p_{ij}^H}{p_j}\right)^{1-\gamma} = \omega_{ij}^H$. Finally, we get equation (2.20) from the main text:

$$\varepsilon_{ij}^H = -\frac{\partial y_{ij}^H}{\partial p_{ij}^H} \frac{p_{ij}^H}{y_{ij}^H} = \left(\omega_{ij}^H \frac{1}{\theta} + (1 - \omega_{ij}^H) \frac{1}{\gamma}\right)^{-1} \tag{A.13}$$

A.3.2 Cost Minimization

We can solve intermediate domestic firm's cost minimization in two stages. First, firms choose between imported and domestic materials:

$$\begin{aligned} &\min_{x_{ij}, v_{ij}} P^* x_{ij} + P^T v_{ij} \\ &\qquad \text{s.t.} \;\; m_{ij} = \left[\phi_{ij}^{\frac{1}{\rho}} x_{ij}^{\frac{\rho-1}{\rho}} + (1 - \phi_{ij})^{\frac{1}{\rho}} v_{ij}^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}} \end{aligned}$$

First order conditions result in relative demands that satisfy:

$$\frac{v_{ij}}{x_{ij}} = \left(\frac{P^T}{P^*}\right)^{-\rho} \frac{1 - \phi_{ij}}{\phi_{ij}}$$

Substituting this in the definition of m_{ij} and then in the equation that defines the price index for the material composite ($P_{ij}^m m_{ij} = P^* x_{ij} + P^T v_{ij}$) we obtain the following expression for P_{it}^m:

$$P_{ij}^m = \left[\phi_{ij}(P^*)^{1-\rho} + (1-\phi_{ij})(P^T)^{1-\rho}\right]^{\frac{1}{1-\rho}} \tag{A.14}$$

Then, in the second stage, firms choose their labor and material demand to minimize the total cost of inputs:

$$\min_{l_{ij},m_{ij}} W l_{ij} + P_{ij}^m m_{ij}$$
$$s.t.\ y_{ij} = a_{ij} l_{ij}^{1-\alpha} m_{ij}^{\alpha}$$

First order conditions lead to relative demands given by:

$$\frac{m_{ij}}{l_{ij}} = \frac{W}{P_{ij}^m}\frac{\alpha}{1-\alpha}$$

Then, following the same steps as before, we can write firm i's marginal cost as:

$$MC_{ij} = \left(\frac{W}{1-\alpha}\right)^{1-\alpha}\left(\frac{P_{ij}^m}{\alpha}\right)^{\alpha}\frac{1}{a_{ij}} \tag{A.15}$$

where P_{ij}^m is defined as in equation (A.14). Finally, we can express factor demands as:

$$l_{ij} = \frac{1-\alpha}{W} MC_{ij} y_{ij} \tag{A.16}$$

$$x_{ij} = \frac{\alpha\phi_{ij}}{(P^*)^{\rho}(P_{ij}^m)^{1-\rho}} MC_{ij} y_{ij} \tag{A.17}$$

$$v_{ij} = \frac{\alpha(1-\phi_{ij})}{(P^T)^{\rho}(P_{ij}^m)^{1-\rho}} MC_{ij} y_{ij} \tag{A.18}$$

A.4 Solving the Planner Problem

The Lagrangian of the global planner problem is:

$$
\begin{aligned}
\mathcal{L} &= \Omega\left(\chi \ln C^T + (1-\chi)\ln C^N\right) + \Omega^*\left(\ln C^*\right) \\
&+ \zeta_T \left(\left(\int_0^1 (y_j)^{\frac{\theta-1}{\theta}} dj \right)^{\frac{\theta}{\theta-1}} - C_T - \int_0^1 \left(\sum_{i=1}^{N_j} v_{ij} \right) dj \right) \\
&+ \zeta_N \left(L_N - C_N \right) \\
&+ \zeta_T^* \left(\left(\int_0^1 (y_j^*)^{\frac{\theta-1}{\theta}} dj \right)^{\frac{\theta}{\theta-1}} - C_T^* - \int_0^1 \left(\sum_{i=1}^{N_j} x_{ij} \right) dj \right) \\
&+ \zeta_j \left(y_j - \left(\sum_{i=1}^{N_j} \psi_{ij}^H (y_{ij}^H)^{\frac{\gamma-1}{\gamma}} + \sum_{i=1}^{N_j} \psi_{ij}^F (y_{ij}^F)^{\frac{\gamma-1}{\gamma}} \right)^{\frac{\gamma}{\gamma-1}} \right) \\
&+ \zeta_{j^*} \left(y_{j^*} - \left(\sum_{i=1}^{N_j} \psi_{ij}^{*F} (y_{ij}^{*F})^{\frac{\gamma-1}{\gamma}} + \sum_{i=1}^{N_j} \psi_{ij}^{*H} (y_{ij}^{*H})^{\frac{\gamma-1}{\gamma}} \right)^{\frac{\gamma}{\gamma-1}} \right) \\
&+ \zeta_{ij} \left(y_{ij}^H + \tau y_{ij}^{*H} - a_{ij} l_{ij}^{1-\alpha} \left(\phi_{ij}^{\frac{1}{\rho}} x_{ij}^{\frac{\rho-1}{\rho}} + (1-\phi_{ij})^{\frac{1}{\rho}} \nu_{ij}^{\frac{\rho-1}{\rho}} \right)^{\frac{\alpha\rho}{\rho-1}} \right) \\
&+ \zeta_{ij^*} \left(\tau y_{ij}^F + y_{ij}^{*F} - a_{ij}^* l_{ij}^* \right) \\
&+ \zeta_L \left(L - \int_0^1 \left(\sum_{i=1}^{N_j} l_{ij} \right) dj - \int_0^1 \left(\sum_{i=1}^{N_j} f_d \psi_{ij}^H + f_x \psi_{ij}^{*H} \right) dj - L_N \right) \\
&+ \zeta_L^* \left(L^* - \int_0^1 \left(\sum_{i=1}^{N_j} l_{ij}^* \right) dj - \int_0^1 \left(\sum_{i=1}^{N_j} f_d \psi_{ij}^{*F} + f_x \psi_{ij}^F \right) dj \right)
\end{aligned}
$$

The FOCs of this problem are:

$$\frac{\Omega\chi}{C_T} = \zeta_T \tag{A.19}$$
$$\frac{\Omega(1-\chi)}{C_N} = \zeta_N \tag{A.20}$$
$$\frac{\Omega^*}{C^*} = \zeta_T^* \tag{A.21}$$
$$y_j^{-\frac{1}{\theta}} Y_T^{\frac{1}{\theta}} \zeta_T = \zeta_j \tag{A.22}$$
$$y_{j^*}^{-\frac{1}{\theta}} Y_{T^*}^{\frac{1}{\theta}} \zeta_{T^*} = \zeta_{j^*} \tag{A.23}$$
$$(y_{ij}^H)^{-\frac{1}{\gamma}} y_j^{\frac{1}{\gamma}} \zeta_j = \zeta_{ij} \tag{A.24}$$
$$(y_{ij}^F)^{-\frac{1}{\gamma}} y_j^{\frac{1}{\gamma}} \zeta_j = \tau\zeta_{ij^*} \tag{A.25}$$
$$(y_{ij}^{*H})^{-\frac{1}{\gamma}} y_{j^*}^{\frac{1}{\gamma}} \zeta_{j^*} = \tau\zeta_{ij} \tag{A.26}$$
$$(y_{ij}^{*F})^{-\frac{1}{\gamma}} y_{j^*}^{\frac{1}{\gamma}} \zeta_{j^*} = \zeta_{ij^*} \tag{A.27}$$
$$(1-\alpha) a_{ij} l_{ij}^{-\alpha} m_{ij}^{\alpha} \zeta_{ij} = \zeta_L \tag{A.28}$$
$$\alpha a_{ij} \phi_{ij}^{\frac{1}{\rho}} m_{ij}^{\alpha-1+\frac{1}{\rho}} x_{ij}^{-\frac{1}{\rho}} l_{ij}^{1-\alpha} \zeta_{ij} = \zeta_T^* \tag{A.29}$$
$$\alpha a_{ij} (1-\phi_{ij})^{\frac{1}{\rho}} m_{ij}^{\alpha-1+\frac{1}{\rho}} v_{ij}^{-\frac{1}{\rho}} l_{ij}^{1-\alpha} \zeta_{ij} = \zeta_X \tag{A.30}$$
$$a_{ij}^* \zeta_{ij^*} = \zeta_L^* \tag{A.31}$$
$$\zeta_N = \zeta_L \tag{A.32}$$

From these F.O.C.s we can obtain expressions for multipliers ζ_{ij} and ζ_{ij^*} that resemble the expressions for marginal costs in the market equilibrium:

$$\zeta_{ij} = \left(\frac{\left[\phi_{ij}(\zeta_T^*)^{1-\rho} + (1-\phi_{ij})\zeta_T^{1-\rho}\right]^{\frac{1}{1-\rho}}}{\alpha} \right)^{\alpha} \left(\frac{\zeta_L}{1-\alpha} \right)^{1-\alpha} a_{ij}^{-1} \tag{A.33}$$
$$\zeta_{ij}^* = \zeta_L^* (a_{ij}^*)^{-1} \tag{A.34}$$

We also obtain the following expressions for industry-level multipliers ζ_j and ζ_j^*:

$$\zeta_j = \left(\sum_{i=1}^{N_j} \psi_{ij}^H (\zeta_{ij})^{1-\gamma} + (\tau)^{1-\gamma} \sum_{i=1}^{N_j} \psi_{ij}^F \left(\zeta_{ij}^*\right)^{1-\gamma} \right)^{\frac{1}{1-\gamma}} \tag{A.35}$$

$$\zeta_j^* = \left(\sum_{i=1}^{N_j} \psi_{ij}^{*F} (\zeta_{ij}^*)^{1-\gamma} + (\tau)^{1-\gamma} \sum_{i=1}^{N_j} \psi_{ij}^{*H} \left(\zeta_{ij}^*\right)^{1-\gamma} \right)^{\frac{1}{1-\gamma}} \tag{A.36}$$

and aggregate multipliers ζ_T and ζ_T^*:

$$\zeta_T = \left(\int_0^1 (\zeta_j)^{1-\theta} dj \right)^{\frac{1}{1-\theta}} \tag{A.37}$$

$$\zeta_T^* = \left(\int_0^1 (\zeta_j^*)^{1-\theta} dj \right)^{\frac{1}{1-\theta}} \tag{A.38}$$

Finally, we can obtain expressions for labor multipliers ζ_L and ζ_L^* from labor market clearing conditions:

$$\zeta_L = \frac{(1-\alpha) \int_0^1 \left(\sum_{i=1}^{N_j} y_{ij}^H \zeta_{ij} + \sum_{i=1}^{N_j} \tau y_{ij}^{*H} \zeta_{ij} \right)}{L - \int_0^1 \left(\sum_{i=1}^{N_j} f_d \psi_{ij}^H + f_x \psi_{ij}^{*H} \right) dj - L_N} \tag{A.39}$$

$$\zeta_L^* = \frac{\int_0^1 \left(\sum_{i=1}^{N_j} y_{ij}^{*F} \zeta_{ij}^* + \sum_{i=1}^{N_j} \tau y_{ij}^F \zeta_{ij}^* \right)}{L^* - \int_0^1 \left(\sum_{i=1}^{N_j} f_d \psi_{ij}^{*F} + f_x \psi_{ij}^F \right) dj} \tag{A.40}$$

A.5 Implementing the Efficient Allocation

I implement the efficient as a market equilibrium by setting taxes/subsidies on the purchase of intermediate goods in both economies that correct the distortion generated by market power. I set a tax (or subsidy) τ_{ij}^k with $k = H, F, *H, *F$ on the purchase of y_{ij}^k by the final good producer in each country, which shifts the demand for these intermediate goods. The final good producers are now subject to total costs of

$$\int_0^1 \left(\sum_{i=1}^{N_j} \tau_{ij}^H p_{ij}^H y_{ij}^H + \tau \sum_{i=1}^{N_j} \tau_{ij}^F p_{ij}^F y_{ij}^F \right) dj \tag{A.41}$$

$$\int_0^1 \left(\sum_{i=1}^{N_j} \tau_{ij}^{*F} p_{ij}^{*F} y_{ij}^{*F} + \tau \sum_{i=1}^{N_j} \tau_{ij}^{*H} p_{ij}^{*H} y_{ij}^{*H} \right) dj \tag{A.42}$$

and demand functions become:

$$y_{ij}^H = \left(\frac{\tau_{ij}^H p_{ij}^H}{p_j}\right)^{-\gamma} y_j, \qquad y_{ij}^F = \left(\frac{\tau\tau_{ij}^F p_{ij}^F}{p_j}\right)^{-\gamma} y_j \tag{A.43}$$

$$y_{ij}^{F*} = \left(\frac{\tau_{ij}^{F*} p_{ij}^{F*}}{p_j^*}\right)^{-\gamma} y_j^*, \qquad y_{ij}^{H*} = \left(\frac{\tau\tau_{ij}^{H*} p_{ij}^{H*}}{p_j^*}\right)^{-\gamma} y_j^* \tag{A.44}$$

To find the taxes that implement a given efficient allocation I first set industry-level and aggregate prices equal to the corresponding multipliers from the efficient allocation, where I first divide all multipliers by ζ_L^* so that W^* is the numeraire as in the market equilibrium.

$$W = \zeta_L \tag{A.45}$$

$$P^T = \zeta_T \tag{A.46}$$

$$P^* = \zeta_T^* \tag{A.47}$$

$$p_j = \zeta_j \tag{A.48}$$

$$p_j = \zeta_j^* \tag{A.49}$$

Notice that this also implies that $MC_{ij} = \zeta_{ij}$ and $MC_{ij}^* = \zeta_{ij}^*$.

We want to obtain the following allocations, which follow from equations (A.24)-(A.27):

$$y_{ij}^H = \left(\frac{\zeta_{ij}}{\zeta_j}\right)^{-\gamma} y_j \tag{A.50}$$

$$y_{ij}^F = \left(\frac{\tau\zeta_{ij}^*}{\zeta_j}\right)^{-\gamma} y_j \tag{A.51}$$

$$y_{ij}^{*F} = \left(\frac{\zeta_{ij}^*}{\zeta_j^*}\right)^{-\gamma} y_j^* \tag{A.52}$$

$$y_{ij}^{*H} = \left(\frac{\tau\zeta_{ij}}{\zeta_j^*}\right)^{-\gamma} y_j^* \tag{A.53}$$

In the market equilibrium with taxes/subsidies demands are determined by equations (A.43)-(A.44). Also since we set $p_j = \zeta_j$ and $p_j^* = \zeta_j^*$, to achieve the efficient allocation we just need to set taxes/subsidies such that:

$$\tau_{ij}^H p_{ij}^H = \zeta_{ij} \tag{A.54}$$

$$\tau\tau_{ij}^F p_{ij}^F = \tau\zeta_{ij}^* \tag{A.55}$$

$$\tau_{ij}^{F*} p_{ij}^{F*} = \zeta_{ij}^* \tag{A.56}$$

$$\tau\tau_{ij}^{H*} p_{ij}^{H*} = \tau\zeta_{ij} \tag{A.57}$$

To separate taxes and prices, we use the price decision of firms. Market shares are defined as $\omega_{ij}^H = \frac{\tau_{ij}^H p_{ij}^H}{p_j}$ (and analogously for ω_{ij}^F, ω_{ij}^{F*}, and ω_{ij}^{H*}) in the presence of taxes/subsidies, which allows us to get ϵ_{ij}^H from equation (2.20) and prices from equation (2.19).

Finally, transfers to the domestic economy are:

$$\text{Transfers} = P^T C^T + P^N C^N - \left(WL + \Pi + P^{Co}\bar{Y}^{Co} + \text{Taxes}^H + \text{Taxes}^F\right)$$

where

$$\text{Taxes}^H = \int_0^1 \left(\sum_{i=1}^{N_j} (\tau_{ij}^H - 1) p_{ij}^H y_{ij}^H\right), \qquad \text{Taxes}^F = \int_0^1 \left(\sum_{i=1}^{N_j} (\tau_{ij}^F - 1) p_{ij}^F y_{ij}^F\right)$$

I then chose the set of weights that give transfers equal to zero, which is the same as setting the trade balance equal to zero (as in the market equilibrium).

A.6 Welfare Losses

As is standard, I define welfare losses in consumption equivalent terms. For home consumers we have:

$$\text{Welfare}^{H,EA} = U\left((1+x)C^{T,CE}, (1+x)C^{N,CE}\right) \tag{A.58}$$

This means that consumers are willing to forgo x*100% of consumption to go from the market equilibrium to the efficient allocation. Similarly for foreign consumers:

$$\text{Welfare}^{F,EA} = U\left((1+x)C^{T*,CE}\right)$$

B Additional Results on Model Quantification

B.1 Cost versus Revenue Weighted Markups

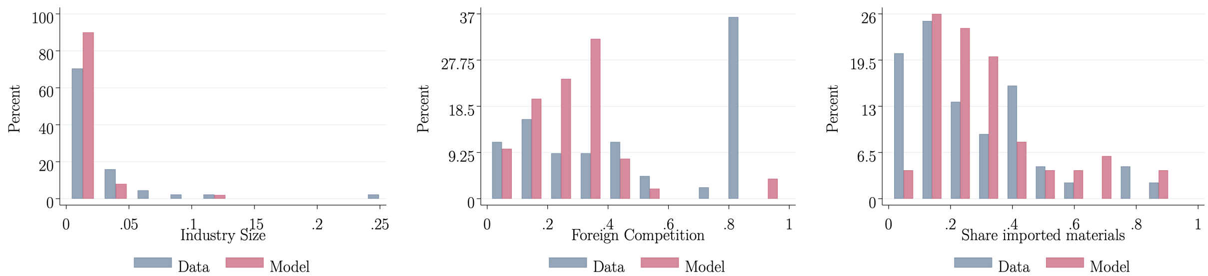
Table 8: Cost versus revenue weighted markups

Panel a. Cost-weighted Average Markups	All	Large	Small
All	1.20	1.23	1.11
Home	1.21	1.25	1.12
Foreign	1.15	1.18	1.11
Panel b. Revenue-weighted Average Markups	All	Large	Small
All	1.21	1.24	1.11
Home	1.22	1.27	1.12
Foreign	1.15	1.19	1.11

B.2 Non-targeted Moments

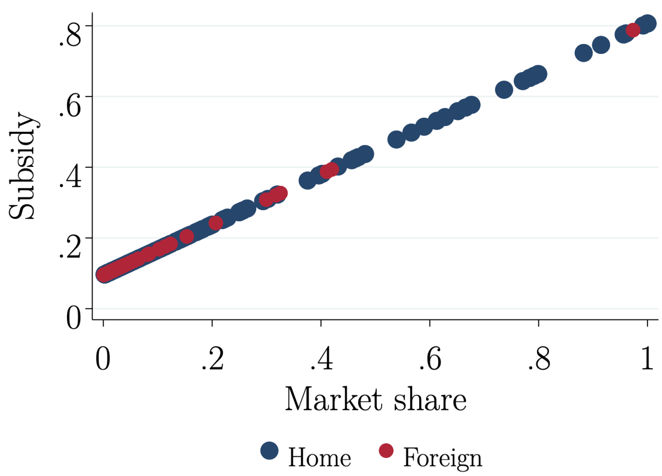
Figure 13: Histograms of industry distributions: data and model

(**a**) Industry size (**b**) Foreign competition (**c**) Share imported inputs



B.3 Implementing the Efficient Allocation

Figure 14: Subsidies



C Additional Results on Quantitative Exercise

C.1 Cost-weighted and Revenue-weighted Average Markups

Table 9: Dispersion across industries

	Before	After	% change
Panel a. Using cost-weighted averages			
All firms	0.075	0.073	-2.4
Home firms	0.095	0.128	35.9
Foreign firms	0.045	0.043	-4.9
Panel b. Using revenue-weighted averages			
All firms	0.109	0.105	-3.4
Home firms	0.130	0.160	23.2
Foreign firms	0.052	0.050	-2.6

Figure 15: Change in revenue-weighted average markups

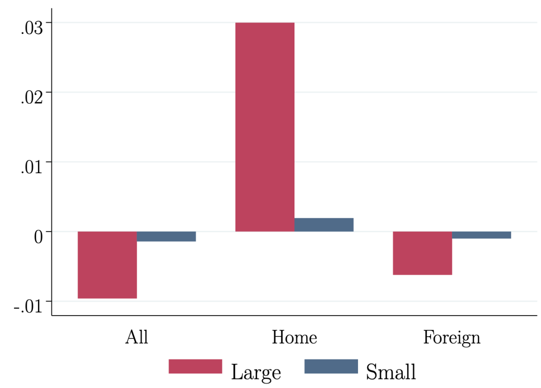


Table 10: Average Markups by Firm Size

	Cost-weighted		Revenue-weighted	
	Before	After	Before	After
All firms	1.197	1.193	1.213	1.208
Large	1.230	1.222	1.245	1.235
Small	1.113	1.112	1.113	1.112
Home firms	1.208	1.222	1.224	1.235
Large	1.253	1.281	1.271	1.300
Small	1.115	1.117	1.115	1.117
Foreign firms	1.147	1.151	1.149	1.154
Large	1.182	1.177	1.189	1.182
Small	1.112	1.111	1.112	1.111

C.2 Booms of Different Sizes

Table 11: Effects of a Commodity Boom

	Initial	Boom (a)	Boom (b)	Boom (c)
Panel a. Aggregates				
$\Delta P_t^{Co}(\%)$		131	262	393
$\Delta RER_t(\%)$		-8.6	-16.4	-23.4
Panel b. Markup Dispersion within Industries				
All firms	0.047	0.046	0.044	0.040
Home firms	0.053	0.057	0.061	0.063
Foreign firms	0.021	0.022	0.022	0.022
Panel c. Markup Dispersion across Industries				
All firms	0.075	0.074	0.073	0.070
Home firms	0.095	0.111	0.128	0.147
Foreign firms	0.045	0.044	0.043	0.042

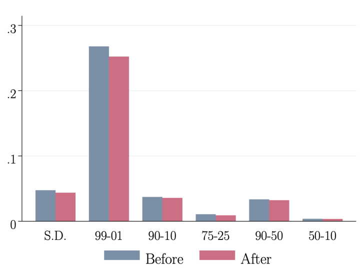
Table 12: Effects on Misallocation and Welfare

	Before Boom	Boom (a)	Boom (b)	Boom (c)
Panel a. Welfare Loss (Consumption Equivalent)				
Home	4.99	2.76	1.68	0.11
Foreign	2.14	1.97	1.79	1.62
Panel b. Output Loss				
Y_t^T	45.95	43.83	40.55	35.39
Y_t^*	2.40	2.23	2.04	1.88

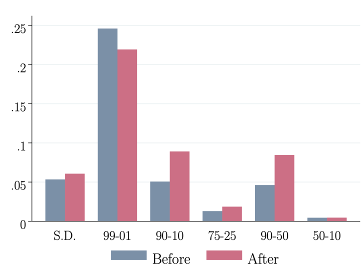
C.3 Other Measures of Dispersion

Figure 16: Alternative Measures of Dispersion

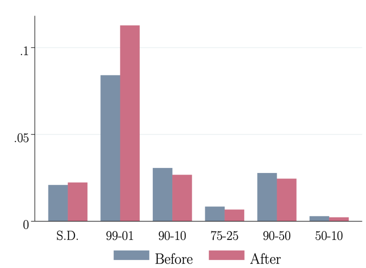
(a) All firms



(b) Home firms



(c) Foreign firms

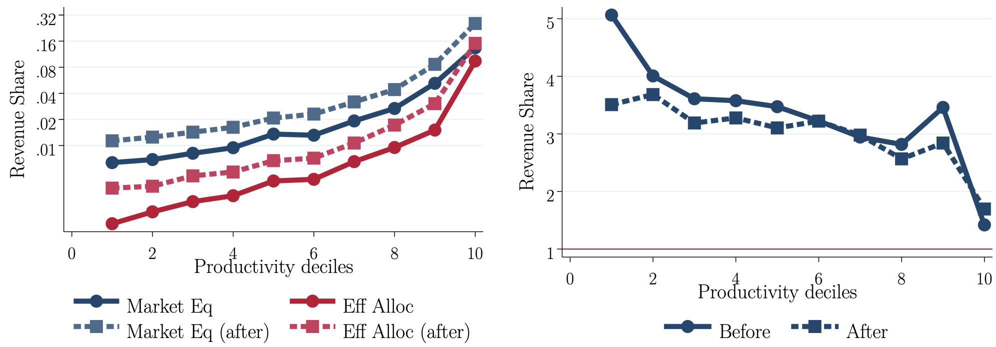


C.4 Reallocation of Foreign Firms

Figure 17: Reallocation for Foreign Firms

(**a**) Before and After

(**b**) Ratio CE over EA



Note: The y-axis in panel (a) is on a log scale.

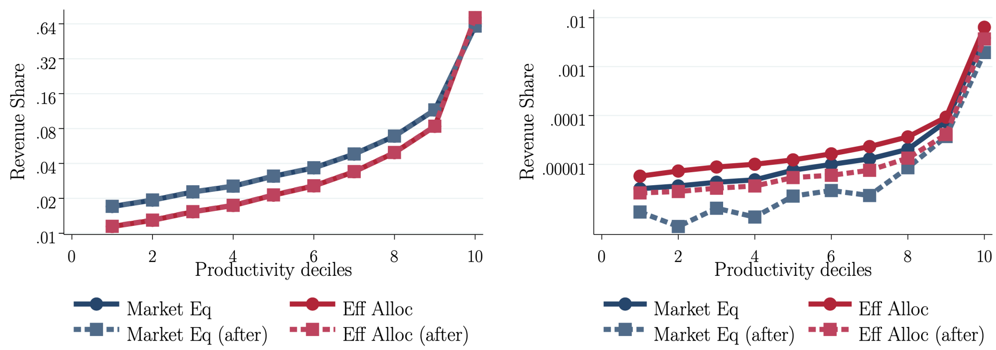
C.5 Results for Foreign Economy

Table 13: Number of active firms

	Before		After	
	CE	EA	CE	EA
Domestic Market				
Home	1573	1155	908	915
Foreign	1096	454	2177	816
Foreign Market				
Foreign	11729	11503	11729	11503
Home	158	186	51	80

Figure 18: Reallocation in Foreign Economy

(**a**) Foreign (**b**) Home



Note: The y-axis is on a log scale.

C.6 Channel Decomposition

Table 14: Change in output and welfare losses with and without heterogeneity in import shares

	Benchmark	$\phi_i = \bar{\phi} \forall i$
Panel a. Output Loss		
Y_t^T	-5.41	-6.95
Y_t^*	-0.36	-0.37
Panel b. Welfare Loss (Consumption Equivalent)		
Home	-3.31	-1.13
Foreign	-0.36	-0.38

Figure 19: Heterogeneous effects across industries

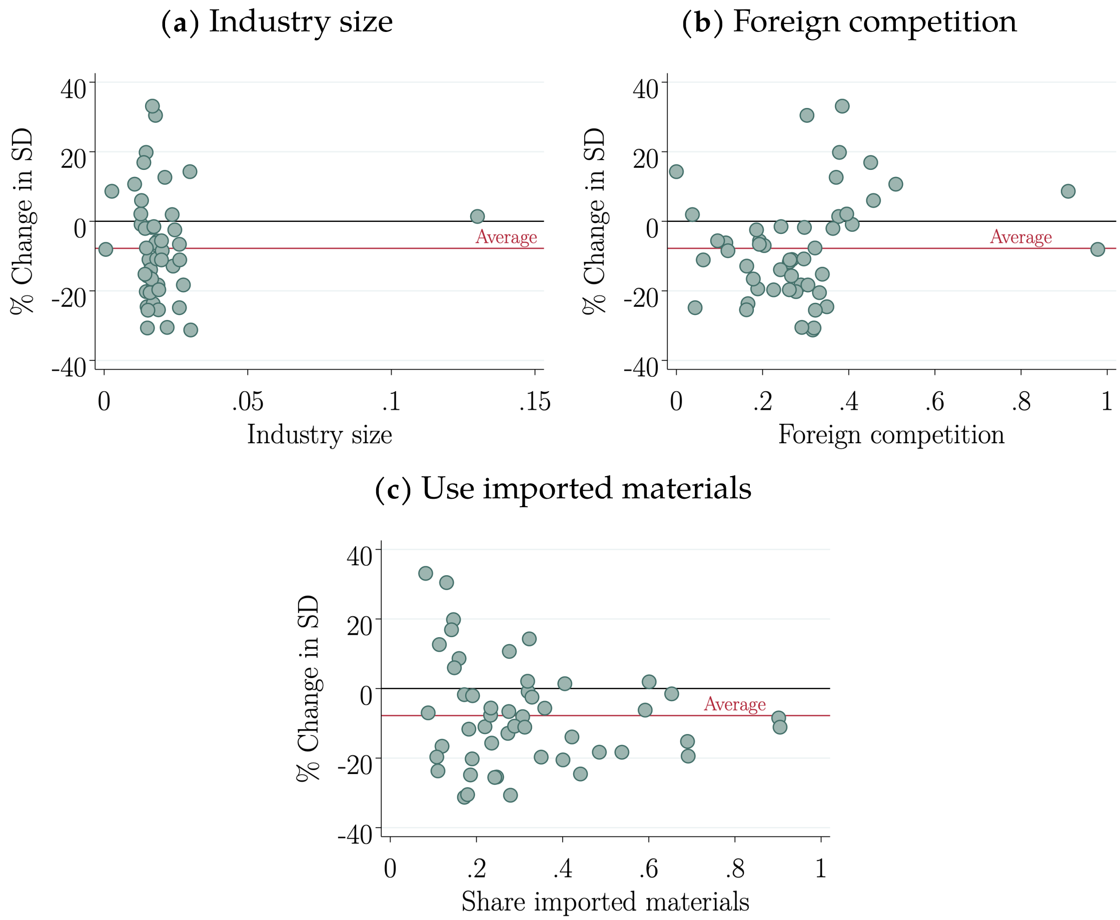
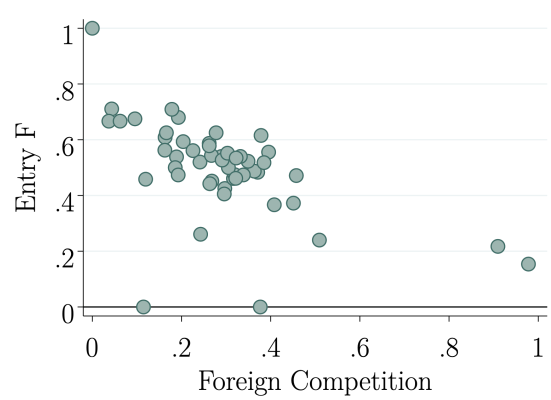


Figure 20: Foreign competition and entry

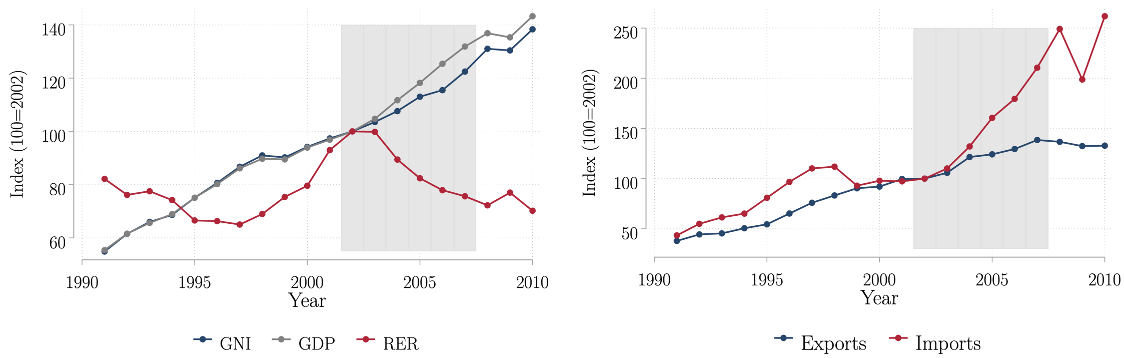


D Supportive Evidence

D.1 Commodity Boom in Chile

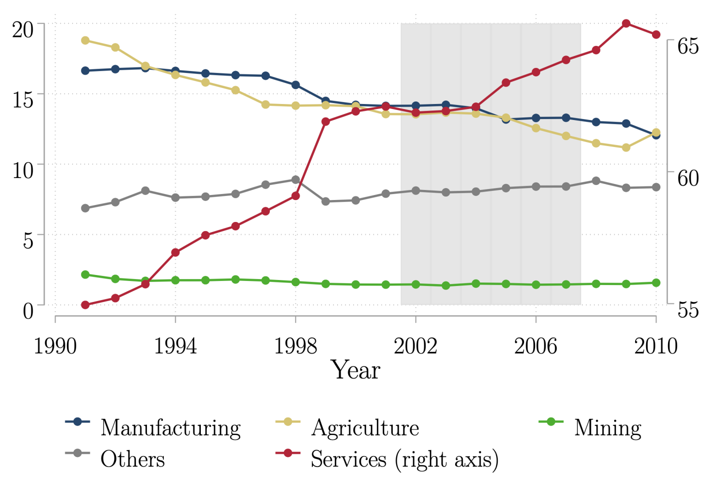
Figure 21: Commodity Boom in Chile

(**a**) Output and exchange rate (**b**) Exports and Imports



Source: World Development Indicators (World Bank).
Note: All values are indexes with respect to 2002. Gross Domestic Product (GDP) and Gross National Income (GNI) were originally in constant 2015 US$. The real exchange rate is defined as the nominal exchange rate of Chile with respect to the US$ times the CPI of the U.S. over the CPI of Chile. Exports and imports are volume indexes.

Figure 22: Employment Shares



Source: Instituto Nacional de Estadística

Table 15: Markups and firm size

	(1) Markups	(2) Markups	(3) Log Markups	(4) Log Markups
Log Sales	0.0159**		0.00869**	
	(0.000)		(0.000)	
Industry Share		0.551**		0.211*
		(0.006)		(0.049)
Observations	43365	43367	43365	43367

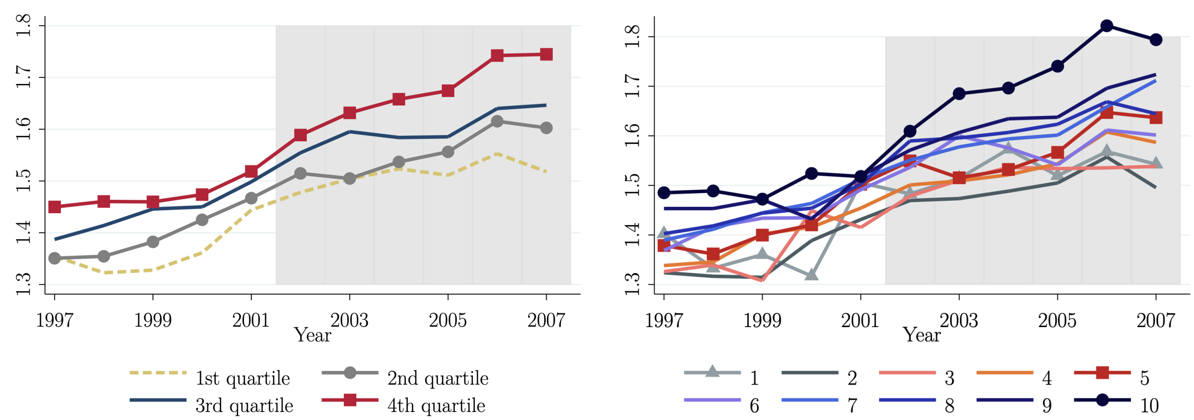
p-values in parentheses

Industry and Year fixed effects

* $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

Figure 23: Markups by firm size

(**a**) Quartiles (**b**) Deciles



D.2 Estimation Details

To estimate firm-level markups I follow the framework in De Loecker & Warzynski (2012), which relies on standard cost minimization conditions for variable inputs free of adjustment costs. This procedure relates firms' markup with the output elasticity of a variable input and the share of that input's expenditure in total sales. While expenditure shares can be taken (almost) directly from the data, output elasticities require estimates of the production function, which this procedure obtains by the use of proxy methods in the tradition of Olley & Pakes (1996), Levinsohn & Petrin (2003), and Ackerberg et al. (2015).

Expression for markups. We start by first deriving the expression for markups used in this procedure. A firm i at time t produces output using the following production technology:

$$Q_{it} = Q_{it}\left(X_{it}^{1}, ..., X_{it}^{V}, K_{it}, \omega_{it}\right) \tag{D.1}$$

where X_{it}^v is the quantity used of variable input $v = 1 : V$, K_{it} is capital and ω_{it} is the firm's productivity. We assume that active producers are minimizing costs, with Lagrangian function:

$$L\left(X_{it}^1, ..., X_{it}^V, K_{it}, \lambda_{it}\right) = \sum_{v=1}^{V} P_{it}^{X^v} X_{it}^v + r_{it}K_{it} + \lambda_{it}\left(Q_{it} - Q_{it}(\cdot)\right) \tag{D.2}$$

Then the FOC for any variable input free of adjustment costs is:

$$\frac{\partial L_{it}}{\partial X_{it}^v} = P_{it}^{X^v} - \lambda_{it}\frac{\partial Q_{it}(\cdot)}{\partial X_{it}^v} = 0 \tag{D.3}$$

Rearranging:

$$\frac{\partial Q_{it}(\cdot)}{\partial X_{it}^v}\frac{X_{it}^v}{Q_{it}} = \frac{1}{\lambda_{it}}\frac{P_{it}^{X^v} X_{it}^v}{Q_{it}} \tag{D.4}$$

We define markups as the ratio of prices over the marginal cost of production, $\mu_{it} \equiv \frac{P_{it}}{\lambda_{it}}$. Denote the output elasticity of input X with $\theta_{it}^X \equiv \frac{\partial Q_{it}(\cdot)}{\partial X_{it}^v}\frac{X_{it}^v}{Q_{it}}$ and the expenditure share of that same input as $\alpha_{it}^X = \frac{P_{it}^{X^v} X_{it}^v}{P_{it}Q_{it}}$. Then we obtain the following expression for markups:

$$\mu_{it} = \theta_{it}^X\left(\alpha_{it}^X\right)^{-1} \tag{D.5}$$

Output elasticity. First, to obtain the output elasticity we perform production function estimation. We restrict to production functions with a scalar Hicks-neutral productivity term and common technology parameters within industries:

$$Q_{it} = F\left(X_{it}^1, ..., X_{it}^V, K_{it}; \beta\right)\exp(\omega_{it}) \tag{D.6}$$

This allows us to rely on proxy methods (Olley & Pakes, 1996; Levinsohn & Petrin, 2003; Ackerberg et al., 2015) to obtain consistent estimates of the technology parameters β. For the empirical specification, we allow for measurement error in output and unanticipated shocks, combined into ϵ_{it}:

$$y_{it} = f(x_{it}, k_{it}; \beta) + \omega_{it} + \epsilon_{it} \tag{D.7}$$

We use a flexible approximation to $f(\cdot)$, the translog production function, meaning that $f(\cdot)$ is approximated by a second order polynomial that includes all inputs, inputs squared and interaction terms. This step can be done using value added or gross output specifications. I choose the latter, as it allows using materials as variable inputs in the markup estimation. To obtain consistent estimates of the production function, we need to control for unobserved productivity shocks, which are potentially correlated with input choices. Following Levinsohn & Petrin (2003) we rely on material demand to proxy for productivity by inverting $m_t(\cdot)$

$$m_{it} = m_t(k_{it}, \omega_{it}, \mathbf{z_{it}}) \rightarrow \omega_{it} = h_t(m_{it}, k_{it}, \mathbf{z_{it}}) \tag{D.8}$$

where $\mathbf{z_{it}}$ collects all additional variables that can affect input demand. As long as $\frac{\partial m}{\partial \omega} > 0$ (monotonicity of intermediate inputs) we can use $h_t(m_{it}, k_{it}, \mathbf{z_{it}})$ to proxy for productivity in the production function estimation[12].

De Loecker & Warzynski (2012) depart from Levinsohn & Petrin (2003) by giving up on identifying any parameter in the first stage. They argue that, conditional on a nonparameteric function in capital, materials, and other variables affecting input demand, identification of the labor coefficient is not plausible.

The procedure then consist on two steps. Consider the gross output translog specification:

$$y_{it} = \beta_l l_{it} + \beta_k k_{it} + \beta_m m_{it} + \beta_{ll} l_{it}^2 + \beta_{kk} k_{it}^2 + \beta_{mm} m_{it}^2 \tag{D.9}$$

$$+ \beta_{lk} l_{it} k_{it} + \beta_{lm} l_{it} m_{it} + \beta_{km} k_{it} m_{it} + \beta_{lkm} l_{it} k_{it} m_{it} + \omega_{it} + \epsilon_{it} \tag{D.10}$$

where l_{it} is labor demand, m_{it} is material demand, and k_{it} is the capital stock. In the first stage, we run:

$$y_{it} = \phi_t(l_{it}, k_{it}, m_{it}, \mathbf{z_{it}}) + \epsilon_{it} \tag{D.11}$$

In $\mathbf{z_{it}}$ I include cubic terms on k and m and their interaction, export status and its interaction with inputs, a price index for intermediate consumption (industry-specific) and the average wage in the firm (firm i's wage bill divided by its employment). This way we can obtain estimates of expected output $\hat{\phi}_{it}$, where expected output is given by:

$$\phi_{it} = \beta_l l_{it} + \beta_k k_{it} + \beta_m m_{it} + \beta_{ll} l_{it}^2 + \beta_{kk} k_{it}^2 + \beta_{mm} m_{it}^2 + \beta_{lk} l_{it} k_{it} \tag{D.12}$$

$$+ \beta_{lm} l_{it} m_{it} + \beta_{km} k_{it} m_{it} + \beta_{lkm} l_{it} k_{it} m_{it} + h_t(m_{it}, k_{it}, \mathbf{z_{it}}) \tag{D.13}$$

The second stage provides estimates for all production function coefficients. After the first stage we can compute productivity for any value of β using:

$$\omega_{it}(\beta) = \hat{\phi}_{it} - \beta_l l_{it} - \beta_k k_{it} - \beta_m m_{it} - (...) - \beta_{lkm} l_{it} k_{it} m_{it} \tag{D.14}$$

Using the following law of motion for productivity:

$$\omega_{it} = g_t(\omega_{it-1}) + \xi_{it} \tag{D.15}$$

we can then recover the innovation to productivity $\xi_{it}(\beta)$ by non-parametrically regressing $\omega_{it}(\beta)$ on its lag. In this step I also control for export participation, as suggested by De Loecker & Warzynski (2012), since it is a decision by the firm that can affect current productivity outcomes. Then we form moments to obtain our estimates of the produc-

[12] Monotonicity condition holds for a large class of models of imperfect competition: Melitz & Levinsohn (2006) show that it holds as long as more productive firms do not set inordinately higher markups that less productive firms.

tion function, by imposing that the innovation to productivity has to be uncorrelated with current capital, lagged labor and materials, and their interactions:

$$E\left(\xi_{it}(\beta)\begin{pmatrix} l_{it-1} \\ k_{it} \\ m_{it-1} \\ l_{it-1}^2 \\ k_{it}^2 \\ m_{it-1}^2 \\ l_{it-1}m_{it-1} \\ l_{it-1}k_{it} \\ k_{it}m_{it-1} \\ l_{it-1}k_{it}m_{it-1} \end{pmatrix}\right) = 0 \tag{D.16}$$

We use standard GMM techniques to get the estimates of the production function coefficients. This stage is done industry-by-industry, obtaining coefficient estimates that are industry-specific. However, the output elasticities are firm-specific, as they are computed in the following way, using the estimated βs:

$$\hat{\theta}_{it}^{M} = \hat{\beta}_m + 2\hat{\beta}_{mm}m_{it} + \hat{\beta}_{lm}l_{it} + \hat{\beta}_{km}k_{it} + \hat{\beta}_{lkm}l_{it}k_{it} \tag{D.17}$$

Expenditure shares. To compute the expenditure shares we first correct output for measurement error (we observe $\tilde{Q}_{it} = Q_{it}\text{exp}(\epsilon_{it})$):

$$\hat{\alpha}_{it}^{M} = \frac{P_{it}^{M}M_{it}^{v}}{P_{it}\frac{\tilde{Q}_{it}}{\text{exp}(\hat{\epsilon}_{it})}} \tag{D.18}$$

This correction is important because it eliminates variation in expenditure shares that comes from variation in output not related to variables impacting input demand, such as prices, productivity, technology parameters, market characteristics. Finally, we obtain an estimate of the markup for firm i at time t as:

$$\hat{\mu}_{it} = \hat{\theta}_{it}^{M}\left(\hat{\alpha}_{it}^{M}\right)^{-1} \tag{D.19}$$