# Government Policies in a Granular Global Economy

Cecile Gaubert
cecile.gaubert@berkeley.edu

Oleg Itskhoki
itskhoki@econ.ucla.edu

Maximilian Vogler
mvogler@princeton.edu

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**Abstract**

We use the granular model of international trade developed in **?** to study the rationale and implications of three types of government interventions typically targeted at large individual firms – antitrust, trade and industrial policies. We find that in antitrust regulation, governments face an incentive to be overly lenient in accepting mergers of large domestic firms. It substitutes for beggar-thy-neighbor trade policy in sectors with strong comparative advantage. In trade policy, governments face marked incentives to target large individual foreign exporters rather than entire sectors. Doing so largely transforms the domestic burden of tariffs into a reduction of foreign producer surplus. Finally, we show that subsidizing 'national champions' is generally suboptimal in closed economies as it leads to an excessive build-up of market power, but it becomes unilaterally welfare improving in open economies. We contrast unilaterally optimal policies with the coordinated globally optimal policy and emphasize the need for international policy coordination in these domains.

# 1 Introduction

Large firms shape national economies (?), and shape international trade even more so. Indeed, ? find that firm-level "granular" forces shape comparative advantage and trade patterns: they account for about 20% of the sectoral variation in export intensity, and are more pronounced in highly export-intensive sectors. In this context, some very micro policy actions taken by governments, which concern only one or a couple of firms, end up having non trivial aggregate consequences. This is true in particular if they impact large exporters. One question that arises against this backdrop is: do governments see benefits in targeting individual firms rather than whole industries, when implementing various policies? Indeed, governments do take policy actions that are sometimes very narrow and appear tailor-made to target individual firms rather than industries. In particular, antitrust regulation, antidumping policies, and international sanctions all target large individual foreign firms.[1]

In this paper, we study the rationale for and consequences of such "granular" policies. We are particularly interested in the impact such national policies may have in a global economy. To do so, we adopt the quantitative model of trade with granular firms developed and estimated in ?. We use our model to study the general equilibrium implications of these policies in a granular open economy, both on the welfare of the home country and that of its trade partners. Across sectors, the model features classic Ricardian forces as in ?; crucially, within sectors, it features a discrete (but potentially large) number of heterogeneous firms, who are oligopolistically competitive. The model is quantified to match patterns of domestic sales and exports of French manufacturing firms. In particular, the distribution of firm size is very skewed, so that some large firms have sectoral market shares well within the two digits even in sectors comprised of a large number of firms. We use this framework to characterize the qualitative and quantitative properties of various government interventions, as well as compute the optimal ones.

We first shed light on merger policy, by studying the potential merger of two domestic firms who are leaders in their sector. We find that the desirability of a merger, from the perspective of the home government, depends crucially on how open the economy is. In general, mergers lead to some cost savings and productivity gains on the one hand; but they also lead to an increase in monopoly power, which reduces overall efficiency and also leads to a transfer of surplus from consumers to producers. In a relatively closed economy, the efficiency loss due to an increase in monopoly power tend to make mergers undesirable. However, in a more

[1] Recent examples of international antitrust regulations are the 2007 case of the European Commission (EC) against Microsoft Corporation and the 2017 fine imposed by the EC on Google. A very recent case of a granular trade war is the 292% tariff imposed by the US on a particular jet produced by the Canadian Bombardier. "Granular" tactics are particularly widespread in antidumping retaliation (see ?) and international sanctions (as in the recent case of the US against the Chinese ZTE).

open economy, mergers lead to a transfer of surplus to the merged home firm which is done, in part, at the expense of the foreign consumer surplus. Therefore, the more open the economy is, the more a given home merger is desirable, especially in sectors where home firms are export champions. This mechanism may lead to excessive leniency towards home mergers, especially in granular sectors and export-oriented sectors, at the expense of foreign trade partners. Indeed, we contrast Home's attitude towards home mergers, with Foreign's attitude towards the same merger. Finally, we contrast unilateral optimal decisions in merger policies with the coordinated global planner's solution. Our estimated model suggests that the negative spillover effects on the Foreign country and aggregate welfare are significant quantitatively, and are particularly pronounced in the most granular and open sectors. This underlines the need for international cooperation over M&A policies to avoid excessive build-up of market power.

In a second exercise, we turn to trade policy. We are interested here in the incentives faced by governments to impose an import tariff on a single large foreign exporter, rather than imposing it to all firms in a given sector. Narrow trade restrictions and antidumping duties that target a narrow set of firms have indeed been regularly emphasized in the policy debate. While all unilateral import tariffs are welfare improving at home at the cost of the foreign (which we assume is passive and does not retaliate), the question we ask here is whether the breadth of tariff imposition matters, for revenue-equivalent tariffs. Specifically, we compare the welfare effects of imposing two different tariff schemes, a granular tariff and a sector-wide tariff, which raise the same revenue. We find that, in a granular world, a country prefers to impose an import tariff on the largest foreign exporter, rather than imposing a uniform tariff on all sectoral imports. This is particularly true in sectors where its trade partner enjoys a granular comparative advantage. The reason is that by taxing the largest foreign firm, a country takes advantage not only of the general-equilibrium terms-of-trade effect, operating via a reduction in the foreign wage rate, but also of the industry-level terms-of-trade improvement, due to a markup reduction by the large foreign firm.

Our last exercise is still work in progress. We study industrial policies that subsidize national champions. We show that they are generally suboptimal in closed economies due to excessive build-up of market power, yet become welfare improving, when used unilaterally, in open economies.

**Related literature** We contribute to the literature that studies the influence of large individual firms on macro aggregates (coined "granularity" in the macro literature), following **?**. This literature typically focuses on the positive question of how much of aggregate fluctuations are driven by idiosyncratic productivity shocks (see e.g. **????**) or how much trade patterns can be traced to firm-level productivity shocks (see **???**). In contrast, we study the normative and policy implications of granularity.

Our study is related to the vast literature on trade policy and market structure, summarized in ?, ? and ?. In particular, early contributions that study profit-shifting motives for trade policy under oligopoly include ?, ?, ?. These papers focus on stylized models with homogeneous firms. A more recent literature explores how optimal trade policy is impacted by the presence of heterogeneous firms that self-select into exporting a la ? (see ? ?, ?, ? ). These analyses all rely on monopolistically competitive models and study a uniform tariff imposed on all firms. ? study non-uniform tariffs imposed on heterogeneous firms in a ? framework. They keep the focus on a setup with monopolistic competition with constant markups; in contrast, our quantitative analysis features strategic interactions between firms and endogenous markups. Our contribution to this literature is to study granular trade policy in a quantitative model of oligopolistic competition with many firms, which captures the salient features of the market structure of modern manufacturing industries.

We also contribute to the literature studying merger policy. In international trade, merger policy is often viewed as part of the toolkit that policymakers use to affect foreign market access (see e.g. ?, Chapter 9), but systematic studies of merger policies in this context remain scarce. The small literature that studies the interaction of mergers and trade policies is reviewed in ?. The literatures includes:

- the early contribution of ? extend the classic ? analysis of desirability of horizontal mergers to open economies
- ? considers conflicts between private, national and global welfare in an open economy environment in various examples for demand and market structure
- ? consider merger and trade policy jointly. They model merger policy in a stylized way: the government chooses the number of firms (firms are identical) as well as export subsidies to maximize welfare. Compare what happens between an equilibrium with no coordination on trade, nor on merger, and an equilibrium with coordianation on trade but not on merger. Find that merger policy is tougher in the second case.
- ? also model merger policy in a stylized way: the government chooses the number of firms ; it also chooses import tariffs
- ? study how trade liberalization impacts merger policy, under Bertrand and cournot.
- ? is a related analysis in a two-country quantitative trade model with oligopolistic competition. Study the conditions on market structure and trade costs under which a merger policy designed to benefit domestic consumers is too tough or too lenient from the viewpoint of the foreign country.

# 2 A Quantified Granular Model

In this section, we outline a granular model of international trade following **?**, as well as its quantification. We then discuss how the various policy experiments analyzed in subsequents sections are implemented in the model.

## 2.1 Theoretical Framework

We study a two-country multi-sector model, which combines a Ricardian **?** model across sectors with the **?** model of granular firms within each sector.[2] The two countries are Home and Foreign that represents the rest of the world. Households inelastically supply $L$ and $L^*$ units of labor, respectively at Home and in Foreign, with $L/L^*$ measuring the relative size of the home country. We describe first the laissez-faire equilibrium in an economy without government policies.

**Preferences** There is a unit continuum of sectors $z \in [0,1]$, with a *finite* number of product varieties $i \in \{1,..,K_z\}$ in each sector. The numbers of varieties offered in each country, $K_z$ at home and $K_z^*$ abroad, is endogenous, as described further below.

Households have Cobb-Douglas preferences over consumption in each sector, which is itself a CES aggregate of each product variety, that is:

$$Q = \exp\left\{\int_0^1 \alpha_z \log Q_z \, \mathrm{d}z\right\} \qquad \text{with} \qquad Q_z = \left[\sum\nolimits_{i=1}^{K_z} q_{z,i}^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}, \tag{1}$$

and $\int_0^1 \alpha_z \mathrm{d}z = 1$. The parameter $\alpha_z$ measures expenditure shares on sector $z$ and $\sigma > 1$ is the within-sector elasticity of substitution, common across all sectors.

Using the properties of the CES demand aggregator, consumer expenditure on variety $i$ in sector $z$ in the home market is given by:

$$r_{z,i} \equiv p_{z,i}\, q_{z,i} = s_{z,i}\, \alpha_z Y \qquad \text{with} \qquad s_{z,i} \equiv \left(\frac{p_{z,i}}{P_z}\right)^{1-\sigma}, \tag{2}$$

where $p_{z,i}$ is the price of variety $i$ in sector $z$, $P_z = \left[\sum_{i=1}^{K_z} p_{z,i}^{1-\sigma}\right]^{1/(1-\sigma)}$ is the sectoral price index, $s_{z,i}$ is the within-sector market share of the product variety, and $Y$ is aggregate income (expenditure) at Home.

[2] The **?** model is a granular version of the **?** model, in its **?** formulation. The model nests as special cases both the DFS-Melitz model, as firms become infinitesimal, as well as the Ricardian DFS model, as varieties of products become perfect substitutes and fixed costs tend to zero.

**Production** Each firm produces a distinct product variety using local labor as input. The technology has constant returns to scale:

$$y_{z,i} = \varphi_{z,i}\,\ell_{z,i},$$

where $\varphi_{z,i}$ denotes the productivity of the firm that produces product $i$ in sector $z$. The output of the firm can be marketed domestically, as well as exported. Exports incur an iceberg trade cost $\tau \geq 1$. The marginal cost of supplying the home market is therefore constant and equal to:

$$c_{z,i} = \begin{cases} w/\varphi_{z,i}, & \text{for a home variety,} \\ \tau w^*/\varphi^*_{z,i}, & \text{for a foreign variety,} \end{cases} \tag{3}$$

where $w$ and $w^*$ are respectively the home and foreign wage rates. Symmetrically, the marginal cost of serving the foreign market is denoted $c^*_{z,i}$. In each market, we sort all potential sellers in increasing order of their marginal cost $c_{z,i}$ ($c^*_{z,i}$ in foreign, respectively). The index $i$ therefore refers to the marginal cost ranking of a firm in a given market, so that the same firm is in general represented by different indexes in different markets.

To access a given market, firms have to pay a fixed cost $F$ in units of labor of the destination country. The fixed cost is independent of the origin of the firm. As a result, the differential selection of domestic and foreign firms into the local market is driven only by iceberg trade costs, not by a differential fixed cost to access the market, to simplify equilibrium characterization.

**Productivity draws** We denote with $M_z$ a potential (shadow) number of domestic products in sector $z$. $M_z$ is the realization of a Poisson random variable with parameter $\bar{M}_z$. Each of the $M_z$ potential entrants takes an *iid* productivity draw from a Pareto distribution with a shape parameter $\theta$ and lower bound $\underline{\varphi}_z$. Given this structure, the combined parameter:

$$T_z \equiv \bar{M}_z \cdot \underline{\varphi}_z^\theta \tag{4}$$

is a sufficient statistic that determines the expected productivity of a sector. Intuitively, a sector is more productive either if it has more potential entrants (driven by $\bar{M}_z$), or if the average productivity of a potential entrant is high (driven by $\underline{\varphi}_z$). Symmetrically, foreign expected sectoral productivity in sector $z$ is $T^*_z$, so that the ratio $T_z/T^*_z$ determines the expected relative productivity of the two countries in sector $z$. It is a measure of the home's fundamental comparative advantage.

**Market structure** On a given market, entrants play an oligopolistic price setting game, following **?**. Firms are large in their own sectors, so that they internalize their influence on the sectoral price index $P_z$ when they maximize profits. On the other hand, they are infinitesimal for the economy as a whole, hence take economy-wide aggregates ($Y$,$w$) as given.

We consider both a Bertrand and a Cournot oligopolistic setting.[3] The Nash equilibrium in these oligopolistic games is a markup price setting rule:

$$p_{z,i} = \frac{\varepsilon_{z,i}}{\varepsilon_{z,i} - 1} \cdot c_{z,i}, \tag{5}$$

where

$$\varepsilon_{z,i} \equiv \varepsilon(s_{z,i}) = \begin{cases} \sigma(1 - s_{z,i}) + s_{z,i}, & \text{under Bertrand}, \\ \left[\sigma^{-1}(1 - s_{z,i}) + s_{z,i}\right]^{-1}, & \text{under Cournot}, \end{cases} \tag{6}$$

with the market share of the firm $s_{z,i}$ defined in (2), and $\varepsilon_{z,i} \in [1, \sigma]$ measuring the effective elasticity of residual demand for the product of the firm. Both Bertrand competition in prices and Cournot competition in quantities result in the same qualitative patterns: the elasticity of residual demand $\varepsilon_{z,i}$ decreasing in the firm's market share, so that in turn the markup $\mu_{z,i} \equiv \frac{p_{z,i}}{c_{z,i}} = \frac{\varepsilon_{z,i}}{\varepsilon_{z,i}-1}$ increases with the firm's market share.

Given the set of entrants and their marginal costs $\{c_{z,i}\}_{i=1}^{K_z}$, the equilibrium, characterized by each firm's price and market share, is unique and has the property that prices $p_{z,i}$ increase with marginal costs $c_{z,i}$, while markups $\mu_{z,i}$ and market shares $s_{z,i}$ decrease with $c_{z,i}$. Finally, firms with higher market shares command higher profits. We turn next to solving for the endogenous set of entrants in each market.

**Entry** Firms enter a market if they make positive profit there, where profits from serving the home market (for instance) are given by:[4]

$$\Pi_{z,i} \equiv \Pi_z(s_{z,i}) = \frac{s_{z,i}}{\varepsilon(s_{z,i})}\alpha_z Y - wF, \tag{7}$$

where, given the markup pricing (5), elasticity $\varepsilon(s_{z,i})$ also equals the ratio of revenues to operating profits (before subtracting the fixed cost).

The setup detailed above opens the possibility of multiplicity in entry patterns. In order to select a unique equilibrium, we consider a sequential entry game. Specifically, in each

[3] Formally, in the case of Bertrand competition, for example, the profit maximization problem of firm $i \in \{1, .., K_z\}$ in the home market is to choose its price $p_{z,i}$ such that:

$$\Pi_{z,i} = \max_{p_{z,i}} \left\{ (p_{z,i} - c_{z,i}) \frac{p_{z,i}^{1-\sigma}}{\sum_{j=1}^{K_z} p_{z,j}^{1-\sigma}} \alpha_z Y - wF \right\},$$

taking as given the prices of its competitors $\{p_{z,j}\}_{j \neq i}$, $w$ and $Y$. Under Cournot, the firm instead takes the quantities of its competitors $\{q_{z,j}\}_{j \neq i}$ as given.

[4] Notice that due to linearity of the production function, each firm's profit maximization problem is separable across markets, and hence can be considered one market at a time.

market separately, firms with lower marginal costs of serving the market move first and decide whether or not to enter. With this equilibrium selection, the entry game has a unique cutoff equilibrium, so that only firms with marginal costs below some cutoff enter the market.

**General equilibrium** is a vector of wage rates and incomes $(w, w^*, Y, Y^*)$, such that labor markets clear in both countries and aggregate incomes equal aggregate expenditures. In particular, in the home country

$$Y = wL + \Pi, \tag{8}$$

where $\Pi$ are aggregate profits of all home firms distributed to home households:

$$\Pi = \int_0^1 \left[ \sum\nolimits_{i=1}^{K_z} \iota_{z,i} \Pi_z(s_{z,i}) + \sum\nolimits_{i=1}^{K_z^*} (1 - \iota_{z,i}^*) \Pi_z^*(s_{z,i}^*) \right] \mathrm{d}z, \tag{9}$$

with profit function $\Pi_z(s_{z,i})$ defined in (7). The indicator function $\iota_{z,i} \in \{0, 1\}$ is 1 if firm $i$ is of local origin, in the domestic market, while $\iota_{z,i}^*$ plays the same role for the foreign market.

Labor market clearing requires that the aggregate labor income $wL$ equals the total expenditure of all firms on domestic labor:

$$wL = \int_0^1 \left[ \alpha_z Y \sum\nolimits_{i=1}^{K_z} \iota_{z,i} \frac{s_{z,i}}{\mu(s_{z,i})} + \alpha_z Y^* \sum\nolimits_{i=1}^{K_z^*} (1 - \iota_{z,i}^*) \frac{s_{z,i}^*}{\mu(s_{z,i}^*)} + wFK_z \right] \mathrm{d}z. \tag{10}$$

The three terms on the right-hand side of (10) correspond to expenditure on domestic labor for (i) production for domestic market, (ii) production for foreign market, and (iii) entry of firms in the domestic market, respectively. A parallel market clearing condition to (10) holds in the foreign country. We normalize $w = 1$ as numeraire.

Conditional on the sectoral equilibrium vectors $\mathbf{Z} \equiv \left\{ K_z, \{s_{z,i}\}_{i=1}^{K_z}, K_z^*, \{s_{z,i}^*\}_{i=1}^{K_z^*} \right\}_{z \in [0,1]}$, the vector of general equilibrium quantities $\mathbf{X} \equiv (w, w^*, Y, Y^*)$ solves conditions (8) - (10) and their foreign counterparts.[5] In turn, given the aggregate equilibrium vector $\mathbf{X}$, the solution to the entry and price-setting game in each country-sector yields the sectoral equilibrium vector $\mathbf{Z}$. The resulting fixed point $(\mathbf{X}, \mathbf{Z})$ is the equilibrium in the granular economy.

## 2.2 Key sectoral characteristics

In our analysis, we focus on two sector-level characteristics — a measure of the overall sectoral comparative advantage and its granular component, which reflects the contribution of idiosyn-

[5]One of the four aggregate equilibrium conditions is redundant by Walras Law, and is replaced by a numeraire normalization. Also note that in the closed economy conditions (8) and (10) are equivalent, and amount to $Y/w = \bar{\mu}[L - FK]$, where $K = \int_0^1 K_z \mathrm{d}z$ is the total number of firms serving the home economy and $\bar{\mu} = \left[ \int_0^1 \alpha_z \sum_{i=1}^{K_z} s_{z,i}/\mu(s_{z,i}) \right]^{-1}$ is the (harmonic) average markup.

cratic productivity draws of the large firms. The first is captured by the sectoral *home share* abroad:

$$\Lambda_z^* \equiv \frac{X_z}{\alpha_z Y^*} = \sum\nolimits_{i=1}^{K_z^*} (1 - \iota_{z,i}^*) s_{z,i}^*, \tag{11}$$

where $X_z$ is total home exports and $\alpha_z Y^*$ is total foreign absorption in sector $z$. It captures the export stance of home in sector $z$. It is a random variable that depends on market shares, and hence realized productivity draws, of the home firms in sector $z$ in the foreign market. Conveniently, this statistics is an observable measure of the effective comparative advantage of home in sector $z$, irrespective of the source of this comparative advantage.

In our granular model, this sectoral outcome $\Lambda_z^*$ is driven by two forces: an expected value based on sectoral characteristics and the contribution of idiosyncratic firm draws around this expected value. Specifically, the expectation of firms's productivities in the sector is formally pined down by the fundamental comparative advantage of the sector, $T_z/T_z^*$, as is common in international trade models. The *expected* foreign share conditional on fundamental comparative advantage $T_z/T_z^*$ is given by:

$$\mathbb{E}\{\Lambda_z^*\} = \frac{1}{1 + (\tau\omega)^\theta \cdot T_z^*/T_z}. \tag{12}$$

Across sectors, expectation of home share abroad is increasing in $T_z/T_z^*$, while in all sectors export shares increase with a reduction in the trade costs $\tau$ and relative wages $\omega \equiv w/w^*$.

In addition, because our model accounts for granularity, the home share $\Lambda_z^*$ is also driven by the idiosyncratic realizations of firm productivities. To the extent that these realizations are variant and exhibit fat tails, they can feature strong outliers that affect realized sectoral productivity. As a result, the realized export stance of a country may differ markedly from its expected value, driven by a handful of firms with outsized productivity draws. We therefore decompose $\Lambda_z^*$ into its expected value based on sectoral characteristics and the contribution of idiosyncratic firm draws around this expected value:

$$\Lambda_z^* = \mathbb{E}_z\{\Lambda_z^*\} + \Gamma_z^* \tag{13}$$

The statistic $\Gamma_z^* \equiv \Lambda_z^* - \mathbb{E}_z\{\Lambda_z^*\}$ is a *granular residual* that captures departures from the population mean, driven by outstanding firms, for the realized sectoral comparative advantage.

In what follows, we are interested in understanding how the economic consequences of various policies vary in the cross-section of sectors. In particular, we study the differential incentives faced by policy makers when designing policies for the export champions of a country at the sectoral level (high overall $\Lambda_z^*$) and at the individual firm level (high granular $\Gamma_z^*$). Note that the realizations of $\Gamma_z^*$ and $\Lambda_z^*$ are positively correlated across sectors, as $\Gamma_z^*$ is one component of the overall comparative advantage, and in the estimated model it accounts for 20–30% of variation in $\Lambda_z^*$.

## 2.3 Evaluating Granular Policies

A range of policies specifically target large firms. Our model is well suited to ask: what impact do these policies have on trade flows and welfare? Indeed, this question cannot be analyzed using standard continuous models where, even in the presence of heterogeneity, every firm is infinitesimal. In contrast, here, firms are granular and their response to policy can affect sectoral productivity and trade flows. In the rest of the paper, we explore in turn three policies: a merger between two large firms in a given sector of an open granular economy, a granular import tariff imposed on a single large foreign exporter, and an industrial policy aimed at subsidizing national champions. We outline here the general methodology we follow to compute and decompose the welfare effects of policies.

**Welfare decomposition** In our model, the welfare of a representative consumer at home is given by $\mathbb{W} = Y/P$, where $Y$ is aggregate home income and $P = \exp\left\{\int_0^1 \alpha_z \log P_z \mathrm{d}z\right\}$ is the price index. In general, aggregate income can be decomposed as $Y = wL + \Pi + TR$, where $wL$ is labor income, $\Pi$ is aggregate profits defined in (9), and $TR$ is government policy revenues distributed lump-sum to workers. Since labor is supplied inelastically and home wage is the numeraire, the log-change in home welfare in response to a policy can be expressed in all generality as follows:[6]

$$\hat{\mathbb{W}} \equiv \mathrm{d}\log\frac{Y}{P} = \frac{\mathrm{d}\Pi}{Y} + \frac{\mathrm{d}TR}{Y} - \int_0^1 \alpha_z \mathrm{d}\log P_z \mathrm{d}z, \tag{14}$$

The three components in (14) correspond to the respective changes in the producer surplus, government revenues, and consumer surplus in general equilibrium.

We are interested in the general equilibrium impact of policies targeted at large firms, and in particular, in contrasting the effects they have in granular versus non-granular sectors. Given that the model features a continuum of sectors, a policy that impacts a sector in isolation will have no aggregate effects. To go around this limitation, we study a given policy change in a positive measure of sectors $Z$ that have similar levels of granularity and comparative advantage. The direct effect of a policy change in sector $z$ is $\big[(\mathrm{d}\Pi_z + \mathrm{d}TR_z)/Y - \alpha_z \mathrm{d}\log P_z\big]\mathrm{d}z$ and has an order of magnitude $\alpha_z \mathrm{d}z$. The general equilibrium impact of the policy on $(w, w^*, Y, Y^*)$ is also of the order $\alpha_z \mathrm{d}z$, which in turn affects every sector $z' \in [0, 1]$, and hence needs to be taken into account on par with the direct effect.

[6] Note that the change in the real wage is fully accounted for by the changes in the price level $P$ since nominal wage $w = 1$ by our choice of the numeraire; otherwise, there would be an additional term $\frac{wL}{Y}\mathrm{d}\log w$.

More concretely, we bin sectors into percentiles of granular residual $\Gamma_z^*$ defined in (13) or into percentiles of realized export share $\Lambda_z^*$ defined in (11). We then compute the corresponding welfare impact $\hat{\mathbb{W}}_Z = \mathrm{d}\log(Y/P)$ of the policy in bin $Z$, and report its *average* aggregate welfare effect, normalized by the size of set $Z$, given by:

$$\hat{W}_Z = \frac{1}{\int_{z\in Z}\alpha_z \mathrm{d}z}\hat{\mathbb{W}}_Z. \tag{15}$$

With this definition, in the limit as sets $Z$ become tight around individual sectors $z$, the aggregate welfare change $\hat{\mathbb{W}}$ can be decomposed into sectoral contributions $\hat{W}_z$. In particular, consider a sectoral policy vector $\boldsymbol{\varsigma} \equiv \{\varsigma_z\}_{z\in[0,1]}$, where $\varsigma_z$ characterizes policy implemented in sector $z$. We can then decompose the overall welfare impact of $\boldsymbol{\varsigma}$ as a cross-sectional weighted-average of the GE welfare effects $\hat{W}_z$ of the sectoral policies $\varsigma_z$:

$$\hat{\mathbb{W}} = \int_0^1 \alpha_z \hat{W}_z \mathrm{d}z.$$

In this sense, by binning the sectors as in (15), we approximate the policy welfare contribution (derivative) of individual sectors, which is our measure of policy impact. We also consider the decomposition of the average welfare effects $\hat{W}_Z$ into the contributions of the changes in the consumer and producer surplus, according to (14). Given the quasi-linear welfare function, the welfare impact $\hat{W}_z$ equal to 0.01 is equivalent to a welfare effect of a 1% productivity improvement in the sector (or, equivalently, a 1% reduction in the sectoral price level holding income constant). These are units in which we report the welfare effects.

## 2.4 Model Quantification

The model is estimated to match salient features of French firm-level data, as discussed in detail in **?**. Here we briefly summarize the main steps.

**Data and estimation strategy** To quantify the model, we first parameterize the distribution of fundamental comparative advantage across sectors. We assume that is is drawn from a log-normal distribution with parameters $\mu_T$ and $\sigma_T$, that is:

$$\log\left(T_z/T_z^*\right) \sim \mathcal{N}(\mu_T, \sigma_T^2). \tag{16}$$

While $\mu_T$ controls the home's absolute advantage, $\sigma_T$ is the key parameter that determines the strength of the fundamental comparative advantage. We also parameterize the distribution of firm productivities in each sector: we assume that $\varphi_{z,i}$ are drawn from a Pareto distribution with shape parameter $\theta$. This latter parameter governs the potential strength of the granular forces. Taking stock, in order to quantify the model, we therefore need to estimate the six parameters of the model, $\Theta \equiv (\sigma, \theta, \tau, F, \mu_T, \sigma_T)$,as well as the Cobb-Douglas shares $\alpha_z$.

To estimate the model, we rely on French firm-level balance sheet data, which reports in particular sales at home and abroad, as well as the firm industry. This data is merged with international trade data from Comtrade, to get the aggregate imports and exports of France in each industry.

The estimation proceeds in two steps. In the first step, we calibrate Cobb-Douglas shares as equal to the sectoral expenditure shares read in the French data. We also calibrate $w/w^* = 1.13$, which corresponds to the ratio of wages in France to the average wage of its trading partners weighted by trade values. Lastly, in our estimation, we find that the elasticity of substitution $\sigma$ and the productivity parameter $\theta$ are only weakly separately identified. Therefore, we choose to fix $\sigma$ at a conventional value in the trade literature ($\sigma = 5$) (see **?**), and estimate the constrained model with five parameters $\Theta' = (\theta, \tau, F, \mu_T, \sigma_T)$.

In the second step, we use simulated method of moments (SMM) to estimate the remaining parameters. We search for parameter values that minimize the distance between data moments and their model counterpart. We are particularly interested in the following salient feature of the data: (a) heterogeneity across sectors in top firm concentration, (b) heterogeneity across sectors in export stance and, importantly, (c) the extent to which the two are correlated, capturing granular forces at play in shaping sectoral outcomes. To that end, we choose to target three types of moments.

**Choice of moments** The first set of moments are informative about the prevalence of large firms in domestic sectoral sales (point (a) above). Namely, we target the average and standard deviation across sectors of two measures of within-industry concentration (the relative sales shares of the largest and top-3 largest French firms within-industry relative to other French firms). We also target the average (log) number of French firms operating within sectors, as well as its standard deviation. This ensures that the model captures simultaneously the large number of firms operating in French sectors with the high concentration of sales. These moments particularly help inform the estimation of the fixed costs $F$, as well as the productivity dispersion parameter $\theta$.

The second set of moments are informative about the intensity of sectoral exports (point (b) above). Specifically, we match the average and standard deviation of foreign shares in the French market $\tilde{\Lambda}_z$, and the French export intensity $\tilde{\Lambda}_z^{*\prime}$, as defined above. We also target the fraction of French sectors in which export sales exceed the overall domestic sales of French firms.These trade moments help inform the estimation of the size of the trade cost $\tau$ and the

Table 1: Estimated parameters

| Parameter | Estimate | Std. error | Auxiliary variables | |
|---|---|---|---|---|
| $\sigma$ | 5 | – | $\kappa = \frac{\theta}{\sigma-1}$ | 1.096 |
| $\theta$ | 4.382 | 0.195 | | |
| $\tau$ | 1.342 | 0.101 | $w/w^*$ | 1.130 |
| $F$ $(\times 10^5)$ | 1.179 | 0.252 | $L^*/L$ | 1.932 |
| $\mu_T$ | 0.095 | 0.150 | $Y^*/Y$ | 1.710 |
| $\sigma_T$ | 1.394 | 0.190 | $\Pi/Y$ | 0.180 |

average productivity advantage of France $\mu_T$.

Finally, the third set of moments are informative about the joint distribution of firm concentration and sectoral exports. We target four moments describing the correlation between French import and export shares and the sectoral sales concentration at home. Specifically, we target the regression coefficients of $\tilde{\Lambda}_z$ and $\tilde{\Lambda}_z^{*\prime}$ separately on $\tilde{s}_{z,1}$ and $\sum_{j=1}^{3} \tilde{s}_{z,j}$, controlling in all four regressions for the size of the sector (log total domestic expenditure, $\log \tilde{Y}_z$). These moments are instrumental for identifying the relative importance of fundamental and granular forces in shaping trade patterns.

**Estimation results** The parameter values resulting from this SMM estimation is reported in Table 1 , and the moment fit is reported in Appendix. Appendix Table A1 reports the model-based values of the 15 moments used in estimation, and compares them with their empirical counterparts. The table also reports the percentage contribution of each moment to the overall loss function $\mathcal{L}(\hat{\Theta})$, as we describe in Appendix **??**.

Overall, the model provides a good fit to the data for the 15 moments targeted in estimation. Armed with these estimated model parameters, we are ready to proceed to a quantitative evaluation of various policies in a granular environment.

# 3 Mergers & Acquisitions, and Antitrust

We are now ready to analyze quantitatively a series of policies typically targeted at large firms in the economy. An obvious example is antitrust policy that regulates mergers of firms with significant market power. Merger policy is often viewed as part of a toolkit that policymakers use to affect foreign market access (see e.g. **?**, Chapter 9).

In this section, we analyze the consequences, on domestic and foreign welfare, of allowing two leading domestic firms in a given sector to merge. To shed light on international spillovers from merger policy in a granular open economy, we then discuss optimal merger policies, both unilaterally from the perspective of the host versus the foreign country, and from the point of view of a utilitarian global planner.

## 3.1 Merger analysis: setup

In this paper, we are particularly interested in the merger of *large* firms: under which conditions can they increase welfare at Home? Since these large domestic firms are typically also large exporters (?), a merger of large domestic firms is likely to have nontrivial implications for the foreign country as well: does Foreign face an incentive to block the mergers of domestic superstar firms? How much does trade openness shape these considerations? We take a stab at these questions by simulating the hypothetical merger of the two top domestic firms in a series of sector. We study quantitatively the welfare implications of such mergers, and study how they systematically vary with the level of comparative advantage and intensity of granularity of the sectors we analyze.

We model mergers as follow. Typically, firms engage in merger and acquisition activities in order to realize cost synergies, to increase efficiency by transferring knowledge and best practices between entities, but also to increase their market power; when evaluating the desirability of such mergers, the policy maker typically trades-off such risk of an increase in market power distortions in the economy, against the efficiency benefits associated with the merger. We capture these channels in the following way. First, we assume that, upon merging, the merged entity continues to produce the two distinct product lines previously produced by the two separate firms, but that it now sets markups to maximize the total profit of the merged entity. As a consequence, the new firm's market power and markups increase.[7] Second, we assume that the merger leads to efficiency gains, as it allows the merged entity to optimize both on fixed and variable costs. Specifically, we assume that the merged firm incurs only one fixed cost rather than two; we note however that this assumption is largely inconsequential quantitatively, as fixed costs are a very small fraction of revenues for the largest firms. We also allow the merger to generate productivity spillovers between the merged entities: the less-productive product may inherit some of the efficiency of the more productive one, with the strength of the spillover governed by the parameter $\varrho \in [0, 1]$. Specifically, the productivity of the post-merger product, $\varphi'_{z,i}$ , is parameterized as:

$$\varphi'_{z,2} = \varrho\varphi_{z,1} + (1 - \varrho)\varphi_{z,2},$$

where $\varphi_{z,i}$ is the productivity of the pre-merger firm $i$.

Given this post-merger market structure and productivity distribution, we solve for the

[7] Given CES demand, the optimal markups are the same for both products and depend on their cumulative market share $s'_{z,1} + s'_{z,2}$ in the new equilibrium, according to the same functional relationship as in (6).

new entry game and price-setting equilibrium in each sector. To get at the full welfare effect of a merger, we simulate it for a positive measure of sectors $z \in Z$, and recompute the corresponding general equilibrium, as discussed in Section 2.3.

In our baseline analysis, we consider an economy where $\tau = 1.34$. These trade costs correspond to the estimated value of $\tau$ for France in **?**, and therefore reflect a fairly high level of trade openness, typical of modern developed economies. Harder to calibrate is the value of the productivity spillover: we choose a value of $\varrho = 0.35$, that is a merger allows to close a third of the productivity gap between the second and the first firm-product. With this value of the spillover parameter we can illustrate some of the most interesting policy trade-offs at play. We report the sensitivity of the analysis to alternative value of the merger spillovers below. The rest of the model parameters are quantified as described in Section 2.4. We use Cournot competition for concreteness, and the results under Bertrand competition are qualitatively similar.

## 3.2 Welfare implications of a merger

The welfare consequences — at home and abroad — of merging the two top domestic firms in a given sector are considerably different across sectors. We report in Figure 1 these findings. To that end, we split domestic sectors into deciles $z \in Z$ based on their comparative advantage ($\Lambda^*_z$; left panel) or their granular residual ($\Gamma^*_z$; right panel), and report the welfare impact $\hat{W}_Z$ (defined in (15)), for Home and Foreign, of allowing mergers of the top two firms in each sector in these deciles.

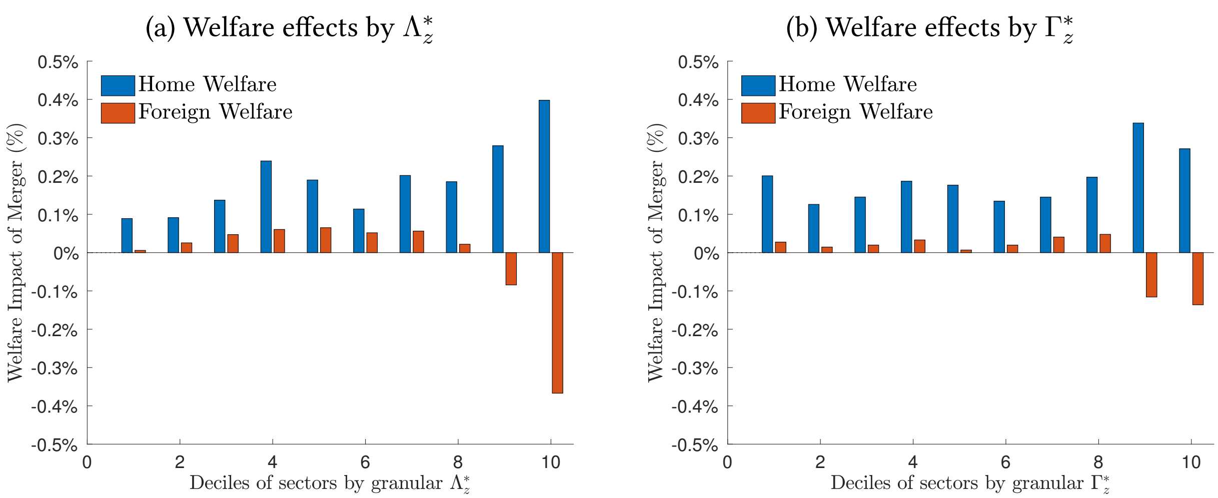


Figure 1: Welfare effects of mergers

Note: Welfare impact $\hat{W}_Z$, as defined in (15), at home and abroad, of a merger of the top two domestic firms, by deciles $Z$ of sectors $z \in [0, 1]$ sorted by overall comparative advantage $\Lambda^*_z$ and its granular contribution $\Gamma^*_z$.

For the bottom 80% of sectors, be it in terms of comparative advantage $\Lambda^*_z$ or in terms of granularity $\Gamma_z^*$, both Home and Foreign benefit from these top mergers, due to the productivity spillover. In each case, welfare gains are more modest for Foreign than for Home, as market shares of the home firms are smaller in the foreign market due to trade costs. In stark contrast, in sectors with the strongest (top $20\%$) comparative advantage or level of granularity, welfare gains are significantly negative for Foreign, and considerably larger (and still positive) for Home.

What are the mechanisms behind the starkly heterogeneous results of Figure 1? A merger has two effect on economic outcomes. First, it increases productivity due to the spillover $\varrho$, which results in lower consumer prices. However, it also increases market power and markups, which results in higher consumer prices and higher firm profits. This second effect has also an international distributive consequence in an open economy, as part of the reduction in foreign consumer surplus is redistributed towards increased home profits (producer surplus). This is one reason for differential welfare effects in the two countries from the same merger.

More specifically, in low-$\Lambda_z^*$ or $\Gamma_z^*$ sectors, the largest firms tend to account for relatively small market shares, and especially so in the foreign market. As a result, the market power increase from a merger is less important in such sectors, as in the model the markup is a convex function of the market share, consistent with the empirical evidence of decreasing cost pass-through with firm size (see **?**). As a result the positive productivity effect (which scales proportionally with market shares) dominates the relatively more modest increase in market power (which is convex in market shares). Furthermore, these net gains are felt more strongly at home, where the top two domestic firms have a more significant presence than abroad.

Matters are different in the top sectors in terms of both granularity and overall comparative advantage. In the foreign country, top domestic mergers now have significant negative welfare effects. The increased monopoly power of the top domestic firm destroys consumer surplus, and is not sufficiently compensated by productivity gains of the merged firm. When the increase in markups dominates the reduction in costs, foreign consumers lose surplus in view of increasing prices. The same effect plays out in the home market as well, and there is a decline in consumer surplus too, but, crucially, it is more than offset by the increase in the producer surplus of the merged domestic firms. Indeed, the merged entity increases profits both in the home and the foreign market. This is why mergers in an open economy have a "beggar-thy-neighbor" spillover effect on the trading partners. This suggests a rationale for governments in open countries to be overly lenient towards mergers, especially in more granular industries with strong comparative advantage, a topic we explore further below.

Overall, the welfare consequences of a top domestic merger are not trivial. In this baseline calibration, a merger between the top two firms in sectors with the strongest comparative

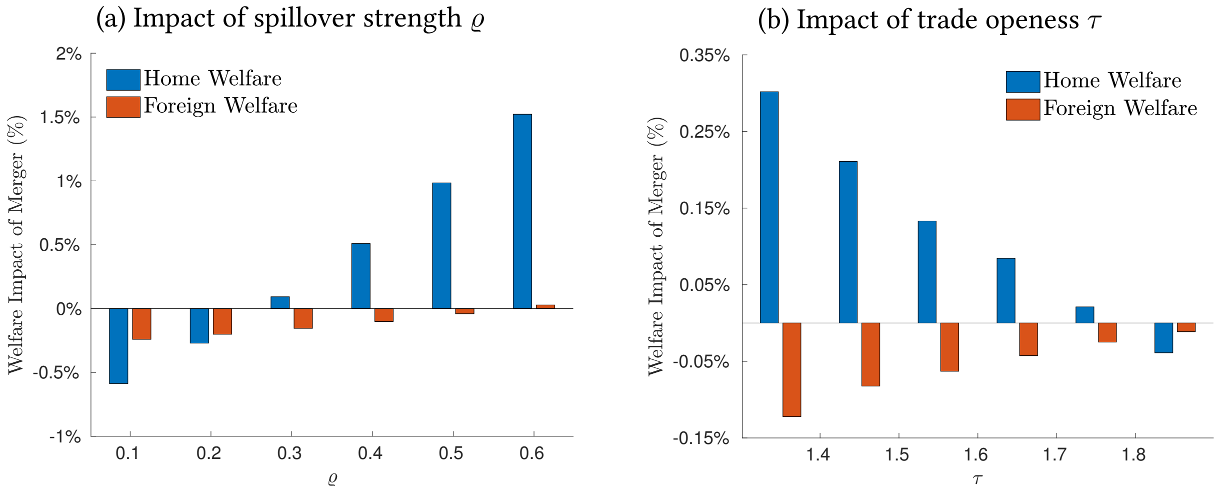


Figure 2: Impact of top mergers in high export intensity sectors: role of $\varrho$ and $\tau$

Note: Welfare impact of mergers in top 20% sectors in terms of export intensity $\Lambda_z^*$. See notes to Figure 1.

advantage has the same welfare effect as a uniform 0.4% sectoral productivity increase at home and 0.35% sectoral productivity reduction abroad for every firm serving the market.

Of course, these numbers hinge importantly on the strength of the productivity spillover $\varrho$. We report how these numbers are sensitive to the intensity of cost savings in the merger in the left panel of Figure 2, focusing on top 20% of sectors in terms of export share $\Lambda_z^*$. In short, increasing $\rho$ increases welfare gains from merger, both for Home and Foreign, but it does so much more strongly for Home, where the market shares of these firms are higher. If spillovers are limited, the mergers are particularly detrimental at home, as the dominant impact comes from the increased market power and markups of the combined entity. The effect is also negative abroad, but is less pronounced. In contrast, as productivity spillover growth larger, Home starts to benefit from mergers very strongly, while Foreign benefits much and only when spillovers are very strong. The reason again is the transfer of foreign consumer surplus into the profits of domestic firms.

The level of trade openness, governed by iceberg trade cost $\tau$, is also crucial to understand the results in Figure 1. At the current level of openness, or for even more open economies, the mergers we simulate in high export intensive sectors tend to be beneficial at home but detrimental abroad. In contrast, if we now study countries that are sufficiently closed (large $\tau$), we see in the right panel of Figure 2 that the consumer loss at home will outweigh the producer gain, resulting in a net loss in domestic welfare, while effects on foreign welfare are still negative, yet very limited, because countries trade little. This highlights the essential role of trade openness for the welfare analysis of granular mergers. Domestic mergers are particularly contentious abroad if they happen in granular comparative advantage sectors, especially if countries have a strong trade relationship.

### 3.3 Optimal M&A policy

We have seen above that different countries may be impacted quite differently by the mergers of large firms. In practice, large mergers of multinational firms may be evaluated by the antitrust authority of each country in which those firms operate, not only in the country that host the headquarters of these firms. We therefore turn to examining the incentives and optimal policies of each country when examining merger proposals.

We call "merger policy" a simple binary policy option of whether or not to allow a merger. In order to cover all the cases of interest using a common notation, we index with $\lambda$ the weight on the foreign welfare, $\hat{W}_z+\lambda\hat{W}_z^*$, where $\hat{W}_z$ is the domestic welfare impact of a merger defined in (15) and $\hat{W}_z^*$ is the corresponding welfare impact abroad. The case with $\lambda = 0$ captures the objective function of the Home government, $\lambda = \infty$ is the objective function of Foreign, and $\lambda \in [0, \infty]$ captures the objective of a global planner that puts a relative weight of $\lambda$ on the rest of the world (vs Home).

We define a corresponding merger policy function, $m_\lambda(z)$. It is an indicator function defined over the set of sectors $z \in [0, 1]$, with $m_\lambda(z) = 1$ iff the merger of the top two Home firms in $z$ is beneficial in equilibrium, that is:

$$m_\lambda(z) \equiv \mathbf{1}\{\hat{W}_z + \lambda\hat{W}_z^* > 0\}.$$

Note that $\lambda = L^*/L$ corresponds to a utilitarian global planner. Note that we focus on the merger of the Home firms only.[8] We study the differential properties of $m_\lambda(z)$ across objective functions $\lambda$, tracing out the international spillovers effects of domestic antitrust policy. We again focus on our baseline case with productivity spillover $\varrho = 0.35$.

Figure 3 plots a first broad summary of the results. Specifically, it shows the fraction of sectors where a merger is beneficial ($\int_0^1 m_\lambda(z)\mathrm{d}z$ ), for Home, for Foreign, and for a utilitarian global planner ( $\lambda \in \{0, \infty, L^*/L\}$). These statistics change as a function of trade openness $\tau$, ranging from a fully open economy to a very closed one. Interestingly, in an economy that is closed enough (high $\tau$), the foreign country benefits from most domestic mergers, as their market power impact is very limit abroad.[9] In contrast, the home government blocks the majority of mergers when the economy is closed to international trade, as mergers in the

[8]We mostly do it for technical reasons, as it is computationally easier to focus on a single fixed point problem in terms of $m_\lambda(z)$ and world GE vector $(w, w^*, Y, Y^*)$, rather than simultaneously solving for a Nash equilibrium in both $m_0(z)$ at home and $m_\infty(z)$abroad. However, such focus likely leads to little loss of generality in our analysis, as we anticipate the optimal M&A policy to be approximately a dominant strategy independently of the M&A policy abroad. We leave this conjecture for future quantitative evaluation. Another interpretation is that we focus on M&A in a large country, which trades with a continuum of small open economies, where M&A within each individual country is quantitatively inconsequential.

[9]Note the difference with Figure 2, where we focused on top-20% of sectors in terms of home export share, while in this analysis we look at merger policy across all sectors.

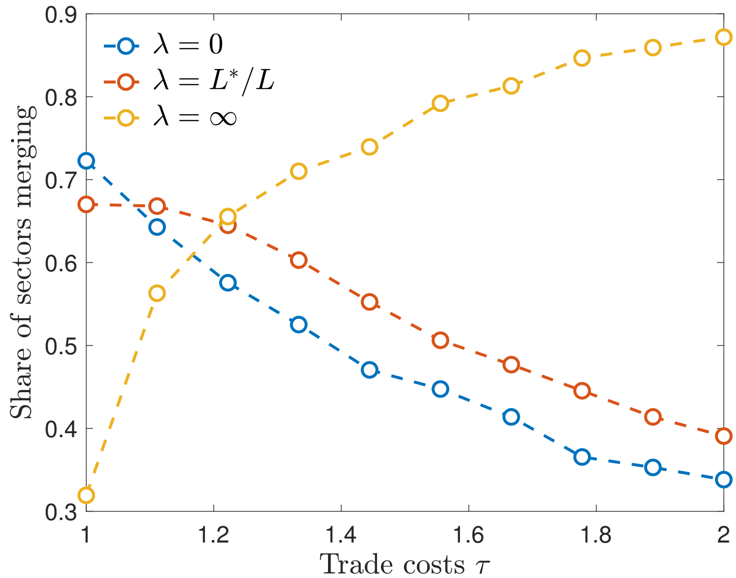


Figure 3: Optimal M&A policy depends on trade openness

Note: share of sectors where merger at the top leads to positive welfare effects — for the local government, the foreign government, and a utilitarian world planner, that is $\int_0^1 m_\lambda(z)\mathrm{d}z$ for $\lambda \in \{0, \infty, L^*/L\}$.

(a) Fraction M&A by $\Lambda_z^*$ (b) Fraction M&A by $\Gamma_z^*$

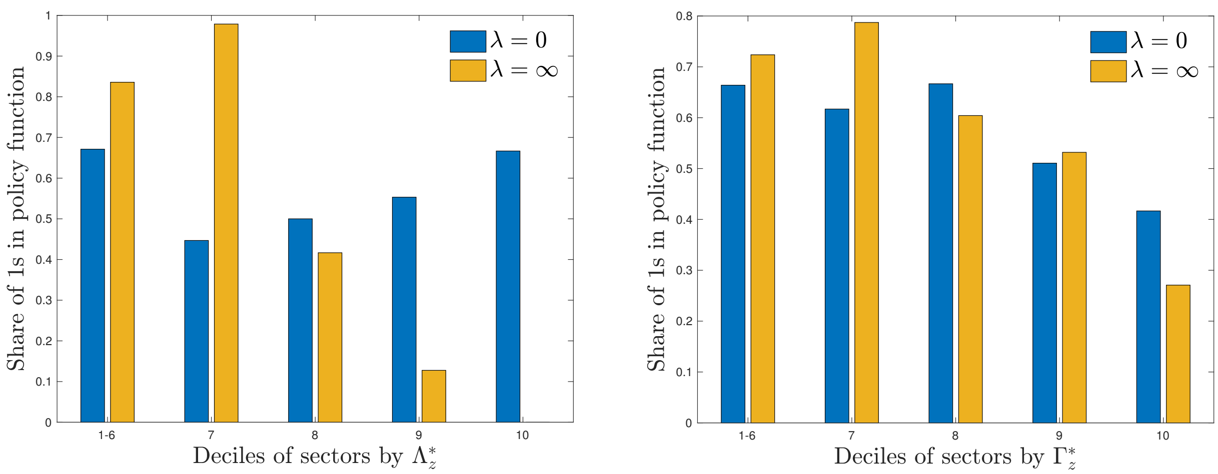


Figure 4: Optimal M&A policy across sectors

Note: Figure plots the fraction of sectors in which home mergers are welfare improving at home ($\lambda = 0$) and abroad ($\lambda = \infty$), by deciles of sectors in terms of home comparative advantage $\Lambda_z^*$ and its granular component $\Gamma_z^*$. The bottom five deciles are binned together. Baseline parameters $\varrho = 0.35$ and $\tau = 1.34$.

closed economy have a particularly strong market power effect, as market share are high due to lacking competition from foreign firms. As trade costs decline and home and foreign trade more with each other, the domestic government is more favorable towards the mergers, while they become increasing less welcome abroad. In particular, a utilitarian global planner would approve fewer mergers than the domestic planner when economies are very open.

The summary statistics in Figure 3, however, hide dramatic heterogeneity in the subsets of sectors in which the various planners would see mergers with a favorable eye. This is the main source of international conflict of interest over the merger policy, which we illustrate in Figure 4. As above, we sort sectors into deciles of comparative advantage $\Lambda_z^*$ in the left panel and deciles of granularity $\Gamma_z^*$ in the right panel, and use the baseline value of trade costs $\tau = 1.34$. We combine together the bottom five deciles, as there is little variation across these lower deciles. We then plot the fractions of sectors within each bin for which the domestic ($\lambda = 0$) and foreign ($\lambda = \infty$) planners would favor a merger.

Two main insights emerge from the cross sectional analysis. The right panel indicates that both Home and Foreign dislike mergers in granular sectors, in relative terms. While they allow the majority of mergers in sectors without large granular firms, the home would only allow mergers in 2 out of 5 sectors and foreign in 1 out of 4 sectors in the top decile of granularity. The reason is the excessive market power that firms generally hold in such sectors, which is particularly costly for consumer surplus abroad without being compensated by any direct gains in the producer surplus.

The pattern in the left panel of Figure 3 is starkly different. From the perspective of home welfare, proportion of favorable mergers to a first approximation does not depend on the comparative advantage: the home planner favors roughly 55-60% of mergers independently of $\Lambda_z^*$. In contrast, the foreign's approval of domestic mergers decreases sharply with home's comparative advantage — while the foreign favors most mergers in comparative disadvantage sectors, it would want to block *every* merger in the top decile of home comparative advantage.

This pattern is not surprising: as we discussed, home mergers in the comparative advantage sectors disproportionately hurt the foreign country due to the transfer of the consumer surplus. This, in turn, is the reason why home favors many mergers in high comparative advantage sectors. Nonetheless, such mergers can also be costly in the domestic economy due to their excessive concentration of market power, and this is the reason why the home planner would favor all such mergers. Appendix Figure A2 illustrates these conflicting welfare effects — sectors with strong comparative advantage have both large consumer surplus losses at home, which are however offset by large producer surplus gains.

Overall, this analysis suggests an important role for international cooperation over M&A policies in open economies to avoid excessive build-up of market power. In the opposite case, each country will pursue excessive mergers, in particular in sectors with strong comparative advantage, resulting in Prisoner-dilemma-like equilibrium. Furthermore, the beggar-thy-neighbor distributional conflict makes some mergers unfavorable for foreign, even in situations when a unilateral global planner may favor them. This suggests that the home decision maker is typically too lenient to domestic mergers in comparative advantage sectors, while the foreign decision maker would try to always block such mergers, sometimes at the cost to multilateral efficiency.

# 4 Granular Tariffs

Another aspect of government policies that may affect and target large firms is trade policy. In fact, trade policy is often so narrow that it appears tailor-made to target individual firms rather than industries. Such "granular" tactics are particularly widespread in antidumping retaliation (see **?**) and international sanctions (as in the recent case of the US against the Chinese ZTE). A recent example of such a granular trade war is the 292% tariff imposed by the US on a particular jet produced by the Canadian Bombardier.

Our quantified model is well-suited to analyze what are economic incentives faced by the Home government that could justify imposing such granular tariffs, rather than industry-wide ones — putting aside the legal ramifications of such decision. Specifically, we study two alternative tariff policies in an open granular economy. We contrast a *uniform* tariff $\bar{\varsigma}_z$, levied on all imports in sector $z$, and a *granular* tariff $\varsigma_{z,1}$, levied exclusively on the largest foreign exporter in the same sector. For concreteness, we compare a 1% uniform tariff with a granular tariff $\varsigma_{z,1}$ that generates the same tariff revenue at the sectoral level.

Intuitively, a government may prefer a granular over a uniform tariff for two reasons. First, it might be more attractive in terms of domestic political economy, though perhaps more complex to impose legally. We leave aside these considerations in our analysis. Second, it might be a more effective policy at extracting surplus from foreign producers and improving the home country's terms of trade at a smaller expense in terms of the loss of consumer surplus at home. As we shall shortly see, this latter consideration is indeed the case in our granular model with oligopolistic competition.

**General setup** Consider firm-specific tariffs $\{\varsigma_{z,i}\}$ imposed by the home government on foreign firms $i$ in sector $z$. In particular, if a foreign firm generates revenues $r_{z,i} = s_{z,i}\alpha_z Y$ in the home market, it needs to pay $\varsigma_{z,i}r_{z,i}$ to the home government, and takes home $(1-\varsigma_{z,i})r_{z,i}$.

Then the foreign firm's profit maximization in the home market is:

$$\Pi_{z,i} = \max_{p_{z,i}} \big[(1-\varsigma_{z,i})p_{z,i} - c_{z,i}\big] p_{z,i}^{-\sigma} \frac{\alpha_z Y}{\sum_{j=1}^{K_z} p_{z,j}^{1-\sigma}} - wF,$$

with the solution for prices and markups as if its costs were increased to $c'_{z,i} = c_{z,i}/(1-\varsigma_{z,i})$, or equivalently productivity draw reduced to $\varphi'_{z,i} = \varphi_{z,i}(1-\varsigma_{z,i})$. We denote the resulting market shares $\{s'_{z,i}\}$, and the resulting profits for foreign firms:

$$\Pi'_{z,i} = (1 - \varsigma_{z,i})\alpha_z Y \frac{s'_{z,i}}{\varepsilon(s'_{z,i})} - wF,$$

where $\varepsilon(s)$ is as before, defined in (6).[10]

The expenditure on foreign goods in the home market is still given by $s'_{z,i}\alpha_z Y$, and the foreign share is still $\Lambda'_z = \sum_{i=1}^{K_z}(1-\iota'_{z,i})s'_{z,i}$. However now, the home government collects $TR_z = \alpha_z Y \sum_{i=1}^{K_z}(1-\iota'_{z,i})\varsigma_{z,i}s'_{z,i}$, while the rest $(\Lambda'_z\alpha_z Y - TR_z)$ is the revenue of foreign firms (total exports). We describe the resulting changes to the general equilibrium conditions in the Appendix.

The resulting change in the home welfare from the tariff policy $\{\varsigma_{z,i}\}$ is described by the general expression in (14), which allows to decompose the overall welfare effect into the tariff revenue, and changes in the consumer and producer surplus respectively. We again calculate the "welfare derivatives" $\hat{W}_z$, as described in (15), by studying the tariff policy in a subset of sectors with similar characteristics. This is necessary to appropriately capture the general equilibrium effects from the sectoral tariffs, which are of the same order of magnitude as the direct sectoral effect on the overall welfare.[11]

**Results** Using the general framework above, we now compare two alternative tariff policies:

1. a uniform tariff with $\varsigma_{z,i} = \bar{\varsigma}_z = 0.01$ for all foreign firms $i$ selling in the home market in sector $z$;
2. a granular tariff $\varsigma_{z,1}$ levied only on the largest foreign exporter to the home market in sector $z$, with the value of the tariff given by $\varsigma_{z,1}r'_{z,1} = \overline{TR}_z = \bar{\varsigma}_z \sum_{i=1}^{\bar{K}_z}(1-\bar{\iota}'_{z,i})\bar{s}'_{z,i}$.

We report here the results when competition takes the Cournot form, and the results for Bertrand competition are qualitatively similar, though quantitatively smaller as markups in that case are less variable. Figure 6 compares the domestic welfare effects of each policy, contrasting sectors with different comparative advantage of the foreign country, $\Lambda_z$.

We find that imposing a "granular tariff " has clear welfare benefits from the point of view of Home, all the more as Foreign has a large penetration at home. Results are very similar

[10] Note that a non-uniform tax creates a computational challenge for the entry game, as the effective condition for entry becomes $\alpha_z Y \frac{s'_{z,i}}{\varepsilon(s'_{z,i})} \geq \frac{wF}{1-\varsigma_{z,i}}$, and ranking firms on $c'_{z,i}$ (and hence $s'_{z,i}$ does not guarantee monotonicity of $\Pi'_{z,i}$. We assume, however, that for a small enough $\varsigma_{z,i}$ (as is the case in our simulation), the approximation $F/(1-\varsigma_{z,i}) \approx F$ is sufficiently accurate in the entry game. Indeed, recall that entry is a discrete zero-one decision, in which most entering firms are inframarginal, with $\Pi'_{z,i} \gg 0$ due to Zipf's law.

[11] The direct effect is first order within the sector, but comes with a weight $\alpha_z \mathrm{d}z$ in aggregation, while the indirect general equilibrium effect (on wages and price levels) is also of the order $\alpha_z \mathrm{d}z$, via general equilibrium conditions. We implement the policy in a subset of sectors $z \in Z$ with cumulative expenditure weight $\int_{z\in Z}\alpha_z \mathrm{d}z$, and scale the resulting welfare effect $\hat{W}_Z$ by $\int_{z\in Z}\alpha_z \mathrm{d}z$.

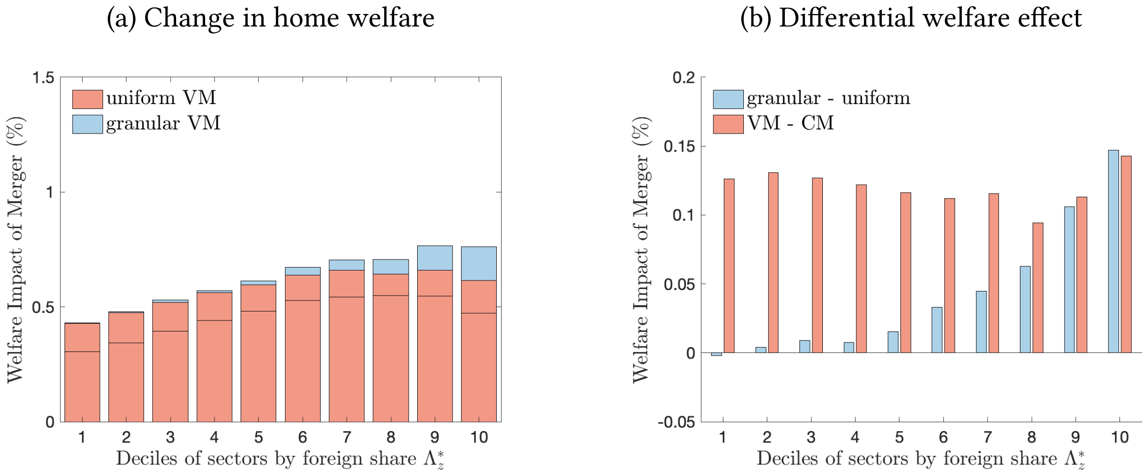


Figure 5: Granular tariff: welfare effect

Note: The welfare effect $\hat{W}_Z$ of tariff policy by deciles of foreign comparative advantage $\Lambda_z$. The left panel plots $\hat{W}_Z$ in the case of uniform tariff (red bars) and granular tariff (sum of red and blue bars) respectively, while the lines inside the red bars indicate the welfare effect in a counterfactual environment with constant markups (approximating the monopolistic competition case). The right panel plots differential welfare effects of the uniform tariff over the counterfactual case with constant markups (red bars), as well as the welfare differentials between a granular and a uniform tariffs (blue bars).

when we group sectors by their level of Foreign granularity $\Gamma_z$, as we report in Appendix Figure XX.

To understand the forces behind these results, we decompose these domestic welfare effects in Figure 5: namely, we report its three components, following equation (14) — tariff revenues, consumer surplus, and producer surplus. A clear picture emerges. First, tariff revenues are equivalent between a granular and a uniform tariff, in all sectors, by construction. Second, the impact of these tariffs on Domestic producer surplus are negligible, as these effects are indirect. Therefore, third, the major driver of the net welfare effects is the loss in domestic consumer surplus that these reforms generate, offsetting much of the gains in tariff revenues. This is where the difference between uniform and granular tariff plays a key role: home consumers are hurt much more by the uniform tariff than by the concentrated granular tariff.

The reason is that with a granular tariff, the pass-through of the import tariff to prices of foreign firms at home is much lower. This is because the tariff hits the largest Foreign firm, which has typically a two digit market share at home, in high $\Lambda_z$ and/or high $\Gamma_z$ sectors. This firm exerts significant market power at home, and absorbs part of the increase in marginal costs coming from the tariff by lowering its markups. Overall, the increase in price is therefore lower for home consumer than if the tariff had hit all firms in the sector. Put differently, a leading firms prices strategically to keep its market share and reduces markups significantly in response to a loss in relative efficiency; while if all firms are subject to tariff, their relative

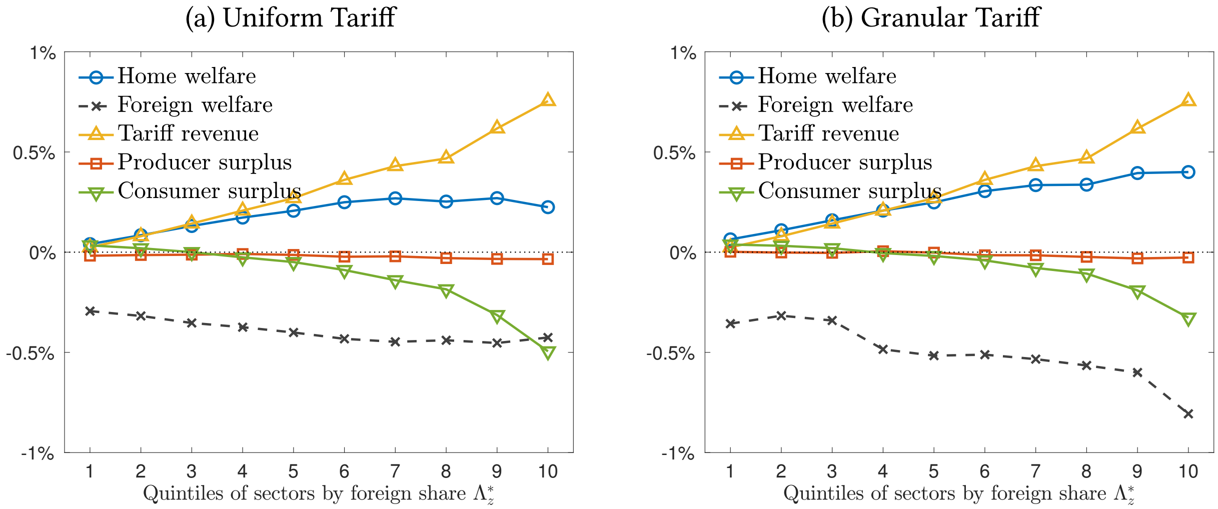


Figure 6: Welfare effect of a tariff: Decomposition

Note: Decompositions of the welfare effect $\hat{W}_Z$ at home into three components according to (14), and the welfare effect abroad, from a uniform and a granular tariff, by deciles of sectors split by the foreign comparative advantage.

stance are largely unchanged, so that markup adjustments are minor. This makes granular tariff an efficient policy tool for the home government — it allows to extract same tariff revenue at minimal costs to consumer surplus.

Notice that this effect is not present in **?**, who study a constant markup setup, with a continuum of heterogeneous firms pricing at constant markup and thus exhibiting complete pass-through of the tariff. We find that the pass-through effect, which operates even in partial equilibrium, is quantitatively large: the loss in consumer is cut by more than a half.

The pass-through effect is present even when we apply a uniform tariff to the sector, so long as markup are variable and foreign share $\Lambda_z < 1$. This is seen in Figure 5 where we report, for comparison, the case where the government applies a uniform tariff to an environment with monopolistic competition and constant markups equal to $\frac{\rho}{\rho-1}$. Of course, this effect is further reinforced by the granular tariff, as opposed to the uniform tariff. The former targets the firm that has the lowest pass-through rate in the sector. Therefore, consumer surplus losses are minimized, for an equivalent tariff revenue.

The right panel of Figure 5 plots the additional welfare effects from variable markup under a uniform tariff and also the gains from the granular tariff. About a third of the welfare effect is due to variable markups, which is roughly stable across all sectors. In contrast, the gains from granular tariff are only present in sectors with substantial foreign comparative advantage — otherwise even the largest foreign firm has a small market share in the domestic market. These gains are large in the sectors with strongest foreign comparative advantage, accounting for another third of the baseline effect.

This analysis suggests that variable markups and incomplete pass-through of large firms is a crucial quantitative component of the optimal tariff analysis. Furthermore, governments likely have strong economic incentives to target only the largest foreign firms with tariffs, which is an effective way of extracting foreign producer surplus with minimal consequences for domestic consumer surplus.

# 5 Industrial Policy in a Granular World

We consider an extension of the model, in which firms can make a one-time investment in boosting their productivity. We characterize under which circumstances the planner wants to subsidize such investment in comparative advantage sectors and by the industrial champions — the largest firms in the economy.

**Baseline economy** Consider a closed economy and the limit of continuum of firms, so that markups are constant and equal $\frac{\sigma}{\sigma-1}$, and the sectoral productivity is given by $\left[\int \varphi_{z,i}^{\sigma-1}\mathrm{d}i\right]^{1/(\sigma-1)}$. At a cost $v_{z,i} = \kappa\varphi_{z,i}^{\delta}\mathrm{d}\log\varphi_{z,i}$ the firm can improve its productivity by $\mathrm{d}\log\varphi_{z,i}$, where $\delta$ controls the returns to scale. With $\delta = 1$, the cost of 1% productivity gain increases proportionally with the level of productivity (that is, the cost is constant per unit of $\mathrm{d}\varphi_{z,i}$). With $\delta = 0$, the cost of 1% productivity gain does not depend on the level of productivity.

**Result 1** *If $\sigma - 1 = \delta$, then the planner is indifferent which firm does innovation. If $\sigma - 1 > \delta$, the planner wants all innovation to be done by largest firms, increasing their edge. If $\sigma - 1 < \delta$, the planner wants all innovation to be done by least productive firms, reducing the dispersion in realized productivities across firms.*

This is intuitive. High $\delta$ makes it costly to improve productivity for firms that are already productive, and so most effective innovation is by unproductive firms. Low $\delta$ eliminates the catch up advantage of unproductive firms, making it beneficial for most productive firms to enhance their edge.

We now focus on the benchmark case with $\sigma - 1 = \delta$ and study a granular economy with large firms, first in a closed economy and then in an open economy.

**Result 2** *With $\sigma - 1 = \delta$, in a closed economy with granular firms and variable markups, the planner wants all innovations to be done by least productive firms to close their productivity gap.*

**Result 3** *With $\sigma - 1 = \delta$, in an economy economy with granular firms and variable markups, the planner may favor some large firms to innovate and increase their edge, to gain market share in the foreign market and extract foreign consumer surplus.*

# 6 Conclusion

Granular firms play a pivotal role in international trade. The granular structure of the world economy offers powerful incentives for governments to adopt trade and industrial policies targeted at individual firms, creating negative international spillovers, which needs to be addressed with international coordination mechanisms such as WTO. Analyzing the role of granular firms and their location decisions in determining the productivity and growth trajectories of individual cities (e.g., the decisions of Microsoft to move from Albuquerque to Seattle in 1979) is another fascinating question that we leave for future research.

# A Additional Figures and Tables

## A.1 Model Quantification

Table A1: Moments used in SMM estimation

| | Moments | | | Data, $\tilde{\mathbf{m}}$ | Model, $\bar{\mathcal{M}}(\hat{\Theta})$ | Loss (%) |
|---|---|---|---|---|---|---|
| 1. | Log number of firms, | mean | $\log \tilde{M}_z$ | 5.631 | 5.429 | 1.9 |
| 2. | | — st. dev. | | 1.451 | 1.230 | 3.9 |
| 3. | Top-firm sales share, | mean | $\tilde{s}_{z,1}$ | 0.197 | 0.205 | 3.0 |
| 4. | | — st. dev. | | 0.178 | 0.148 | 4.5 |
| 5. | Top-3 sales share, | mean | $\sum_{j=1}^{3} \tilde{s}_{z,j}$ | 0.356 | 0.343 | 2.0 |
| 6. | | — st. dev. | | 0.241 | 0.176 | 12.2 |
| 7. | Imports/dom. sales, | mean | $\tilde{\Lambda}_z$ | 0.365 | 0.354 | 1.5 |
| 8. | | — st. dev. | | 0.204 | 0.266 | 15.2 |
| 9. | Exports/dom. sales, | mean | $\tilde{\Lambda}_z^{*\prime}$ | 0.328 | 0.345 | 3.9 |
| 10. | | — st. dev. | | 0.286 | 0.346 | 7.2 |
| 11. | Fraction of sectors with exports>dom. sales | | $\mathbb{P}\{\tilde{X}_z > \tilde{D}_z\}$ | 0.185 | 0.095 | 39.7 |
| Regression coefficients:† | | | | | | |
| 12. | export share on top-firm share | | $\hat{b}_1^*$ | 0.215 (0.156) | 0.240 (0.104) | 2.2 |
| 13. | export share on top-3 share | | $\hat{b}_3^*$ | 0.254 (0.108) | 0.222 (0.090) | 2.6 |
| 14. | import share on top-firm share | | $\hat{b}_1$ | −0.016 (0.097) | −0.011 (0.079) | 0.1 |
| 15. | import share on top-3 share | | $\hat{b}_3$ | 0.002 (0.074) | 0.008 (0.069) | 0.1 |

Note: Last column reports the contribution of the moment to the loss function $\mathcal{L}(\hat{\Theta})$, as described in Appendix **??**.
†Moments 12–15 are regression coefficients of $\tilde{\Lambda}_z^{*\prime}$ and $\tilde{\Lambda}_z$ on $\tilde{s}_{z,1}$ and $\sum_{j=1}^{3} \tilde{s}_{z,j}$ (pairwise), controlling in all cases for the size of the sector with the log domestic sectoral expenditure $\tilde{Y}_z$; OLS standard errors in brackets.

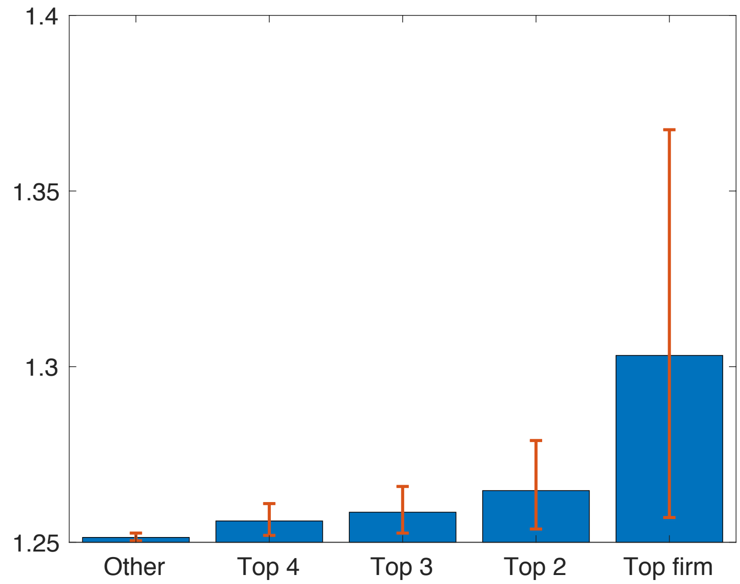


Figure A1: Equilibrium markups

Note: The bars in the figure correspond to markups for the four largest French firms in each sector and for the residual fringe of French firms, averaged across sectors, while the intervals correspond to the 10–90 percentiles across sectors. Markups under monopolistic competition with continuum of firms equal $\frac{\sigma}{\sigma-1} = 1.25$ for all firms, and this constitutes the lower bound for all markups in our oligopolistic model.

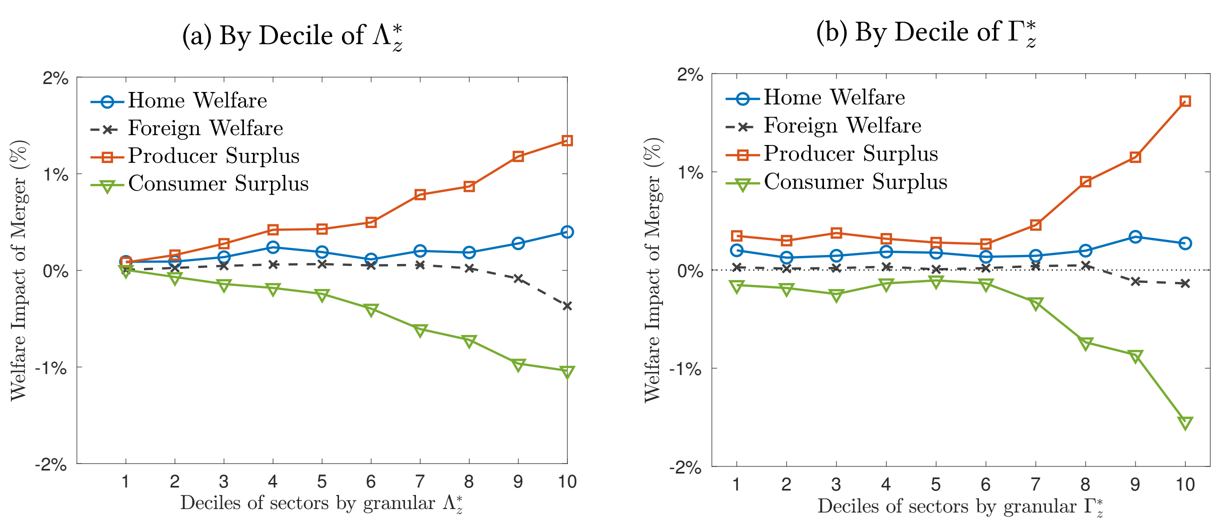


Figure A2: Welfare effects of a merger: Decomposition into producer and consumer surplus

Note: Decomposition of home welfare effects from the merger policy (see Figures 1 and 4).

# B Theory Appendix

**Foreign share** Consider the foreign share $\Lambda_z$ defined in (11). We reproduce

$$\Lambda_z = \sum\nolimits_{i=1}^{K_z} (1-\iota_{z,i}) s_{z,i},$$

where $\iota_{z,i}$ is an indicator for whether the firm is of home origin. There is no analytical characterization for the distribution of $s_{z,i}$, which are complex transformation of the realized productivity vector, which relies both on the price setting and entry outcomes (e.g., see (2), (5) and (7)). Nonetheless, following **?**, we can prove that the conditional distributions of $s_{z,i}|\iota_{z,i} = 1$ and $s_{z,i}|\iota_{z,i} = 0$ are the same, i.e. the distribution of $s_{z,i}$ is symmetric for firms of home and foreign origin, and hence the expectation of $\Lambda_z$ simply equals the unconditional expectation that any entrant is of foreign origin (i.e., the relative extensive margin of entry into the home market).

The formal argument proceeds in two steps (all expectations $\mathbb{E}_T\{\cdot\}$ are conditional on the realization of fundamental productivity $T_z$ and $T_z^*$, which are hence treated as parameters):

1. For any $s > 0$, $\mathbb{E}_T\{\iota_{z,i}|s_{z,i} > s\} = \mathbb{P}_T\{\iota_{z,i} = 1|s_{z,i} > s\} = \frac{T_z w^\theta}{T_z w^\theta + T_z^*(\tau w^*)^\theta} = 1 - \Phi_z$, as defined in (12). Hence, $\mathbb{E}_T\{\iota_{z,i}|s_{z,i} > s\}$ does not depend on $s$, and $\mathbb{E}_T\{\iota_{z,i}|s_{z,i}\} = \mathbb{E}_T \iota_{z,i}$. See a sketch of a proof below.

2. $\mathbb{E}_T\Lambda_z = \sum_{i=1}^{K_z} \mathbb{E}_T\{(1-\iota_{z,i})s_{z,i}\} = \sum_{i=1}^{K_z} \mathbb{E}_T\{s_{z,i} \cdot \mathbb{E}_T\{1-\iota_{z,i}|s_{z,i}\}\} = \Phi_z \sum_{i=1}^{K_z} \mathbb{E}_T s_{z,i} = \Phi_z$, since $\mathbb{E}_T\{\sum_{i=1}^{K_z} s_{z,i}\} = \mathbb{E}_T\{1\} = 1$, and where the third equality uses property 1.

Property 1 follow from the Poisson-Pareto productivity draw structure and the application of the Bayes' formula. Indeed, in a given sectoral equilibrium, $s_{z,i}$ decreases with the cost of the firm $c_{z,i}$, which in turn decreases with the firm productivity ($\varphi_{z,i}$ if the firm is home and $\varphi_{z,i}^*$ if the firm is foreign; see (3)). Given the productivity draw structure, the number of home firms with productivity above $\varphi$ is a Poisson random variable with parameter $\varphi^{-\theta}T_z$, and symmetrically for the foreign firms. Consequently, the number of home and foreign firms with a cost below $c$ are independent Poisson random variables with parameters $(w/c)^{-\theta}T_z$ and $(\tau w^*/c)^{-\theta}T_z^*$, respectively. Therefore, we can calculate:

$$\begin{aligned}\mathbb{P}_T\{\iota_{z,i} = 1|s_{z,i} > s\} &= \mathbb{P}_T\{\iota_{z,i} = 1|c_{z,i} < c\} \\ &= \frac{\mathbb{P}_T\{c_{z,i} < c, \iota_{z,i} = 1\}}{\sum_{\iota\in\{0,1\}} \mathbb{P}_T\{c_{z,i} < c, \iota_{z,i} = \iota\}} = \frac{(w/c)^{-\theta}T_z}{(w/c)^{-\theta}T_z + (\tau w^*/c)^{-\theta}T_z^*} = 1 - \Phi_z.\end{aligned}$$

Therefore, we conclude that indeed $\mathbb{E}_T\Lambda_z = \Phi_z$, and the granular residual $\Gamma_z = \Lambda_z - \Phi_z$ is zero in expectation for any sector $z$ (see (12) and (**??**)).

**Equilibrium system** We reproduce here the full general equilibrium system of the granular model, which consists of the aggregate budget constraints and labor market clearing in both countries. Using (7) and (9), we write the home country budget $Y = wL + \Pi$ constraint as:

$$Y = wL + Y(1-\Lambda)\frac{\bar{\mu}_H - 1}{\bar{\mu}_H} - wFK_H + Y^*\Lambda^*\frac{\bar{\mu}_H^* - 1}{\bar{\mu}_H^*} - w^*F^*K_H^*, \tag{A1}$$

where

$$\begin{aligned}
K_H &= \int_0^1 \Big[\sum\nolimits_{i=1}^{K_z} \iota_{z,i}\Big]\,\mathrm{d}z,\\
K_H^* &= \int_0^1 \Big[\sum\nolimits_{i=1}^{K_z^*} (1-\iota_{z,i}^*)\Big]\,\mathrm{d}z,\\
1-\Lambda &= \int_0^1 \alpha_z(1-\Lambda_z)\mathrm{d}z = \int_0^1 \alpha_z\Big[\sum\nolimits_{i=1}^{K_z} \iota_{z,i}s_{z,i}\Big]\,\mathrm{d}z,\\
\Lambda^* &= \int_0^1 \alpha_z\Lambda_z^*\mathrm{d}z = \int_0^1 \alpha_z\Big[\sum\nolimits_{i=1}^{K_z^*} (1-\iota_{z,i}^*)s_{z,i}^*\Big]\,\mathrm{d}z,\\
\frac{1}{\bar{\mu}_H} &= \frac{1}{1-\Lambda}\int_0^1 \alpha_z\Big[\sum\nolimits_{i=1}^{K_z} \iota_{z,i}\frac{s_{z,i}}{\mu(s_{z,i})}\Big]\,\mathrm{d}z,\\
\frac{1}{\bar{\mu}_H^*} &= \frac{1}{\Lambda^*}\int_0^1 \alpha_z\Big[\sum\nolimits_{i=1}^{K_z^*} (1-\iota_{z,i}^*)\frac{s_{z,i}^*}{\mu(s_{z,i}^*)}\Big]\,\mathrm{d}z,
\end{aligned}$$

where $\mu(s) = \frac{\varepsilon(s)}{\varepsilon(s)-1}$ and $\varepsilon(s) = \sigma(1-s)+s$, as defined in (5). Note that:

- $K_H$ and $K_H^*$ are the total numbers of the home firms selling in the home and foreign markets respectively, across all industries;
- $1-\Lambda$ and $\Lambda^*$ are the average shares of the home firm sales in aggregate home and foreign expenditure $Y$ and $Y^*$ respectively;
- $\bar{\mu}_H$ and $\bar{\mu}_H^*$ are the (harmonic) average markups of the home firms in the home and foreign markets respectively, and hence $(\bar{\mu}_H-1)/\bar{\mu}_H$ and $(\bar{\mu}_H^*-1)/\bar{\mu}_H^*$ are the average shares of operating profits in aggregate revenues of the home firms in the home and foreign markets respectively, since $\frac{\mu(s_{z,i})-1}{\mu(s_{z,i})} = \frac{p_{z,i}-c_{z,i}}{p_{z,i}}$ for a firm with market share $s_{z,i}$.

A similar equation defines foreign budget $Y^* = w^*L^* + \Pi^*$, which we write as:

$$Y^* = w^*L^* + Y^*(1-\Lambda^*)\frac{\bar{\mu}_F^* - 1}{\bar{\mu}_F^*} - w^*F^*K_F^* + Y\Lambda\frac{\bar{\mu}_F - 1}{\bar{\mu}_F} - wFK_F, \tag{A2}$$

with $K_F^*$, $K_F$, $\bar{\mu}_F^*$ and $\bar{\mu}_F^*$ defined by analogy with the respective variables for home firms.

Now consider the home labor market clearing condition in expenditure terms (10), which we write as:

$$wL = wFK + Y(1-\Lambda)\frac{1}{\bar{\mu}_H} + Y^*\Lambda^*\frac{1}{\bar{\mu}^*_H}, \tag{A3}$$

where

$$K = K_H + K_F = \int_0^1 K_z \mathrm{d}z$$

is the total entry of firms in the home market across all sectors. A symmetric labor market clearing condition for foreign is:

$$w^*L^* = w^*F^*K^* + Y^*(1-\Lambda^*)\frac{1}{\bar{\mu}^*_F} + Y\Lambda\frac{1}{\bar{\mu}_F}, \tag{A4}$$

where $K^* = K^*_H + K^*_F$ is the total entry of firms in the foreign market across all sectors.

It is immediate to verify that the equilibrium system (A1)–(A4) has the following properties:

1. It is linear in the general equilibrium vector $(w, w^*, Y, Y^*)$ conditional on the vector

$$(\Lambda, \Lambda^*, K_H, K^*_H, K_F, K^*_F, K, K^*, \bar{\mu}_H, \bar{\mu}^*_H, \bar{\mu}_F, \bar{\mu}^*_F),$$

   which depends on the outcome of the partial equilibrium $\big\{K_z, K^*_z, \{s_{z,i}\}_{i=1}^{K_z}, \{s^*_{z,i}\}_{i=1}^{K^*_z}\big\}_{z\in[0,1]}$.

2. It is linearly dependent, so that any of the four equations follow from the other three. Normalizing $w = 1$ and dropping any of the equations (for example (A2)) results in a linearly independent system of three equations in three unknown $(w^*, Y, Y^*)$ with a unique solution.

3. Substituting in labor market clearing (A3) into the budget constraint (A1) (or equivalently (A4) into (A2)) results in the current account balance condition (which in general differs from the trade balance $NX = \Lambda^*Y^* - \Lambda Y$):

$$\Lambda Y - wFK_F = Y^*\Lambda^* - w^*F^*K^*_H. \tag{A5}$$

   The equilibrium system can be represented by system of three linearly independent equations (A3)–(A5). Note the similarity and differences of this equilibrium system with a corresponding system in the continuous model (**??**)–(**??**). In particular, due to discreteness and variable markups, the shares of labor income and profits in aggregate income are no longer constants $(\sigma\kappa-1)/(\sigma\kappa)$ and $1/(\sigma\kappa)$.

Finally, using the same strategy we used to prove that $\mathbb{E}_T\Lambda_z = \Phi_z$ above, we can show that

$$\Lambda = \frac{K_F}{K_H+K_F} = \Phi = \int_0^1 \alpha_z\Phi_z \mathrm{d}z \qquad \text{and} \qquad \Lambda^* = \frac{K^*_H}{K^*_H+K^*_F} = \Phi^* = \int_0^1 \alpha_z\Phi^*_z \mathrm{d}z,$$

where the integrals of $\Phi_z$ and $\Phi_z^*$ can be viewed as expectations taken over the joint distribution of $(\alpha_z, T_z/T_z^*)$. As $\alpha_z$ and $T_z/T_z^*$ are assumed independent, the values of $\Phi$ and $\Phi^*$ depend only on the parameters $\theta$, $\tau$ and $(\mu_T, \sigma_T)$ of the distribution of $T_z/T_z^*$. Using this result, we can simplify the equilibrium system. For example, conditions (A1) and (A5) can be rewritten as:

$$Y = wL + (1-\Phi)\left[Y\frac{\bar{\mu}_H - 1}{\bar{\mu}_H} - wFK\right] + \Phi^*\left[Y^*\frac{\bar{\mu}_H^* - 1}{\bar{\mu}_H^*} - w^*F^*K^*\right],$$

$$\Phi\big[Y - wFK\big] = \Phi^*\big[Y^* - w^*F^*K^*\big],$$

which corresponds to the expression in footnote **??**. Lastly, note that in a closed economy $\Phi = \Phi^* = 0$, and therefore the country budget constraint (A1) becomes $Y = \bar{\mu}w[L - FK]$, as we have it in footnote 5.

## Granular tariff

Consider firm-specific tariffs $\{\varsigma_{z,i}\}$ imposed by the home government on foreign firms $i$ in sector $z$. In particular, if a foreign firm generates revenues $r_{z,i} = s_{z,i}\alpha_z Y$ in the home market, it needs to pay $\varsigma_{z,i}r_{z,i}$ to the home government, and takes home $(1-\varsigma_{z,i})r_{z,i}$.

Then the foreign firm's profit maximization in the home market is:

$$\Pi_{z,i} = \max_{p_{z,i}} \big[(1-\varsigma_{z,i})p_{z,i} - c_{z,i}\big] p_{z,i}^{-\sigma}\frac{\alpha_z Y}{\sum_{j=1}^{K_z} p_{z,j}^{1-\sigma}} - wF,$$

with the solution for prices and markups as if its costs were increased to $c'_{z,i} = c_{z,i}/(1-\varsigma_{z,i})$, or equivalently productivity draw reduced to $\varphi'_{z,i} = \varphi_{z,i}(1-\varsigma_{z,i})$. We denote the resulting market shares $\{s'_{z,i}\}$, and the resulting profits for foreign firms:

$$\Pi'_{z,i} = (1-\varsigma_{z,i})\alpha_z Y \frac{s'_{z,i}}{\varepsilon(s'_{z,i})} - wF,$$

where $\varepsilon(s) = s + \sigma(1-s)$ is as before.[12]

The expenditure on foreign goods in the home market is still given by $s'_{z,i}\alpha_z Y$, and the foreign share is still $\Lambda'_z = \sum_{i=1}^{K_z}(1-\iota'_{z,i})s'_{z,i}$. However now, the home government collects $TR_z = \alpha_z Y \sum_{i=1}^{K_z}(1-\iota'_{z,i})\varsigma_{z,i}s'_{z,i}$, while the rest $(\Lambda'_z\alpha_z Y - TR_z)$ is the revenue of foreign

[12] Note that a non-uniform tax creates a computational challenge for the entry game, as the effective condition for entry becomes $\alpha_z Y \frac{s'_{z,i}}{\varepsilon(s'_{z,i})} \geq \frac{wF}{1-\varsigma_{z,i}}$, and ranking firms on $c'_{z,i}$ (and hence $s'_{z,i}$ does not guarantee monotonicity of $\Pi'_{z,i}$. We assume, however, that for a small enough $\varsigma_{z,i}$ (as is the case in our simulation), the approximation $F/(1-\varsigma_{z,i}) \approx F$ is sufficient accurate in the entry game. Indeed, recall that entry is a discrete zero-one decision, in which most entering firms are inframarginal, with $\Pi'_{z,i} \gg 0$ due to the Zipf's law.

firms, which are split between production labor $\alpha_z Y \sum_{i=1}^{K_z}(1-\iota'_{z,i})(1-\varsigma_{z,i})\frac{s'_{z,i}}{\mu(s'_{z,i})}$, fixed costs $wF\sum_{i=1}^{K_z}(1-\iota'_{z,i})$, and profits $\sum_{i=1}^{K_z}(1-\iota'_{z,i})\Pi'_{z,i}$, where $\mu(s)=\frac{\varepsilon(s)}{\varepsilon(s)-1}$.

Therefore, there are changes to the three general equilibrium conditions (A1), (A2) and (A4). In particular, (A1) becomes:

$$Y = wL + \Pi + TR, \qquad \text{where} \qquad TR = Y\int_0^1 \alpha_z \left[\sum\nolimits_{i=1}^{K'_z}(1-\iota'_{z,i})\varsigma_{z,i}s'_{z,i}\right]\mathrm{d}z,$$

and where the profits of home firms $\Pi$ is still expressed as in (A1). Foreign income (A2) is still $Y^* = w^*L^* + \Pi^*$, but now the profits from the home market need to be adjusted for tariffs:

$$\Pi^* = Y^*(1-\Lambda^*)\frac{\bar{\mu}_F^* - 1}{\bar{\mu}_F^*} - w^*F^*K_F^* + Y\Lambda\frac{\bar{\mu}_F - 1}{\bar{\mu}_F} - wFK_F - Y\int_0^1 \alpha_z\left[\sum\nolimits_{i=1}^{K'_z}(1-\iota'_{z,i})\frac{\varsigma_{z,i}s'_{z,i}}{\varepsilon(s'_{z,i})}\right]\mathrm{d}z.$$

Finally, the foreign labor market clearing (A4) also needs to be adjusted as follows:

$$w^*L^* = w^*F^*K^* + Y^*(1-\Lambda^*)\frac{1}{\bar{\mu}_F^*} + Y\Lambda\frac{1}{\bar{\mu}_F} - Y\int_0^1 \alpha_z\left[\sum\nolimits_{i=1}^{K'_z}(1-\iota'_{z,i})\frac{\varsigma_{z,i}s'_{z,i}}{\mu(s'_{z,i})}\right]\mathrm{d}z.$$

Lastly, the current account balance (A5) becomes:

$$\Lambda Y - wFK_F - TR = Y^*\Lambda^* - w^*F^*K_H^*,$$

as now the foreign income from exporting is reduced by $TR$.