The London School of Economics and Political Science

Trade in Raw Materials and Economic Development

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Declaration

I certify that the thesis I have presented for examination for the PhD degree of the London School of Economics and Political Science is solely my own work other than where I have clearly indicated that it is the work of others (in which case the extent of any work carried out jointly by me and any other person is clearly identified in it).

I warrant that this authorisation does not, to the best of my belief, infringe the rights of any third party.

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Statement of conjoint work

I confirm that Chapter 2 was jointly co-authored with Francisco JM Costa and João Paulo Pessoa and I contributed a minimum of one-third of this work. I played a major role in almost all aspects of the project, especially in developing our empirical strategy and concording the various datasets we used. I also drafted the text.

I confirm that Chapter 3 was jointly co-authored with David Atkin, Dave Donaldson and Amit Khandelwal and I contributed a minimum of 90% of this work. I collected background information, collected and cleaned data, developed the empirical strategy, conducted the empirical analysis and drafted the text.

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Abstract

This thesis considers three cases in which trade in natural resources and other raw materials can inform us about wider questions of economic development.

The first chapter, "Capturing the Value Chain: The Persistence of Trade Policy in China After WTO Accession", considers whether in the GATT/WTO era, developing countries are still able to actively conduct trade policy. In this study, I show that after China's entry into WTO, required import tariff reductions on downstream sectors have been partly offset by an alternative policy with similar effects: export restrictions on raw materials. I also find that larger rises in Chinese raw materials export taxes after WTO accession have been associated with greater downstream export growth.

The second chapter, "Winners and Losers from a Commodities-for-Manufactures Trade Boom", examines two contrasting outcomes of the 'de-industrialization' associated with rising trade between China and other developing countries. In particular, this chapter compares changes in labour market outcomes in Brazilian regions stimulated by rising demand from China for raw materials, with Brazilian regions whose manufacturing sectors have been harmed by Chinese import competition. While there was slower growth in manufacturing wages and greater rises in local wage inequality in 'loser' regions between 2000 and 2010, 'winner' regions experienced higher wage growth, lower takeup of cash transfers and positive effects on job quality.

The third chapter,"Access to Raw Materials and Local Comparative Advantage: The Effects of India's Freight Equalization Policy", considers the importance of access to raw materials for industrial development. It does so by looking at the effects of a Indian policy that aimed to remove regional comparative advantages associated with proximity to raw materials, by equalizing prices of steel across India. The results suggest that in practice, this policy may have had only a limited effect on access to raw materials across Indian states.

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Chapter 1

Capturing the Value Chain: The Persistence of Trade Policy in China After WTO Accession

> [A] WTO deal – one which included surprising concessions on the Chinese side – was successfully brokered at the end of 1999. However, we note that there is a difference between signing a trade treaty and fully implementing its provisions. ... Our interviews of expatriate managers in China strongly indicate that these individuals believe tariff cuts will be at least partially undone by the simultaneous construction of more subtle non-tariff barriers....
>
> – Branstetter and Feenstra (2002)

> China's industrial strategy is to leverage and exploit the differences in the international and domestic markets for raw materials and downstream, processed products, using restraints on exports as the linchpin.
>
> – US government submission to *China - raw materials* (WTO 2011)

1.1 Introduction

A striking stylized fact about the international economy of the last several decades is the dramatic worldwide decline in the most widely observed instrument of trade policy: the import tariff. Much of this decline has been credited to the GATT/WTO process of multilateral trade negotiations, in which governments have committed to the implementation of ever smaller tariffs. But does the demise of the import tariff signal a retreat from activist trade policy among governments, or has trade policy simply persisted in other forms instead?

Long-established results in international trade theory suggest that other policy instruments may partially or entirely reproduce the effects of import tariffs. This may be accomplished even with policies that only indirectly affect imports; for instance, symmetries between the effects of export taxes and import tariffs in general equilibrium have been known to economists at least since the work of Lerner (1936). Yet while we have excellent data on import tariffs across products, countries and time, there is little systematic information on countries' usage of the other instruments that could substitute for tariffs in the implementation of their trade and industrial policies. This gap in the data leaves us unable to fully judge the extent to which such policies remain an active feature of the global economy, or establish the effectiveness of GATT/WTO negotiations in actually changing governments' behaviour.

This issue is of particular relevance to developing countries, for whom the instruments of trade policy, especially import tariffs, have historically been important tools of industrial strategy. While some observers have suggested that there is still much scope for less developed countries to implement industrial policies in the current multilateral system (e.g. Rodrik 2004), others have portrayed multilateral trade agreements as overly restrictive in this respect (e.g. Chang 2002). Here, I consider whether participation in WTO, and the accompanying restrictions on policy choice, have served as an effective constraint on developing countries' industrial strategies.

In particular, I study the persistence of trade policy in China – a developing country with a well-known history of interventionist economic policy, and the most important recent entrant into WTO – after its WTO accession. China's 2001 entry into WTO allowed it to benefit from improved access to foreign markets, including permanent most-favoured-nation status in the United States. At the same time, in order to secure the agreement of incumbent members to its WTO accession, China was also required to agree to changes in its own policies. For example, like other WTO members, China pledged as a condition of its accession to permanently keep its import tariffs below agreed maximum levels. This required cuts to its pre-WTO tariffs, and a resulting change in the pattern of protection across Chinese industries.

However, although these tariff cuts have been successfully completed, China has recently been the subject of trade disputes involving several other policies, such as domestic content requirements, preferential loans and discriminatory tax treatment. The above quote from Branstetter and Feenstra (2002) raises the question of whether such policies may have served to partly restore China's pre-WTO pattern of industrial protection. As noted above, economic theory suggests that China could use various instruments to achieve the trade or industrial policy goals previously accomplished with import tariffs. Here, I consider one particularly important class of instruments for which comprehensive and readily quantifiable data on Chinese policies is available: export taxes.

In particular, I construct panel data on the joint export tax equivalent of two instruments – VAT rebates for exported products and export duties – for which, like import tariffs, product-level policy schedules are published regularly in China. As shown in Figure 1.1, which plots the standard deviation across products of both import tariffs and these export tax equivalents over time, I find that compression in China's tariff schedule due to its WTO accession commitments has been followed by a rise in variation in export taxes across products. Moreover, I document in the empirical analysis below that these post-accession changes in China's export taxes are systematically related to its pre-WTO schedule of import tariffs, and thus to the tariff cuts required by its WTO accession (which are highly correlated to China's pre-WTO tariff levels).

This relationship between China's pre-WTO pattern of protection and its post-accession export taxes may usefully be viewed through the lens of the value chain. First, while the industries with the largest pre-WTO tariffs were producers of goods relatively downstream in the value chain, China's subsequent export tax rises have been concentrated on raw materials (Figure 1.2). As I show below, a simple two-country theoretical framework with two stages of production suggests that import tariffs on downstream products and export taxes on raw materials may both serve to protect domestic downstream sectors. By imposing export taxes on raw materials, an exporter of these goods (such as China, which is a major producer of a wide range of raw materials) can generate a wedge between their domestic and world prices, supporting domestic downstream firms by providing them with an input cost advantage. Indeed, the US and EU have twice taken China to the WTO's dispute settlement mechanism over its export restrictions on raw materials with the claim that these are used to support downstream industries.

It is also the case that across raw materials industries, lower import tariffs before China's WTO entry are highly predictive of subsequent increases in export taxes. I find that a raw materials sector with a one point lower tariff in 1999 was subject to a 0.9 point larger increase in export taxes after China's WTO accession on average. This implies that downstream sectors indirectly protected through relatively lower input tariffs before WTO accession were subsequently supported via larger increases in export taxes on inputs from the same industries.

I next consider whether export tax rises across raw materials industries are also related to the pre-WTO tariffs of the downstream users of those raw materials. Dividing raw materials into broad categories (such as metal, wood and plastic), I calculate both the mean and the maximum of the 1999 tariffs of the downstream industries associated with each material. I find evidence that raw materials industries with higher maximum pre-WTO downstream tariffs experienced larger increases in export taxes, while the same is not true for industries with higher mean downstream tariffs before China's WTO entry. I interpret this as suggestive evidence that China's post-accession trade policy might be driven by the targeting of a relatively small subset of strategic downstream industries.

Overall, the results imply that the changes in China's export taxes are likely to have partly restored China's pre-WTO pattern of industrial protection. Using the effective rate of protection (ERP) of an industry as a summary measure of the protection afforded by trade policies incident on both an industry itself and its inputs, I show that a one percentage point decline in ERP due to China's tariff cuts is associated on average with a 0.36 percentage point rise in ERP due to changes in its export taxes at the industry level. Given the above evidence that trade policy substitution in China may have been strategic in nature, and the fact that it has probably encompassed a wider range of policy instruments than the two studied here – some of which I also document below – the incomplete substitution from import tariffs to export taxes implied by this back-of-the-envelope estimate seems reasonable.

After establishing this relationship between China's export taxes and its import tariffs, I check whether China's export taxes have been effective in actually changing its industrial structure, using data on Chinese production and exports. I first find that higher export taxes have been associated with diversion of sales to the domestic market. In particular, in panel regressions with industry and year fixed effects, I observe that export taxes are negatively and significantly associated with the share of exports in an industry's total sales. This result is robust to an IV strategy suggested by the first part of the empirical analysis: rewriting the empirical specification in long differences and instrumenting for China's post-accession changes in export taxes with its pre-accession tariff levels.

I then examine whether increases in export taxes on raw materials after China's WTO entry have been associated with rises in the exports of goods using these materials. To do so, I exploit information on materials usage embodied in the Harmonized System (HS) product classification to identify input-output relationships at the product level, linking primary raw materials such as copper ore to processed intermediates such as copper springs. I then apply this information to panel data on trade flows covering 2002 to 2012, and observe a positive and statistically significant relationship between upstream export taxes and exports of products further downstream. This finding is also robust to the instrumental variables strategy outlined above.

While this study is concerned with a single country and event, the issue of trade policy substitution is relevant well beyond China's WTO accession. As early as 1984, Baldwin suggested in the first Handbook of International Economics that non-tariff barriers "have been used more extensively by governments to attain the protectionist goals formerly achieved with tariffs." Since then, a handful of other empirical studies have found evidence of substitution from import tariffs to other policies in developing countries including India (Bown and Tovar 2011) and Turkey (Limão and Tovar 2011), as well as in the US (Ray and Marvel 1984) and across countries (Bown and Crowley 2014).[1] However, these studies all consider substitution between import tariffs and other import-side measures (such as anti-dumping duties); the study of substitution between import-side and export-side policies in the same country is an innovation of this study.[2]

In fact, although there is a long theoretical literature on symmetries between import tariffs and export taxes, beginning with Lerner's classic contribution in 1936, very few papers have actually observed an empirical relationship between tariffs and export taxes.[3] This dearth of empirical papers on a long-studied theoretical topic is partly due to the fact that global data on export taxes is sparse. The construction of detailed panel data on export taxes in China, allowing for comparisons with trends

[1]See Feinberg and Reynolds (2007), Vandenbussche and Zanardi (2010) and Moore and Zanardi (2011) for other cross-country analyses. Anderson and Schmitt (2003) present a theoretical study of substitution between import-side policies.

[2]Some observers have drawn parallels between cuts in import tariffs in one country and the negotiation of agreements requiring its *trading partners* to place quotas on exports ('voluntary export restraints', or VERs). See Yu (2000) for a theoretical discussion.

[3]Golub and Finger (1979) observe a cross-country relationship of this kind, noting parallels between import tariffs on downstream goods in developed countries and export taxes on raw materials in their less developed trading partners. See also Latina et al. (2011).

in import tariffs, is thus a contribution to this literature.[4]

The relationship between the trade policies studied here and the value chain also situates this chapter in a literature linking growth in exports of manufactures to advantageous access to raw materials. In particular, parallels with the case of the United States around the turn of the twentieth century, as studied by Wright (1990) and Irwin (2003), are notable. Wright finds that intensive exploitation of a wide range of local resource endowments played an important role in US manufacturing success during this period, while Irwin reaches similar conclusions in a more focused study of the American iron and steel industry. According to Irwin, the rise in US exports of iron and steel around 1900 was driven in part by the exploitation of a large new deposit of iron ore, whose output was kept within the US due to high transportation costs and vertical integration. Like the US at that time, present-day China is a global leader in the production of many raw materials, but my analysis suggests that privileged access to those inputs for Chinese manufacturers has been generated, at least in part, by state-imposed restrictions on their export.

Finally, because of China's size and the importance of its WTO accession to the world economy, studies of the effects of China's WTO entry such as this one are of particular interest to scholars of both economic development and international trade. Existing papers have focused mainly on the effects of tariff cuts on local outcomes (e.g. Chen and Ravallion 2004, Brandt et al. 2012a), rather than their implications for local policies. The apparent presence of policy substitution in China suggests that these and other studies might underestimate the direct effects of China's tariff cuts if they do not take domestic policy responses into account.

The remainder of the chapter is laid out as follows. Section 1.2 outlines a simple theoretical framework. Section 1.3 provides background information on China's WTO accession, including its commitments regarding import tariffs, and discusses the sources and summary statistics of the export tax data. Section 1.4 presents an empirical analysis of the relationship between China's export taxes and import tariffs, while Section 1.5 examines whether export taxes on raw materials have actually affected China's export patterns. Section 1.6 then draws conclusions.

[4]Eisenbarth (2014) and Gourdon et al. (2014) also use data on Chinese VAT export rebates and export duties, but do not integrate these policies into a single export tax equivalent or explore their implications for the effects of import tariffs. Chandra and Long (2013) calculate the elasticity of Chinese exports to VAT rebate rates using firm-level data on VAT payments. Solleder (2013) has recently compiled data on export taxes from twenty countries, including two years of data on export duties in China.

1.2 Theoretical framework

In this section, I present a simple theoretical framework that will serve to elucidate the key mechanisms by which import tariffs and export taxes can achieve similar economic effects, and to motivate the empirical analysis below. As mentioned in the introduction, the historical background to this model is the concept of symmetry between import tariffs and export taxes originating from Lerner (1936). In its most basic form, this states that in a two-country, two-product framework in which each country has an import and an export good, a government may achieve identical changes in resource allocation and real income by imposing either a tariff on imports or a tax on exports.[5] However, the empirical relevance of this insight has been cast in doubt by the large number of goods actually traded and their complex input-output relationships (about which the available information is relatively coarse), leading Grossman and Horn (2013) to suggest that it is "not a practical possibility to compute a system of export taxes that would come anywhere near having the same effects" as a given set of import tariffs.

I therefore explore a more limited concept of symmetry between a few simple 'rule-of-thumb' policies in the presence of a two-stage value chain, highlighting two types of policies – downstream tariffs and upstream export taxes – that I will later show are broadly representative of China's pre- and post-accession trade policy regimes. I posit a two-country economy with two industries, in which both countries produce in both industries, and limit the symmetric outcome of interest to the 'pattern of protection', defined here as the pattern of employment of domestic factors across industries relative to the free trade equilibrium. I then evaluate the real income implications of the policies achieving identical patterns of protection, in order to draw conclusions about policy choice.

Consider a world with two countries, home (H) and foreign (F), hereafter indexed by c. There are also two industries, upstream (U) and downstream (D). Each country produces one distinct product in each of the two industries (an Armington (1969)-type framework). A key assumption of the model will be that these goods are imperfectly substitutable in production (for upstream goods) and consumption (for downstream goods). Many firms in each country are assumed to produce in each industry under conditions of perfect competition. Each country also has an

[5] See McKinnon (1966) for an extension of Lerner symmetry to an economy with intermediate goods.

endowment L of a single factor (labour) that is mobile across industries but not countries, and is inelastically supplied to firms. Trade in goods between the two countries is assumed to be costless in the absence of trade policy.

For simplicity, I will assume that production of upstream goods requires only labour l and that there are constant returns to scale, so that quantity produced for a given firm in either country c is $q_U^c = z_U l_U^c$. However, production of downstream goods requires a Cobb-Douglas combination of labour and the two upstream goods m_U^H and m_U^F, with elasticity of substitution across upstream inputs of $\sigma_U > 1$:[6]

$$q_D^c = z_D \left((m_U^{Hc})^{\frac{\sigma_U - 1}{\sigma_U}} + (m_U^{Fc})^{\frac{\sigma_U - 1}{\sigma_U}} \right)^{\frac{\sigma_U}{\sigma_U - 1}\beta} (l_D^c)^{1-\beta}$$

Finally, the two downstream goods are consumed by labourers in each country according to constant elasticity of substitution (CES) preferences with elasticity of substitution $\sigma_D > 1$:

$$U^c = \left((x_D^{Hc})^{\frac{\sigma_D - 1}{\sigma_D}} + (x_D^{Fc})^{\frac{\sigma_D - 1}{\sigma_D}} \right)^{\frac{\sigma_D}{\sigma_D - 1}}$$

Given the model's symmetry assumptions, the allocation of labour across industries is identical in H and F in the free trade equilibrium: a share $1 - \beta$ of each country's labour force is employed in production of downstream goods, $L_D^H = L_D^F = (1 - \beta)L$. Moreover, because of the imperfect substitutability of products at each stage of the value chain, the two countries engage in bilateral trade of both upstream and downstream goods.

Now consider the implications for domestic industrial structure of the imposition by H of a unilateral trade policy, by characterizing the change in the allocation of labour in H relative to the free trade equilibrium. First, imagine that starting from free trade, H adopts either a small ad valorem import tariff $t_D \equiv \tau_D - 1 > 0$ on imports of downstream goods produced by F, or a similar tariff $t_U \equiv \tau_U - 1 > 0$ on imports of upstream products. Also assume that all tariff revenue is returned to consumers in H as a lump sum. Then either of these policies result in movement of

[6] This assumption about the relationship between the two countries' upstream products in the downstream production function is a simple analogue of the 'CES aggregate' approach taken in recent quantitative trade models such as di Giovanni et al. (2014) and Caliendo and Parro (2015).

labour in H into the sector on which tariffs are imposed, i.e:

$$\frac{dL_D^H}{d\tau_D} > 0, \quad \frac{dL_D^H}{d\tau_U} < 0$$

However, this shift in industrial structure occurs via different mechanisms in each case. To see this, define the expenditure share of the product of country c in stage k on that industry by country c' as $s_k^{cc'}$. Then the familiar direct effect of either import tariff is to increase s_k^{HH} at the expense of s_k^{FH}. In the case of a downstream tariff:

$$s_D^{HH} = \frac{w^{(1-\beta)(1-\sigma_D)}}{w^{(1-\beta)(1-\sigma_D)} + \tau_D^{1-\sigma_D}}$$

which increases in τ_D, where w is the relative wage w^H/w^F. The increase in domestic demand for H downstream goods then leads to a rise in w, reducing the competitiveness of both of the goods produced by H in both markets because of higher input costs. The net effect is to shift labour into the downstream industry in H and out of the downstream sector in F by the same amount, i.e. to generate a 'relocation effect' on industrial location:

$$\begin{aligned} dL_D^H &= \frac{1}{4}\frac{\beta(1-\beta)\sigma_U\sigma_D L}{\beta\sigma_U + (1-\beta)^2(\sigma_D - 1) + (1-\beta)} d\tau_D > 0 \\ dL_D^F &= -dL_D^H < 0 \end{aligned}$$

Now instead consider a tariff imposed by H on imports of upstream goods. Like the downstream tariff, such a tax has a direct effect on the competitiveness of the goods that are taxed, in this case reducing the market share in F of upstream goods produced by H. However, imposition of τ_U affects relative input costs in the two countries not only via changes in relative wages, but also by generating a wedge between the local price indices of upstream inputs in the two markets:

$$\frac{P_U^H}{P_U^F} = \left(\frac{w^{1-\sigma_U} + \tau_U^{1-\sigma_U}}{w^{1-\sigma_U} + 1}\right)^{\frac{1}{1-\sigma_U}} > 1$$

This input price disadvantage for downstream firms in H serves to depress the relative competitiveness of their output at home and abroad, since:

$$s_D^{HH} = s_D^{HF} = \frac{w^{(1-\beta)(1-\sigma_D)}}{w^{(1-\beta)(1-\sigma_D)} + \left(\frac{P_U^H}{P_U^F}\right)^{\beta(\sigma_D-1)}}$$

which decreases in P_U^H/P_U^F.

Together, the direct encouragement of the upstream industry in H via protection from import competition and the indirect discouragement of its downstream industry through changes in relative input prices again lead to a shift in industrial structure relative to free trade:

$$dL_D^H = \left(\frac{1}{4}\beta(1-\beta)L - \frac{1}{4}\frac{\beta(1-\beta)\sigma_U\sigma_D L}{\beta\sigma_U + (1-\beta)^2(\sigma_D - 1) + (1-\beta)}\right)d\tau_U < 0$$
$$dL_D^F = -dL_D^H + \frac{1}{2}\beta(1-\beta)Ld\tau_U > 0$$

However, trade policy no longer generates a simple 'relocation effect', since now $dL_D^H + dL_D^F > 0$. This is because an upstream import tariff induces substitution away from higher-cost CES bundles of raw materials and towards labour among downstream firms in H, distorting the global allocation of labour across industries. In contrast, a downstream import tariff taxes the final stage of production, which embodies the output of both stages of the value chain, thus avoiding such an inter-stage reallocation.

Next consider analogously defined ad valorem taxes ν_D and ν_U on exports of downstream and upstream goods produced by H respectively, again assuming lump-sum redistribution of government revenue to consumers. Starting from the free trade equilibrium, either of these taxes may be shown to induce movement of labour in H into the untaxed sector, i.e.:

$$\frac{dL_D^H}{d\nu_D} < 0, \quad \frac{dL_D^H}{d\nu_U} > 0$$

A downstream export tax decreases foreign demand for H downstream goods, leading to a fall in w, which increases the competitiveness of both goods produced by H in each country. This results in the opposite 'relocation effect' to that caused by a downstream import tariff:

$$dL_D^H = -\frac{1}{4}\frac{\beta(1-\beta)\sigma_U\sigma_D L}{\beta\sigma_U + (1-\beta)^2(\sigma_D - 1) + (1-\beta)}d\nu_D < 0$$
$$dL_D^F = -dL_D^H > 0$$

An upstream export tax, however, also increases the relative price of upstream goods in F, resulting in an input price advantage for the downstream industry in H;

i.e. $P_U^H/P_U^F < 1$. This not only stimulates production of H downstream goods, but as with an upstream import tariff, also leads to a distortion in the global allocation of labour across industries:

$$dL_D^H = \left(\frac{1}{4}\frac{\beta(1-\beta)\sigma_U\sigma_D L}{\beta\sigma_U + (1-\beta)^2(\sigma_D - 1) + (1-\beta)} + \frac{1}{4}\beta(1-\beta)L\right) d\nu_U > 0$$
$$dL_D^F = -dL_D^H + \frac{1}{2}\beta(1-\beta)Ld\nu_U < 0$$

where again $dL_D^H + dL_D^F > 0$.

Thus, in this simple two-industry framework, labour is shifted into the downstream industry by a higher import tariff on D or lower import tariff on U, but by a lower export tax on D or higher export tax on U. In other words, the import tariffs and export taxes that generate the same patterns of protection are imposed on different industries. Moreover, either a higher export tax or lower import tariff on the upstream industry may increase the input price advantage (or decrease the disadvantage) of the downstream industry using those inputs. Both of these predictions of the model will be relevant to the empirical analysis below.

An additional result of the model is also notable: a downstream import tariff achieving the same shift of labour into the downstream sector as an upstream export tax does so at a lower cost (i.e. larger benefit) to aggregate domestic real income.[7] If governments prioritize the protection of downstream industries (as suggested by the ubiquity of tariff schedules affording greater protection to downstream sectors) but take account of real income when choosing the instrument by which this is accomplished, this result provides a possible reason for the popularity of import tariffs as compared to export taxes in practice.[8]

The proportional effect of a downstream tariff on real income in H is determined by the gain in nominal income Y^H (via wage growth and government revenue), offset by the rise in the consumer price index in H, P_D^H (due to tariffs on F goods and

[7]The downstream export subsidy or upstream import subsidy achieving the same allocation of labour also do so at a higher cost to real income relative to a downstream import tariff. This is a less surprising result, given the well-known negative effects of trade subsidies on domestic terms of trade.

[8]See Balassa (1965) and Cadot et al. (2004) for empirical evidence on 'tariff escalation' covering two different time periods. Cadot et al. (2004) also outline a political-economy rationale for the systematic favouritism of downstream sectors, based on Grossman and Helpman (1994). For cross-country evidence that export taxes are rarely used in practice, but used more often on upstream goods, see Solleder (2013). Finally, see Ethier (2004) for an alternative rationale for the rarity of export taxes, which he suggests constitutes a puzzle for the terms-of-trade-based theory of trade agreements proposed by Bagwell and Staiger (1999).

higher nominal labour costs for firms in H), relative to free trade:

$$\frac{dY^H}{Y^H} - \frac{dP_D^H}{P_D^H} = \left(dw + \frac{1}{2}d\tau_D\right) - \left(\frac{1}{2}d\tau_D + \frac{1}{2}dw\right) = \frac{dL_D^H}{\beta\sigma_U L} > 0$$

Thus, for the tariff that leads to $dL_D^H = kL$, the associated change in real income in H is $k/(\beta\sigma_U) > 0$.

However, the implications of an export tax achieving $dL_D^H = kL$ on real income in H are as follows:

$$\begin{aligned}\frac{dY^H}{Y^H} - \frac{dP_D^H}{P_D^H} &= \left(dw + \frac{1}{2}\beta d\nu_U\right) - \left(\frac{1}{2}dw + \frac{1}{4}\beta d\nu_U\right) \\ &= \frac{k}{\beta\sigma_U} + \underbrace{\left(\frac{1}{2}\beta - \frac{1}{4}\right) d\nu_U}_{revenue} \underbrace{-\frac{1}{4}\left(\frac{1-\beta}{\sigma_U}\right) d\nu_U}_{distortion} \underbrace{-\frac{1}{4}\beta d\nu_U}_{pass-through} \\ &= \frac{k}{\beta\sigma_U} - \frac{1}{4}(1-\beta)\left(\frac{\sigma_U + 1}{\sigma_U}\right) d\nu_U\end{aligned}$$

Given that $d\nu_U > 0$, this is an unambiguously smaller gain in real income than in the case of a downstream import tariff. The difference between the two gains is due to three separate effects, highlighted in the equations above.

The first effect, of ambiguous sign, results from the fact that government revenue from the two instruments depends on the share of value added in the free-trade economy accruing from the upstream stage. If the two stages are of equal importance to gross domestic product under free trade – i.e. if $\beta = \frac{1}{2}$ – then the revenue implications of a tax on either sector are identical.

The second effect, which is negative, derives from the aforementioned distortion to the world allocation of labour across stages induced by an upstream export tax but not a downstream import tariff, which reduces real income in both countries. This effect decreases in σ_U because this distortion has a smaller impact on real income if the raw materials from F are more substitutable for those in H, since downstream firms in F can more readily replace higher-cost raw materials from H with local raw materials rather than hiring more labour.

The final effect, also negative, is due to the fact that part of the price increase resulting from the export tax is paid for by consumers in H via imports of downstream goods from F. To better understand this pass-through effect, imagine instead an analogous model of two final goods with equal Cobb-Douglas consumption shares and identical production functions linear in labour. In such a model, the effects on sectoral distribution and real income of an import tariff on one sector and an export tax on the other are identical. This is in part because the implications of each of the policy instruments for government revenue and production choices are the same. But it is also because of the key insight of Lerner's (1936) original symmetry result: that an import tariff, which raises both relative nominal wages and local prices, and an export tax, which depresses relative nominal wages and causes price increases abroad, result in the same shift in a country's terms of trade. In the two-stage model here, this symmetry does not hold because the price increases resulting from an export tax instead accrue partly in H itself.

1.3 Background and data

In this section, I first provide background information on China's accession to WTO and the resulting cuts in its import tariffs. I then introduce my data on Chinese export taxes and outline the recent history of the two policies from which I construct this dataset.

1.3.1 China's WTO accession

After finalizing WTO accession agreements with the United States in 1999 and the European Union in 2000, China entered WTO in December 2001. China already held most-favoured-nation (MFN) status in each of its main trading partners at the time of its entry into WTO, so the schedule of import tariffs that it faced in these countries did not change after its WTO membership. However, China gained market access abroad through a decline in trade policy uncertainty: perhaps most importantly, China's MFN status in the US was subject to annual renewal before 2001, but was made permanent upon China's accession to WTO.[9]

As a WTO member, China became bound both by WTO rules and by additional specific commitments made as conditions of its accession. Like other countries joining WTO, one of China's key commitments was to permanently set its import tariffs at or below levels agreed in international negotiations. For almost all products, this

[9] Handley and Limão (2013) and Pierce and Schott (2013) find that uncertainty related to the difference between US MFN tariffs and the non-MFN tariffs that would otherwise have prevailed for China has explanatory power for the evolution of US manufacturing employment after 2001.

bound tariff rate was equal to or smaller than China's applied tariff in 1999, the year in which agreement on tariffs on industrial products was reached, and so tariff cuts were required in order to meet this condition.[10] The schedule for implementation of China's bound tariffs extended to 2010, with most tariffs to be reduced to their bound rates by 2005.

In practice, China's nonagricultural applied tariffs were indeed reduced to their bound levels after its WTO accession. As a consequence, China's mean applied tariff across nonagricultural products decreased from 16% in 1999 to 9% in 2012, as shown in Figure 1.3.[11] Importantly, because negotiated tariff cuts were highly correlated to initial tariff levels (with a correlation coefficient of approximately 0.8 across nonagricultural products), these cuts led to a compression of China's tariff schedule. Figure 1.3 accordingly shows that the standard deviation of China's applied tariffs across products declined along with the mean. A key question to be explored in the empirical analysis below is whether the resulting decrease in the variation in protection across Chinese industries was offset by changes in other policies.

1.3.2 Export taxes in China

In order to examine whether China's post-accession export policies are systematically related to its pre-WTO pattern of import tariffs, I have gathered detailed panel data on two policies that may readily be combined into a single export tax equivalent: value-added tax (VAT) rebates for exporters and export duties. As noted by Feldstein and Krugman (1990), in an international system where countries charge VAT on imports (as do China and other countries with value-added taxes), the nondistortionary policy is for countries to also fully rebate VAT on exports, so that the effective VAT rates charged on domestically produced and imported goods are equalized within each country. This means that incomplete rebates of VAT constitute a tax on exports. However, in China, the official VAT rebate rates for Chinese exporters, which are set at the product level, are often lower than the rate of VAT

[10]Throughout the chapter, I restrict the analysis to nonagricultural products (or industries), and also omit important agricultural inputs (fertilizers and pesticides); see the data appendix for details. This is because liberalization of trade in agricultural products, where nontariff barriers tend to be particularly important, often involved replacement of nontariff barriers with tariff-based protection during this period rather than tariff cuts (Branstetter and Lardy 2008).

[11]Note that in a small number of cases, China's pre-accession applied tariffs were already lower than its bound tariffs. Summary statistics of China's 1999 applied tariffs and its bound tariffs may be found in Panel A of Table 1.1.

charged (which is either 13% or 17% for most goods).

I therefore gather data on VAT rates and rebate rates at the product level and use this data to calculate export tax equivalents of China's export VAT rebate policies for each product and year (see the data appendix for details). The data is taken from policy updates that are periodically disseminated to firms in electronic format from official sources and used to calculate and apply for tax rebates. The set of these updates starting from 2004 is available from the web site www.taxrefund.com.cn, and data for 2003 may be found at www.cnnsr.com. To this I add product-level data for 2002 from the *2001-2002 Export Commodity Code and Tax Rebate Rate Quick Reference Handbook* (State Administration of Taxation 2002). Finally, I extrapolate the 2002 product-level data back to 1994 using more aggregate summaries of pre-2002 changes in rebate policies from the *China Master Tax Guide* published by Deloitte Touche Tomatsu (2005).[12]

As shown in Figure 1.4, which charts the mean and standard deviation of these export tax equivalents between 1994 and 2012, there have been many changes to China's export rebate policies over this period. When VAT was put at the center of China's taxation system in 1994, a policy of full export VAT rebates for most nonagricultural goods was maintained. However, the widespread practice of claiming rebates for goods that were not actually exported resulted in excessive fiscal obligations for the central government, and official rebate rates were significantly reduced soon afterwards (Branstetter and Lardy 2008). This led to a steep rise in the average export tax equivalent of rebate policies, but because this cut in rebates applied across the board, variation across products in export taxes did not rise accordingly. Rebate rates were raised again in the late 1990s in response to the negative export demand shock associated with the Asian financial crisis, and China's export VAT rebate policy was then relatively stable until 2003.

However, an official notice in October 2003, less than two years after China's WTO accession, announced a significant reform of rebate rates to be effective in January 2004.[13] This was the first in a series of notices frequently amending China's export rebate rates over the following several years. Figure 1.4 shows that these policy changes often increased the average export tax equivalent of VAT rebate policies, but sometimes instead served to support exports through decreases in mean export

[12] Summary statistics of export tax equivalents of these policies for 2002 and 2012 (the two years of data used in much of the empirical analysis below) are displayed in Panel B of Table 1.1.

[13] *Caizheng bu, guojia shuiwu zongju caishui* (2003) no. 222.

taxes (especially at the time of the late-2000s global recession). However, unlike the pre-WTO policy changes, the 2003 notice and subsequent reforms consistently increased the variation in export taxes across products.

In addition to charging export taxes via incomplete rebates of VAT to exporters, China also directly imposes duties on some exported products. The lists of goods subject to export duties and the corresponding rates are published by China annually together with its schedule of import tariffs in the *Customs Import and Export Tariff of the People's Republic of China*. I have collected product-level data on export duties from this publication for the years 1997 to 2012 and calculated the joint export tax equivalent of export duties and VAT export rebate policies for each product and year (see the data appendix for details).

While neither export duties nor incomplete VAT rebates for exporters are prohibited under WTO rules, China's WTO accession agreement allows for export duties only on a small group of products, ruling out such duties on other goods "except under exceptional circumstances" (WTO 2001). Until 2004, China's schedule of export duties only included a subset of the goods identified in its accession agreement. However, starting in 2005, China began imposing 'temporary' export duties on some other products. These export duties still affect a relatively narrow range of goods (approximately 5% of nonagricultural six-digit products in 2012), but have become increasingly coordinated with China's VAT export rebate policies. Thus, although they have been quite sparingly applied, Figure 1.5 shows that rising export duties have made an important additional contribution to the increasing variation in export taxes across products since China's WTO accession. Inclusive of both policies, the standard deviation across nonagricultural goods of China's export taxes rose from 3.3% to 9.3% between 2002 and 2012, as shown in Panel B of Table 1.1.

Since its accession to WTO, a number of China's policies have been the subject of disputes addressed through the WTO's dispute settlement mechanism; China has been the respondent in 19 separate cases brought by other WTO members. Two of these disputes have involved its export duties, along with a set of quantitative export restrictions (to be discussed in Section 1.4.2) that are prohibited under WTO rules: *China - Measures related to the exportation of various raw materials* (brought to the dispute settlement mechanism by the US, EU and Mexico in 2009) and *China - Measures related to the exportation of rare earths, tungsten and molybdenum* (brought by the US, EU and Japan in 2012). In both cases, WTO panels ruled that the policies identified by the complainants were inconsistent with China's WTO accession commitments.[14] In response to the ruling in the first case, China altered some of its export policies, including some export duties, in 2013. The empirical analysis below will cover the period before these changes, i.e. until 2012. However, because these changes left most export duties untouched and did not affect China's VAT policies, the empirical results below change very little when the sample period is extended.

1.4 Export taxes and import tariffs: protection through the back door?

In this section, I examine the link between China's export taxes and its import tariffs, with the goal of determining whether the changes in Chinese export taxes since its WTO accession tend to reproduce its pre-WTO pattern of protection. I first study the link between export taxes and pre-WTO import tariffs across industries, considering in particular how the relationship between the two policies interacts with industries' stage of production. I then check whether products subject to export taxes are actually exported by China, consider whether my results may instead be explained by export taxes' likely effects on China's terms of trade, and take other import and export policies into consideration in the analysis. Finally, I summarize the extent to which the changes in China's export taxes have offset the effects of the tariff cuts associated with its WTO accession.

1.4.1 Export taxes, pre-WTO import tariffs and stage of production

I begin by considering whether the changes in China's export taxes after WTO accession are systematically related to its pre-WTO pattern of industrial protection, as defined by its schedule of import tariffs in 1999. I use China's 1999 tariffs because this was the final tariff schedule released by China before agreement was reached on the nonagricultural tariff cuts required for its WTO accession; however, the results below are robust to using other pre-WTO base years. Because there is a high

[14] China had argued that its policies were covered by Article XX of the General Agreement on Tariffs and Trade, which allows for exceptions from GATT/WTO rules for measures "relating to the conservation of exhaustible natural resources" or "necessary to protect human, animal or plant life or health".

correlation between China's 1999 tariffs and its subsequent tariff reductions, the results are similar when tariff cuts are substituted for pre-WTO tariff levels in the analysis. I will directly consider the extent to which China's export tax rises have offset its tariff cuts in Section 1.4.3. Export taxes are defined below as the joint export tax equivalent of both China's VAT export rebate policies and its export duties unless stated otherwise.

I conduct the analysis in this section at the industry level, defining industries at the four-digit level according to the Chinese industrial classification.[15] This level of aggregation allows me to capture the concept from my theoretical framework of industries encompassing both import and export products, while maintaining a reasonably large sample size of 402 nonagricultural industries. The average four-digit industry consists of approximately nine six-digit products, and the majority of these industries include both products for which China was a net importer and goods for which China was a net exporter in 2002 (the first full year after its entry after WTO). The results in this section also hold when the unit of analysis is defined at higher or lower levels of aggregation.

Some of the key changes over time in the relationship between China's export taxes and its pre-WTO import tariffs may be seen in the two scatter plots in Figure 1.6. In this figure, the position of each point represents the simple average across products of an industry's import tariffs in 1999 relative to the simple average of its export taxes in 2002 (in the left-hand panel) or 2012 (in the right-hand panel). Meanwhile, the colour of each point represents the position of the industry in a simple two-stage value chain. For this, I use the United Nations Broad Economic Categories (BEC) classification of traded products to identify HS products that are either final goods, parts or accessories, and define the remainder of goods as raw materials (see the data appendix for details). If more than half of a four-digit industry's products are raw materials, I classify it as a raw materials industry. As a result, 174 of the 402 industries in the sample (43%) are categorized as producers of raw materials, while all others are defined as downstream industries.

The figure shows that while raw materials industries had generally lower tariffs in 1999, export taxes rose by much more for raw materials than for downstream industries on average between 2002 and 2012. Moreover, export taxes increased

[15] An example of a four-digit industry is 'Manufacture of glass apparatus', which lies within the two-digit category 'Manufacture of non-metal products'.

most for the raw materials industries for which average pre-WTO import tariffs were lowest. The overall result is a striking negative relationship across industries between 2012 export taxes and pre-WTO tariffs, with very few industries subject to both large 1999 tariffs and large 2012 export taxes.[16] Importantly, these patterns are not driven by the concentration of large 2012 taxes and/or 1999 tariffs in a narrow range of industrial categories: the top quartile of 1999 import tariffs spans 21 of 35 two-digit industries, while 20 of 35 two-digit industries include at least one of the four-digit industries in the top quartile of 2012 export taxes.

Before considering the interaction between export taxes, import tariffs and stage of production in more depth, I first note two additional facts that are not apparent from Figure 1.6. First, although Figure 1.6 portrays a large change in the relationship between China's export taxes and its pre-WTO tariffs between two points in time, the transition between these two states took shape gradually over several years. To show this, I summarize the relationship between 1999 tariffs and export taxes in each year t between 1997 and 2012 using a series of simple regression specifications:

$$exporttax_i^t = \alpha^t + \beta^t tariff_i^{1999} + \epsilon_i^t \tag{1.1}$$

I then plot the estimated coefficients $\hat{\beta}^t$ from this series of regressions in Figure 1.7; the full set of results may be found in Table 1.2. The figure shows that the relationship between export taxes and 1999 tariffs became progressively more negative in each year between 2003 and 2010, while both before and after this period, $\hat{\beta}^t$ remained relatively stable.

I next use a similar summary measure of the link between export taxes and 1999 tariffs to show that their relationship is the result of both of the two policies studied here. I first define $\Delta exporttax_i \equiv exporttax_i^{2012} - exporttax_i^{2002}$ and regress this long-difference variable on the same right-hand side as above. As shown in column (1) of Table 1.3, I find that a one percentage point larger 1999 tariff is associated with a one-half point smaller export tax rise from 2002 to 2012. I then run two additional regressions redefining the left-hand-side variable of equation (1.1) as the change (again between 2002 and 2012) in the export tax equivalent of one of the two

[16]Of the 100 industries in the top 25% of each of these two distributions, only three are shared in common. By the binomial theorem, conditional on the 1999 pattern of tariffs, the probability of randomly and independently drawn export taxes resulting in three or fewer industries in the intersection of these two sets is 0.000000002%.

policies only, holding the export tax due to the other policy equal to zero. These specifications show that a one point higher tariff in 1999 is associated with a 0.3 point lower rise in the export tax equivalent of China's VAT rebate policies (column (2)), and a 0.14 point smaller increase in export duties (column (3)) from 2002 to 2012. Both of these estimates are statistically significant at the 1% level, using p-values derived from wild bootstraps as in Cameron et al. (2008) due to the small number of clusters (two-digit industries).[17]

To consider more carefully the role of the value chain in the relationship between pre-WTO import tariffs and post-accession export tax changes, I again use the UN BEC classification to create a further division of the downstream part of the value chain into producers of capital goods and other downstream industries. While both of these types of downstream industries produce parts, accessories and finished goods, capital goods industries sit uneasily into a simple vertical definition of the value chain because of the role of capital in the production process. Moreover, because imported capital often embodies important technological inputs into production, industries producing capital goods are rarely protected with high import tariffs, which means that 1999 tariffs may not be a good proxy for Chinese support to these industries. I similarly divide upstream industries into sectors producing primary raw materials (e.g. mining of iron ore) and semiprocessed raw materials sectors (e.g. production of steel).

Tables 1.4 and 1.5 display how pre-WTO tariffs and post-accession export tax rises vary across these four categories. Table 1.4 shows that of the 37 primary raw materials industries, 33 were subject to export tax increases in the top quartile between 2002 and 2012, while none of the industries at this stage of production fell into the top 25% of 1999 tariffs. Meanwhile, 54 of the 90 downstream industries not producing capital goods were in the top quartile of 1999 tariffs, while only two of these 90 sectors were in the top 25% of post-accession export tax increases. Overall, 96 of the 101 industries in the top 25% of export tax rises were producers of either primary or semiprocessed raw materials, while of the top 25% of industries by 1999 tariffs, 68 of 100 were producers of downstream goods.

Table 1.5 displays the results of regressions of 1999 tariffs and changes in export taxes from 2002 to 2012 on indicators for whether an industry is a producer of

[17] The estimated coefficient in column (1) is larger than the total of these two estimates because the joint export tax equivalent of the two policies generally exceeds the sum of the export tax equivalent of each policy separately; see data appendix for details.

primary raw materials, semiprocessed raw materials, or capital goods; the omitted category is other downstream industries. Column (1) shows that on average, China's 1999 applied tariffs were 8 percentage points lower on semiprocessed raw materials industries and 19 percentage points lower on primary industries as compared to tariffs on industries producing final consumption goods. Export tax rises, on the other hand, vary in the opposite way with the value chain: these were 7 points higher for the semiprocessed stage and 22 points higher for the primary stage on average as compared to industries producing products for final consumption. Notably, this inverse relationship between the two policies is not present for capital goods industries. While capital goods industries have relatively lower pre-WTO import tariffs than those of sectors producing final consumption goods, export taxes on this subset of industries remained relatively low after 2002. As discussed above, this may be because capital-producing industries were protected via other means before China's WTO accession, so that pre-WTO import tariffs may not fully represent the position of these sectors in China's pattern of industrial protection.

Having established that pre-WTO import tariffs and post-accession export taxes differ across stages of production in a way that is broadly in line with two of the simple policies considered in my theoretical framework, I now step outside that framework to consider variation in incidence across industries within stages of production. This variation is much higher for raw materials: while among downstream industries the average increase in export taxes from 2002 to 2012 is 1.5% with a standard deviation of 2.7%, the corresponding mean and standard deviation across raw materials industries is 12.0% and 11.1% respectively. The scatter graph above (Figure 1.6) suggests that much of the variation across industries in raw materials export taxes may be explained by average pre-WTO tariffs on the same industries; I first check this hypothesis, and then discuss its implications.

To do this, I run a regression of changes in China's export taxes after WTO accession on its 1999 tariffs, but restricted to raw materials industries only:

$$\Delta exporttax_i = \alpha + \beta tariff_i^{1999} + \epsilon_i \tag{1.2}$$

The results may be found in column (1) of Table 1.6. This shows that a raw materials industry with a one point lower tariff in 1999 was subject to a 0.9 point larger increase in export taxes after China's WTO accession on average. Moreover, this simple specification has substantial explanatory power for export tax rises on raw materials industries, with an R^2 of nearly 0.5. In columns (2) and (3), I check that this result is not simply driven by variation across the early stages of the value chain, by re-estimating specification (1.2) separately for primary and semiprocessed raw materials industries. I find that the negative and statistically significant relationship in column (1) also holds within each of these two sets of industries, and again explains much of the variation in export tax increases in each case.

Given that I have defined industries so that they tend to encompass both import and export products, this finding has implications both for the pattern of protection across raw materials industries themselves and for the protection afforded to downstream sectors. The direct effect is that raw materials industries whose products were less protected from import competition by tariffs before WTO were then subject to higher taxes on exported goods after accession. However, also recall from the theoretical framework that downstream industries may be supported indirectly via lower upstream import tariffs or higher upstream export taxes, either of which may affect the gap between the domestic and world prices of raw materials. The results in Table 1.6 thus imply that the same downstream industries receiving greater protection through lower import tariffs on raw materials inputs in 1999 were subsequently supported through larger increases in export taxes on inputs from the same industries, after the distribution of tariffs across raw materials sectors was compressed by WTO accession.[18]

To what extent do the two main findings of the analysis so far – that China's export taxes have risen for upstream industries in general, and have increased by more in upstream sectors with initially lower tariffs – explain the distribution of export tax increases across industries? These two results may be summarized by estimating a single specification on the full sample of nonagricultural industries, including both of the two main explanatory variables discussed above – pre-WTO tariffs and a dummy for raw materials industries – along with an interaction term:

$$\Delta exporttax_i = \alpha + \beta rawmaterials_i + \gamma tariff_i^{1999} + \theta(rawmaterials_i * tariff_i^{1999}) + \epsilon_i \tag{1.3}$$

Table 1.7 shows that this parsimonious specification explains 62% of the variation

[18] While the mean of China's 1999 tariffs on raw materials industries was 12.1% and their standard deviation was 8.3%, these were reduced to 6.9% and 4.8% respectively by 2012.

in the post-WTO changes in export taxes across industries, measured according to R^2. I will use this preferred specification as the baseline for the robustness checks of Section 1.4.2.

Notably, the estimated $\hat{\beta}$ displayed in the first row of Table 1.7 suggests that there is no relationship between export tax rises and pre-WTO tariffs across *downstream* industries. This is confirmed in columns (4) and (5) of Table 1.6, which show the results of running specification (1.2) separately for capital goods industries and other downstream industries. In both cases, the result is a precisely estimated zero. In other words, it is not the case that export taxes have emerged on downstream industries on which China set relatively low import tariffs before its WTO entry. Instead, to the extent that China's pre-WTO pattern of protection across downstream industries has been restored by the export taxes observed here, this is due to policies directly incident on raw materials, but with indirect effects on downstream sectors.

The role of indirect effects on downstream sectors in shaping post-accession changes in China's export taxes is further explored in Table 1.8. Here, I consider whether variation in raw materials export tax rises may be explained by the pre-WTO tariffs of the downstream industries using those inputs, controlling for the 1999 tariff on the raw materials industry itself. In particular, I run the following regression for the set of raw materials industries:

$$\Delta exporttax_i = \alpha + \beta tariff_i^{1999} + \beta^D tariff_i^{downstream,1999} + \epsilon_i \qquad (1.4)$$

A challenge in estimating this specification is to calculate downstream pre-WTO import tariffs for each raw materials industry. Although China publishes an input-output table, its sectors are relatively coarse and often aggregate raw materials and downstream industries into a single category (e.g. paper pulp, paper and paper products; rubber and rubber products). I thus define eight main types of materials (chemicals; leather and furs; metal; nonmetallic minerals; plastic; rubber; textiles; wood and paper) and identify the raw materials sectors corresponding to these materials in China's 2002 input-output table, whether or not these sectors also include downstream industries.[19] I then associate each of the remaining input-output

[19] I exclude raw materials industries producing fuels from this analysis, since the procedure used here does not classify these as the main constituent of any downstream sectors. I also drop a small group of sectors producing aquatic products.

sectors with a particular material according to the maximum of the input shares of each of these raw materials categories in the production of that sector's goods. Finally, I assign four-digit industries to materials using a concordance of industries and input-output sectors. For instance, this procedure associates rail transportation equipment with metal; all four-digit industries constituting the input-output sector 'Rail transportation equipment' are then defined as downstream of all of the raw materials industries producing metals.[20]

In Table 1.8, I estimate specification (1.4), measuring downstream tariffs alternatively according to their mean or their maximum across the downstream industries associated with a particular material. I consider the maximum tariff because of the possibility that China's trade policy is driven by the strategic targeting of a small subset of downstream industries rather than a more general preference for production in a wide range of favoured industries, as suggested by the right-skewed nature of China's pre-WTO tariffs (see Figure 1.6). Column (1) of Table 1.8 shows that surprisingly, a higher mean downstream tariff in 1999 is associated with a *smaller* increase in upstream export taxes between 2002 and 2012. However, this result is driven entirely by the inclusion of capital goods industries, since the estimated coefficient switches sign and loses statistical significance when mean downstream tariffs are calculated using other downstream industries only (column (2)).

On the other hand, column (3) suggests that raw materials industries with higher maximum pre-WTO downstream tariffs subsequently experienced larger rises in export taxes. As shown in column (4), this result is robust to the exclusion of capital goods industries in the calculation of maximum downstream tariffs. While these findings should be treated with some caution due to the coarseness of the input-output measure I have used, they indicate that China's post-accession export taxes on raw materials may have been influenced by a relatively narrow group of strategic downstream industries.

[20] See data appendix for details. I define more detailed data on input-output linkages in Section 1.5.2; however, that data mostly provides information on linkages between primary and semiprocessed raw materials rather than downstream goods and is thus inappropriate for this exercise.

1.4.2 Additional results

Relevance of export taxes

Even if export taxes have risen since China's WTO accession, this is empirically relevant only if the goods subject to high export taxes are products actually exported by China. I check the relevance of China's export taxes in two ways: first by examining the share of China in world trade for products with high 2012 export taxes, and then by comparing estimated revenue from China's 2012 export taxes to the revenue that would result from the reinstatement of its 1999 import tariffs.

I first use international trade data for 2012 from UN COMTRADE to calculate the share of Chinese exports in the total value of world trade by product. I find that among the six-digit nonagricultural products for which 2012 export taxes are greater than or equal to 10% (which encompasses approximately 25% of these goods), Chinese exports constitute more than 10% of world trade for one third. Among raw materials products above the 10% export tax threshold, China's exports exceed 10% of total world trade in 31% of cases. China is thus a large player in world trade for a wide variety of the products on which it has placed high taxes, despite the presumed negative impact of these taxes on export volumes (which is examined in Section 1.5).

I next examine whether China's 2012 export taxes and 1999 import tariffs are incident on trade flows of similar size. To do this, I first note that the simple average across six-digit nonagricultural products of China's 2012 export taxes (7.3%) is 44% of the simple average of its 1999 import tariffs (16.1%). I then multiply China's 2012 exports and imports (by value) by 2012 export taxes and 1999 tariffs respectively, and find that the resulting estimated export tax revenue is 34% of what tariff revenue would have been if 1999 tariffs applied to 2012 trade flows.[21] Since export taxes presumably have a negative effect on exports, I repeat the same exercise using trade flows from 1999 instead of 2012, and find that the counterfactual export tax revenue is 40% of estimated import tariff revenue. This back-of-the-envelope exercise suggests that post-accession export taxes apply to trade flows of comparable size to those on which pre-WTO import tariffs, if restored in 2012, would be incident.[22]

[21] I first deduct export taxes due to VAT policy from reported Chinese exports by value, so as to avoid double-counting.

[22] Note that this calculation ignores the differences in the applicability of these policies to goods imported or exported via China's different modes of trade (e.g. processing trade vs. 'ordinary trade').

Terms-of-trade motivation

The fact that China is so important in world trade in so many of the products subject to export taxes suggests that the distribution of these taxes across products might be shaped by potential terms-of-trade gains, rather than their effects on the pattern of industrial protection. For example, export taxes on rare earth elements might be designed to exploit China's near-monopoly on global rare earths production.[23] I thus check the robustness of the results of the preferred specification of Section 1.4.1 (equation (1.3)) to the inclusion of China's share of world trade in 2012 as a control. Because China's trade share, and the resulting terms-of-trade motivation for an export tax, tends to vary across products within each industry, I run this robustness check at the product level. Also, since Chinese exports in 2012 are presumably affected by its export taxes, I instrument for China's 2012 trade share with its share of world trade in 2002.

The results of this robustness check may be found in Table 1.9. Column (1) reproduces regression (1.3) at the product level; the estimated coefficients are similar to those from the equivalent industry-level regression. Column (2) then displays the results of a simple IV regression of 2012 export taxes on 2012 Chinese trade shares. The estimated coefficient suggests that an increase in China's share of world trade by 10% is associated with a 0.4% *lower* export tax, and this result is statistically insignificant. Moreover, as shown in column (3), including this covariate in specification (1.3) (again instrumented with China's 2002 share of world trade) has a negligible effect on the baseline results of column (1). When I also include the square of China's 2012 share of world trade and use both China's 2002 share and its square as instruments (column (4)), the results are unchanged.

Other policies

I next revisit the concern that export taxes and import tariffs might not be representative of the full suite of policies implemented by China during the period of interest. Unfortunately, it would be infeasible to gather information on all of the Chinese policies relevant to the pattern of protection across industries. However, there are some other import and export policies for which product-level information

[23] The Vice Chairman of China's Inner Mongolia province (Zhao Shuanglian) suggested otherwise in a September 2009 press conference: "We are certainly not focusing on the short-term benefits of raising the rare earth price. Our wish is for Baotou in Inner Mongolia to become the world's 'Rare Earths Valley', the world's rare earths industrial base." (china.com.cn 2009)

is also available, and here I investigate whether consideration of these additional policy instruments supports the conclusions of the empirical analysis above.

In addition to a schedule of bound tariffs, China's WTO accession agreement also included a list of products for which non-tariff barriers to imports were to be removed. Treating this list as a proxy for the full set of China's pre-WTO non-tariff import restrictions, I add this variable and its interaction with an indicator for raw materials industries to specification (1.3). The results, which may be found in Table 1.10, show that as with pre-WTO import tariffs, the relationship between non-tariff import barriers and changes in export taxes across raw materials industries is negative and statistically significant, while this association is insignificantly different from zero across downstream sectors.

On the export side, I collect data on all other policies identified by the WTO Trade Policy Reviews of China (World Trade Organization 2006, 2008, 2010, 2012) as 'policies affecting exports' for which product-level schedules are available.[24] I source data on the set of products requiring export licenses or subject to export quotas, and goods which may only be exported by designated (usually state-owned) firms, from the annual official notices relating to these measures for 2002 to 2012.[25] I also collect information from ad hoc official notices on the list of products prohibited from export via processing trade, beginning with a 2004 notice declaring that "[a]djustments and updates will be made annually to the list of prohibited processing trade goods ... in accordance with the country's economic development and industrial policies."[26] Approximately half of Chinese exports by value leave the country via processing trade, a system by which inputs from abroad may be imported duty-free, processed and then re-exported, again duty-free.

To check whether the post-accession changes in these policies have been coordinated with rises in export taxes, I tabulate increases in their incidence separately for six-digit nonagricultural products in different quantiles of total export tax growth, and display the results in Figure 1.8. The figure shows clear evidence of coordination

[24] This includes information on goods whose export is prohibited by China (see data appendix); however, I simply drop any good whose export is prohibited in any year throughout the empirical analysis. Also, some policies that are classified as 'policies affecting exports' in the WTO reviews but that do not vary primarily at the product level, such as tax concessions to foreign-invested enterprises, are not considered here.

[25] I gather data only for unilateral policy measures; export quotas related to the multilateral Multifiber Arrangement are thus not included here. See the data appendix for details.

[26] *Shangwu bu, haiguan zongshu, guojia huanjing baohu zongju gonggao* (2004) no. 55. In practice, subsequent updates were not announced on a strictly annual basis.

of China's various product-level export policies. While only a miniscule proportion of products were prohibited from export via processing trade as of 2005, this share had risen to 78% for goods in the top 5% of post-accession export tax increases, 43% for the next 20% and 4% for the bottom 75% of products by 2012.[27] Meanwhile, among six-digit products whose total export tax increase between 2002 and 2012 was in the top 5%, the share of goods subject to license requirements, quotas or state trading increased from 14% in 2002 to 25% in 2012. The other products in the top quartile of export tax rises saw a rise in the coverage ratio of these policies from 4% to 7%, while only 3% of the bottom three quartiles were covered by such an export restriction in 2012, a rise of one percentage point from 2002.

1.4.3 Extent of substitution

I have established in Section 1.4.1 that the changes in China's export taxes after its WTO entry are systematically related to its pre-WTO pattern of industrial protection. I now attempt to summarize the extent to which China's post-accession export tax reforms have offset the effects of the tariff *reductions* required by its WTO entry. In particular, the goal of this subsection is to examine the offsetting changes in the pattern of protection across Chinese industries induced by the two sets of policy reforms.[28]

To do this, I employ a simple summary measure of the protection resulting from the trade policies incident on both an industry itself and its inputs: the effective rate of protection (ERP) as defined by Corden (1966).[29] This measure allows for both a higher tariff on an industry and lower tariffs on sectors upstream of that industry to increase the protection afforded to the industry. I first define the ERP for each industry resulting from China's 1999 tariff schedule using the Chinese input-output matrix. I then calculate the ERPs implied by China's schedule of bound tariffs, reassigning bound tariff rates to be equal to 1999 tariffs whenever tariff bindings actually exceed China's applied tariffs in 1999.[30] I also use a formulation for ERPs

[27]In fact, product-level changes in VAT rebate policies and processing trade eligibility have sometimes been made in the same official notice.

[28]Note that China's bound tariffs were an outcome of negotiations that involved both incumbent WTO members and the Chinese government itself, and may thus reflect a mix of the trade policy preferences of the two parties. This means that the results of this exercise should not necessarily be interpreted straightforwardly as a relationship between a set of policy changes imposed by China's trading partners and a unilateral Chinese response.

[29]See the data appendix for details of my calculations of ERPs.

[30]Because there are very few cases where bound tariffs exceed China's 1999 applied tariffs, this

proposed by Corden for export-side policies, in which protection may be derived from a lower export tax on an industry or a higher export tax on its inputs, to calculate the ERPs implied by China's 2002 and 2012 export taxes. Finally, I take the difference for each industry between the ERPs implied by bound tariffs and the ERPs resulting from 1999 tariffs, and compare this to the change in protection resulting from the transition between the 2002 and 2012 schedules of export taxes, using the following regression specification:

$$\Delta ERP(exporttax)_i = \alpha + \beta \Delta ERP(tariff)_i + \epsilon_i \tag{1.5}$$

Table 1.11 displays the results of this regression. This suggests that the post-accession changes in China's export taxes have indeed offset the effects of its import tariff cuts on the pattern of protection, but only in part. In particular, a one percentage point decline in ERP due to tariff cuts is associated on average with a 0.36 percentage point rise in ERP due to changes in export taxes at the industry level.

This finding of incomplete substitution between the two types of policies is unsurprising for several reasons. First, the left-hand side measure is incomplete, both in the sense that not all of China's export-side policy instruments are taken into account (as discussed in the previous subsection), and because changes to other non-export policies such as domestic content requirements and preferential loans may also have altered the post-accession pattern of protection. Second, if the primary motivation for China's export taxes is to target a subset of strategic downstream industries, as suggested by the results in Table 1.8, we might not necessarily expect to observe one-for-one substitution in protection on average across all industries. Finally, the result is consistent with the implication of the theoretical framework that export taxes on raw materials are a costlier means (in terms of real income) of protecting downstream industries as compared to import tariffs on downstream goods. A government valuing both aggregate real income and a particular pattern of protection might thus be expected to decrease the relative protection afforded to downstream industries when import tariffs become unavailable as an instrument of trade policy.

adjustment makes little difference to the results.

1.5 Export taxes and exports: capturing the value chain?

Having shown that China's export taxes on raw materials are systematically related to its pre-WTO pattern of protection, I now consider whether increases in export taxes have resulted in changes in China's actual export patterns. I first evaluate whether industries subject to larger export taxes consequently sell a greater share of their output on the domestic market. I then consider this section's main question of interest: whether Chinese export taxes on raw materials have been effective in stimulating exports of downstream goods.

1.5.1 Effects on exports as a share of sales

If export taxes on raw materials are actually effective in supporting domestic downstream industries, we should observe a diversion of sales of local raw materials to the domestic market. I thus begin this section by examining whether industries subject to higher rises in export taxes have experienced falls in the share of exports in total sales. To do this, I draw upon industry-level tabulations of China's annual firm-level survey of industrial production for 2002 to 2007.[31] I use reported sales by value and export value (both in current Renminbi) from the survey data to calculate the proportion of exports to foreign markets in firms' sales in each industry and year.[32] I then run the following panel regression of the export share of sales on export taxes, controlling for import tariffs as well as year and industry fixed effects:

$$exports/sales_{it} = \alpha + \beta exporttax_{it} + \gamma tariff_{it} + \theta_i + \phi_t + \epsilon_{it} \tag{1.6}$$

The results of this regression, with and without import tariffs on the right-hand side, are displayed in Table 1.12. As shown in column (1), I find that during this period, the estimated impact of a one percentage point increase in export taxes is to decrease the share of exports in total sales by 0.28 percentage points; this result is statistically significant at the 10% level. Controlling for import tariffs yields very similar results (column (2)). While the estimated effect of tariffs is insignificantly

[31] This data, collected by China's National Bureau of Statistics, includes all non-state industrial firms with sales above five million Renminbi and all state-owned industrial firms. See the data appendix for details.

[32] Because the end of the Multifiber Arrangement probably had a significant impact on textiles and apparel exports during this period, I drop all textiles and apparel industries from the sample.

different from zero, its sign is consistent with the prediction that higher import tariffs stimulate domestic sales, thus increasing the denominator of the left-hand-side variable. Finally, I check in column (3) whether the main result holds across raw materials industries, by dropping all downstream industries from the sample. This slightly reduces the magnitude of the estimated coefficient on export taxes to -0.22, but it remains statistically significant at the 10% level.

While the evolution of China's import tariffs during this period is shaped by the schedule of tariff cuts agreed before its WTO accession, export taxes might have responded endogeneously to changes in exports or sales, making this specification susceptible to problems of joint causation. However, the results of Section 1.4 suggest a natural instrumental variables strategy for the subsample of raw materials industries. Since changes in export taxes after WTO entry are highly correlated to pre-WTO tariffs for these industries, I can instrument for the change in export taxes using 1999 tariffs in the following long-difference specification spanning the length of the sample period (2002 to 2007):

$$\Delta exports/sales_i = \alpha + \beta \Delta exporttax_i + \gamma \Delta tariff_i + \epsilon_i \tag{1.7}$$

The results of estimating this specification on the subsample of raw materials industries may be found in Table 1.13. The OLS results in column (1) are little different from those of the panel regression in column (3) of Table 1.12, although the coefficient on the change in export taxes is now significant at the 5% level. In column (2), I use 1999 tariffs and their square as instruments for $\Delta exporttax_i$, which produces a first stage with a Kleibergen-Paap Wald F statistic of approximately 50. The IV results are very similar to the OLS results, and indicate that a one percentage point increase in export taxes reduces the share of exports in total sales by 0.26 percentage points.

1.5.2 Effects on exports

Next, I directly consider the effects of export taxes on Chinese exports, using a more disaggregate source of data – product-level information on trade flows – in order to facilitate identification. If China's export taxes have been effective, I should observe a negative relationship between export taxes on a product and exports of that product, but a positive relationship between upstream export taxes and exports of downstream products. I thus use panel trade data by product p and year t to estimate the following baseline specification:

$$\ln exports_{pt} = \alpha + \beta exporttax_{pt} + \beta^U exporttax_{pt}^{upstream} + \theta_p + \phi_t + \eta' X_{pt} + \epsilon_{pt} \quad (1.8)$$

All regressions include product and year fixed effects. In most specifications, I also add a set of time-varying regression controls X_{pt}, including import tariffs, upstream import tariffs and the logarithm of the value of world trade by product and year. The sample covers 2002 to 2012, the period over which my data on export taxes is observed at the product level. Because the left-hand-side variable is the logarithm of export value, observations with zero trade flows are dropped, and so the coefficients should be interpreted as pertaining to the intensive margin of trade. Since Chinese exports are equal to zero in fewer than 3% of the product-year observations in the sample, this is a reasonable specification here. Along with the trade policy data discussed above, I use annual product-level trade flow data from UN COMTRADE for 2002 to 2012 (see data appendix for details).[33]

As with the analysis of specification (1.4) in Section 1.4.1, the key challenge in assembling the data on upstream trade policies for this exercise is to define input-output relationships between products with minimal measurement error. A natural choice (which will serve as a robustness check below) would be to use data from China's input-output table, but as stated earlier, this information is quite coarse: input-output sectors aggregate a wide range of raw materials (e.g. 'Mining of non-ferrous metal ores') and sometimes include multiple stages of production (e.g. paper pulp, paper and paper products). Moreover, the broadly defined materials (such as chemicals and metal) used in Section 1.4.1 to link raw materials and downstream industries are too aggregate for the purposes of identification here.

I thus instead define input-output linkages between goods using a different source: information on materials usage embodied in the Harmonized System product classification. In particular, I identify all nonagricultural primary raw materials in the HS classification (such as 'copper ores and concentrates') using the UN BEC data discussed in Section 1.4.1, and then find all other (nonprimary) HS products for which at least one of these raw materials is mentioned in the product description

[33] I again exclude textiles and apparel, by dropping all products in section 11 of the HS product classification (which covers textiles and apparel) from the sample.

(such as 'copper springs'). For this, I use both the English-language descriptions of six-digit products and Chinese-language descriptions of products at the more detailed eight-digit level to identify six-digit goods containing these materials; further details may be found in the data appendix.

This results in a total of 42 raw materials for which both primary and nonprimary products can be found. The sample consists of the nonprimary products, for each of which I define the upstream export tax (or import tariff) as the export tax (or import tariff) on the primary raw material with which the good is associated.[34] For the regressions below, I keep only nonprimary products linked to exactly one material, so that I can cluster all standard errors by primary raw material. This leaves a total of 588 products in the sample.

Importantly, most of the nonprimary products identified by this exercise are semiprocessed raw materials such as metals or chemicals rather than parts, accessories or final goods.[35] This is a convenient outcome for two reasons. First, this means that the goods in this sample vary greatly in both their export taxes and their upstream export taxes, facilitating identification of both β and β^U. Second, as shown in Table 1.6, export taxes on both primary and semiprocessed raw materials industries are highly correlated with their 1999 tariffs, which will allow for the simultaneous instrumentation of both of the export tax variables as long differences in Table 1.16 below. In columns (1) and (2) of Table 1.14, I run regression (1.8) with and without controlling for import tariffs and total world trade. Both of the key coefficient estimates are statistically significant and of the predicted sign in each of the two columns. The estimated coefficients in column (2) indicate that a rise in export taxes of one percentage point is associated with a 6.80 percentage point decline in the value of Chinese exports, while a one point rise in upstream export taxes is associated with a rise in exports of 0.82 percentage points. Given the indirect nature of the effect of upstream export taxes, the difference in magnitudes between these two coefficients seems reasonable.

In column (3), I replace year fixed effects with section-year fixed effects in the regression specification. This means that the results are based on a comparison

[34] This sometimes spans more than one six-digit product (for example, fluorspar is divided into two six-digit HS products according to calcium fluoride content), in which case I use the simple average of export taxes (import tariffs) across these products as the upstream export tax (import tariff).

[35] It is for this reason that I do not use this input-output data in the analysis of the link between upstream export taxes and downstream import tariffs in Section 4.1.

of product-level trends in exports within each of the sections of the HS product classification, such as chemicals ('Products of the Chemical and Allied Industries') or metals ('Base Metals and Articles of Base Metal'). Twelve HS sections (out of a total of 21) are represented in the sample used here. The main results remain similar to those in the baseline specification in column (2), though the estimated coefficient on upstream taxes drops from 0.82 to 0.59.

One issue with this data is that a large proportion (41%) of the goods in the sample are linked to a single primary raw material, iron ore. This is due to the detailed subdivision of iron and steel products in the HS classification. In column (4), I thus rerun the regression with section-year fixed effects dropping all products of this raw material; this does not substantially change the coefficient estimates.

I include the results of several robustness checks in Table 1.15. Since export taxes are likely to affect the prices of both exports and downstream exports, in column (1) I instead run the regression using log export quantity instead of log export value. This makes little difference to the coefficients, although the p-value of the estimated effect of upstream export taxes now slightly exceeds 0.1. Also, while it is important to account for trends in world demand that are unrelated to China, the control for world export value is potentially endogenous because Chinese exports often form a substantial share of total world trade. I thus estimate a specification without this control, in which I instead use China's log share of world trade as the left-hand-side variable. This also results in little change to either of the coefficients of interest, as shown in column (2) of Table 1.15.

I next return to the original specification but add indicator variables for other export-side policies – prohibition of exports via processing trade, and the incidence of either an export license requirement, export quota or state trading requirement – to the right-hand side. Column (3) of Table 1.15 shows that the coefficients on the export tax variables are not substantially affected by this new specification, and that the estimated coefficient on export processing prohibitions is negative and significant as expected. However, other export policies are positively associated with exports, suggesting that the choice of these policies may be endogenous to expected export growth.[36]

As in the previous section, I deal with the potential endogeneity of export policies

[36]Dropping Chinese exports to the US from the baseline regression, so as to address the possibility that these trends are driven by the changes in US trade policy uncertainty discussed in Footnote 9, also yields extremely similar coefficient estimates, as shown in column (4) of Table 1.15.

to exports by instrumenting for the export tax variables with pre-WTO tariffs in a long-difference specification:

$$\Delta \ln exports_{pt} = \alpha + \beta \Delta exporttax_{pt} + \beta^U \Delta exporttax_{pt}^{upstream} + \eta' \Delta X_{pt} + \epsilon_{pt} \quad (1.9)$$

Here, I take differences between 2002 and 2012 (the two endpoints of the sample) and instrument for changes in export taxes and upstream export taxes with quadratics in 1999 tariffs and upstream 1999 tariffs. As noted above, this is feasible because most of the 'downstream' products in the sample are actually semiprocessed raw materials, for which export tax changes and 1999 tariffs are highly correlated.

The results of OLS and instrumental variables estimation of specification (1.9) may be found in columns (1) and (2) of Table 1.16 respectively. The coefficients on export taxes and upstream export taxes in the long-difference specification in column (1) are somewhat larger in magnitude than those from the panel regressions, and the effect of upstream export taxes is now statistically insignificant. However, the IV estimates in column (2) are both statistically significant, and in the case of upstream export taxes, substantially larger in magnitude than the corresponding OLS estimate. The results now suggest that a one percentage point rise in export taxes on a primary raw material between 2002 and 2012 is associated with a 4.63 percentage point increase in exports of downstream products using that material on average.

Although the above empirical analysis of the indirect effects of export taxes benefits from the precision of product-level input-output data, this comes at the cost of the omission of most downstream products from the sample. In Table 1.17, I thus also present results from panel regressions in which upstream taxes and tariffs are instead calculated using information from China's 2002 input-output table (as discussed in the data appendix). I first reproduce the results of specification (1.8) (adding section-year fixed effects) using the same sample of products as above, but this alternative data on upstream policies. As column (1) of Table 1.17 shows, this results in much larger estimates of the effects of upstream export taxes: the relevant coefficient estimate is 6.55, as compared to 0.59 in column (3) of Table 1.14.

While this estimate is surprisingly high given the indirect nature of the effect, it would nonetheless be encouraging if it remained consistent across different sub-samples of products. In columns (2) and (3) of Table 1.17, I therefore run the same regression using two different samples: the full sample of nonagricultural products and the subsample of final goods, parts and accessories (i.e. omitting both primary and semiprocessed raw materials). In both cases, this results in a coefficient estimate on upstream export taxes that is similar to that of column (1) and statistically significant at the 1% level, clustering standard errors by input-output sector.

1.6 Conclusion

In this chapter, I have studied the persistence of trade policy in China after its 2001 entry into the World Trade Organization. While the conditions of its WTO accession required China to make cuts to its import tariffs that led to heterogeneous reductions in protection across sectors, I have documented the recent emergence of export taxes that are likely to have partly restored China's pre-WTO pattern of industrial protection. China's export taxes are mainly incident on raw materials, and I have used product-level input-output data to show that larger rises in these export taxes after WTO accession are associated with greater downstream export growth.

To what extent might China's policy of export restrictions on raw materials be adopted by other developing countries? China's situation with respect to raw materials production is an exceptional one, thanks to its large size, capital stock and land endowments. For instance, as documented by the British Geological Survey (2010), China was the world's leading producer in at least 37 categories of minerals and metals in 2008, in 12 of which it produced more than half of total world output. In practice, many countries are net importers of most of their raw materials, and very few countries produce a significant proportion of world output in such a wide range of upstream sectors. For most developing countries, then, a systematic policy of restrictions on raw materials exports would probably have a more limited aggregate effect.

China is nonetheless not the only country to adopt such a policy as an apparent strategy for industrial development. For example, a ban on the export of 41 unprocessed minerals from Indonesia became effective in January 2014, and associated regulations set out the extent to which each mineral must be processed in order to be eligible for export.[37] More targeted raw materials export restrictions have

[37] At a G20 meeting soon after the initial enactment of these regulations, Indonesia's Minister

been documented in such diverse settings as Tudor England and nineteenth-century Egypt. In the former case, export restrictions on raw wool and unfinished cloth were implemented in order to relocate downstream production from continental Europe (Chang 2002), while in the latter, state policies equivalent to export taxes offered advantageous cotton and flax prices to domestic producers of textiles as part of a push for industrialization (Panza and Williamson 2013).

More generally, as discussed at the beginning of this chapter, economic theory suggests that developing countries may achieve their trade and industrial policy goals via a wide variety of possible policies, of which the restriction of raw materials exports is only one. The full impact of multilateral negotiations in reshaping trade and industrial policy worldwide will remain an open question as long as comprehensive information on these many other possible policy instruments remains sparse.

of Trade spoke of "...the aspiration to move up trade's value chain, starting from providing raw materials, then processing raw materials into semi-finished and end products in order for developing countries, such as Indonesia, to be able to enjoy the benefit of the added value." (Indonesia Ministry of Trade 2012)

1.A Data appendix

Import tariffs and non-tariff barriers

Data for 1997 to 2011 on China's applied import tariffs and data on China's bound tariffs is sourced from the UNCTAD TRAINS and WTO Tariff Analysis Online databases. Data for 2012 on China's applied import tariffs is transcribed from the 2012 volume of the annual official publication *Customs Import and Export Tariff of the People's Republic of China*. Information on the set of products for which China's accession agreement specifies that non-tariff barriers were to be removed is sourced from the documents associated with China's WTO accession available on the WTO web site.

Export duties

Data sources are discussed in the main text. According to Chinese regulations, for a published export duty rate t_x^p for a product p (hereafter this p is dropped), the tax owing on export sales of that product is calculated according to:

$$\frac{t_x}{t_x + 1} \cdot exportsales^{FOB}$$

Here, the free on board (FOB) price is the price at which goods are sold abroad (i.e. the price of goods after clearing customs). This implies a tax rate of t_x on export sales in terms of pre-duty prices.

VAT export rebates

Data sources are discussed in the main text. For each product and time period, the data specifies a VAT rate, a rebate rate and the type of rebate policy applied to the product. Different policy types imply different calculations of equivalent export taxes based on the associated Chinese regulations (see e.g. Deloitte Touche Tomatsu 2005, Chan 2008).

First note that firms whose sales are entirely domestic normally pay VAT on value added (at rate t_v^p for product p), by paying VAT on sales while claiming credit for the VAT paid on purchases of inputs; i.e. they are charged 'output VAT' while claiming credit for 'input VAT'. This corresponds to the following formula (again omitting p):

$$t_v \cdot \frac{sales}{t_v + 1} - inputVAT$$

Nonzero rebate, not tax-exempt

Consider a firm which produces the goods it sells abroad, and which exports in a single product category for which the rebate rate is not zero. Such a firm may calculate its VAT payable as the difference of output VAT on local sales and input VAT on local purchases as above, plus a third term d:

$$d = (exportsales^{FOB,p} - \sum_{p'} bonded^{p'})(VATrate^p - rebaterate^p)$$

where $bonded^{p'}$ corresponds to purchases of imported inputs in sector p' that do not go through customs, which may be nonzero if the firm participates in processing trade.

Say that the firm does not purchase bonded imports, and that its input purchases may be unambiguously allocated across inputs used for goods sold domestically and inputs used for exported goods. Then the tax applicable on exports is:

$$exportsales^{FOB,p} \cdot (VATrate^p - rebaterate^p) - inputVAT$$

Under the assumption that the nondistortionary policy is a full rebate of VAT on exports, this would imply an export tax bill on a given product with VAT rate t_v and rebate rate r of:

$$(t_v - r) \cdot exportsales^{FOB}$$

While the firm's actual tax bill will differ from this depending on its input VAT, the firm may be assumed to take reimbursement of input VAT into account when purchasing inputs; i.e. the reimbursement of input VAT may be considered to be a component of input prices. This implies a tax rate of $\frac{t_v - r}{1-(t_v-r)}$ on pre-tax export sales.

Note that if the firm does not produce the goods exported, but instead buys these from another firm for export, then input VAT (here, the amount of VAT paid by the firm producing the goods to be exported) is rebated to this firm according to the prevailing rebate rate, so that it should be the pre-tax rather than the FOB price that is used in the calculation above. I abstract from this distinction by assuming that all exporters are the producers of the goods exported.

Zero rebate, not tax-exempt

Products with a zero rebate rate are treated as products sold domestically, so that the applicable formula for tax payable is:

$$t_v \cdot \frac{sales}{t_v + 1} - inputVAT$$

Again assuming that that the nondistortionary policy is a full rebate of VAT on exports, this implies a tax rate of t_v on pre-tax export sales.

Exempt from taxes

A small subset of products are classified as 'exempt from taxes', which means that they pay no output VAT on exports, but their input VAT is not reimbursed. I thus model the applicable export tax in this case as equal to exporters' input VAT. I use the 2002 Chinese input-output table, in which I observe pre-tax gross output and input shares, to calculate the rate of implied export tax per unit of pre-tax gross output for a given input-output sector. I then use a concordance between HS products and 2002 Chinese input-output sectors (see below for details of this concordance) to apply these export tax rates to each product in the 'tax-exempt' category. This assumes uniformity of production functions across products within input-output industries.

The export tax rate per unit of output for a given input-output sector k is thus calculated to be:

$$\sum_{k'} \beta^{kk'} \frac{t_v^{k'}}{1 + t_v^{k'}}$$

where $\beta^{kk'}$ is the observed expenditure share per unit currency of (pre-tax) output of sector k on inputs from sector k'.

Constructing export tax equivalents

Here, I calculate the export tax rate jointly implied by the two policies above, for each of the three types of VAT export rebate policies.

Nonzero rebate, not tax-exempt

The applicable export taxes are:

$$\frac{t_x}{t_x+1} exportsales + (t_v - r) \cdot exportsales$$

We may calculate the tax rate on pre-tax export sales using:

$$\begin{aligned} p^{pretax} &= p^{FOB} - \frac{t_x}{t_x+1} p^{FOB} - (t_v - r) \cdot p^{FOB} \\ \implies p^{FOB} &= \left(1 - \frac{t_x}{t_x+1} - (t_v - r)\right)^{-1} p^{pretax} \\ \implies p^{FOB} &= \left(\frac{t_x + (t_v - r) + t_x(t_v - r)}{1 - (t_v - r) - t_x(t_v - r)} + 1\right) p^{pretax} \end{aligned}$$

So the applicable export tax rate on pre-tax export sales is $\frac{t_x+(t_v-r)+t_x(t_v-r)}{1-(t_v-r)-t_x(t_v-r)}$.

Zero rebate, not tax-exempt

The applicable export taxes are:

$$\frac{t_x}{t_x+1} exportsales + \frac{t_v}{t_v+1} exportsales$$

We may calculate the tax rate on pre-tax export sales using:

$$\begin{aligned} p^{pretax} &= p^{FOB} - \frac{t_x}{t_x+1} p^{FOB} - \frac{t_v}{t_v+1} p^{FOB} \\ \implies p^{FOB} &= \left(1 - \frac{t_x}{t_x+1} - \frac{t_v}{t_v+1}\right)^{-1} p^{pretax} \\ \implies p^{FOB} &= \left(\frac{t_x + t_v + 2t_x t_v}{1 - t_x t_v} + 1\right) p^{pretax} \end{aligned}$$

So the applicable export tax rate on pre-tax export sales is $\frac{t_x+t_v+2t_xt_v}{1-t_xt_v}$.

Exempt from taxes

The export tax rate on pre-tax sales due only to non-reimbursement of input VAT may be calculated as:

$$p^{VAT} = p^{pretax} + \sum_{k'} \beta^{kk'} \frac{t_v^{k'}}{1+t_v^{k'}} p^{VAT}$$
$$\implies p^{VAT} = \frac{1}{1 - \sum_{k'} \beta^{kk'} \frac{t_v^{k'}}{1+t_v^{k'}}} p^{pretax}$$

Export duties then imply that:

$$p^{FOB} = p^{VAT} + \frac{t_x}{1+t_x} p^{FOB}$$
$$\implies p^{FOB} = \left(1 - \frac{t_x}{t_x+1}\right)^{-1} \left(\frac{1}{1 - \sum_{k'} \beta^{kk'} \frac{t_v^{k'}}{1+t_v^{k'}}}\right) p^{pretax}$$
$$\implies p^{FOB} = \left(\frac{t_x + \sum_{k'} \beta^{kk'} \frac{t_v^{k'}}{1+t_v^{k'}}}{1 - \sum_{k'} \beta^{kk'} \frac{t_v^{k'}}{1+t_v^{k'}}} + 1\right) p^{pretax}$$

So the applicable export tax rate on pre-tax export sales is $\frac{t_x + \sum_{k'} \beta^{kk'} \frac{t_v^{k'}}{1+t_v^{k'}}}{1 - \sum_{k'} \beta^{kk'} \frac{t_v^{k'}}{1+t_v^{k'}}}$.

Prohibitions of exports via processing trade

Data for 2005 to 2012 on products prohibited from export via processing trade is assembled from the set of ad hoc official notices updating the list of prohibited products; I observe these notices starting in 2004. I define the policies prevailing on January 1 of each year as the data for that year, with the exception of 2008, when I also include major changes to the list of prohibited products that took effect in mid-January. The data is observed at the ten-digit product level, and I define a six-digit HS product as subject to a prohibition if at least one of its constituent ten-digit goods is subject to such a prohibition. The full list of notices is as follows:

Shangwu bu, haiguan zongshu, guojia huanjing baohu zongju gonggao (2004) no. 55

Shangwu bu, haiguan zongshu gonggao (2005) no. 26

Shangwu bu, haiguan zongshu gonggao (2005) no. 50

Shangwu bu, haiguan zongshu, huanbao zongju gonggao (2005) no. 105

Shangwu bu, haiguan zongshu, huanbao zongju gonggao (2006) no. 63

Shangwu bu, haiguan zongshu, guojia huanjing baohu zongju gonggao (2006) no. 82

Shangwu bu, haiguan zongshu, huanbao zongju gonggao (2007) no. 17

Shangwu bu, haiguan zongshu gonggao (2007) no. 110

Shangwu bu, haiguan zongshu gonggao (2008) no. 22

Shangwu bu, haiguan zongshu gonggao (2008) no. 121

Shangwu bu, haiguan zongshu gonggao (2009) no. 37

Shangwu bu, haiguan zongshu lianhe gonggao (2010) no. 63

Export licenses, quotas, state trading and designated trading

Data for 2002 to 2012 on products requiring export licenses, subject to export quotas, or subject to designated trading or state trading requirements is taken from the annual official notices announcing this list of products. I do not include textiles and apparel products affected by the Multifiber Agreement or subsequent bilateral agreements. I also exclude goods on lists of dual-use products subject to export quotas or lists relating only to small-scale border trade. Some categories of goods are moved from the 'main' list to the list of dual-use products during the sample period, and I do not include these products in any year. I do include a separately published list of tobacco products that are subject to export restrictions throughout the period. The data is observed at the ten-digit product level, and I define a six-digit HS product as subject to one of these policies if at least one of its constituent ten-digit goods is subject to the policy. The full list of notices is as follows:

Duiwai maoyi jingji hezuo bu, haiguan zongshu gonggao (2001) no. 17

Duiwai maoyi jingji hezuo bu gonggao (2001) no. 44

Duiwai maoyi jingji hezuo bu, haiguan zongshu gonggao (2002) no. 59

Shangwu bu, haiguan zongshu gonggao (2003) no. 64

Shangwu bu, haiguan zongshu gonggao (2004) no. 78

Shangwu bu, haiguan zongshu gonggao (2005) no. 85

Shangwu bu, haiguan zongshu gonggao (2006) no. 100

Shangwu bu, haiguan zongshu gonggao (2007) no. 101

Shangwu bu, haiguan zongshu gonggao (2008) no. 100

Shangwu bu, haiguan zongshu gonggao (2009) no. 125

Shangwu bu, haiguan zongshu gonggao (2010) no. 128

Shangwu bu, haiguan zongshu gonggao (2011) no. 98

Export prohibitions

Data for 2002 to 2012 on goods prohibited from export is assembled from a set of ad hoc official notices. I drop any product (at the level of aggregation used in the relevant official notice) subject to an export prohibition in any year from the data used in the empirical analysis in all years. The full list of notices is as follows:

Duiwai maoyi jingji hezuo bu gonggao (2001) no. 19

Shangwu bu, haiguan zongshu, linyeju gonggao (2003) no. 27

Shangwu bu, haiguan zongshu, linyeju gonggao (2004) no. 40

Shangwu bu, haiguan zongshu, guojia huanjing baohu zongju gonggao (2005) no. 116

Shangwu bu, haiguan zongshu gonggao (2006) no. 16

Shangwu bu, haiguan zongshu gonggao (2006) no. 35

Shangwu bu, haiguan zongshu gonggao (2006) no. 87

Shangwu bu, haiguan zongshu gonggao (2008) no. 96

Shangwu bu, haiguan zongshu gonggao (2009) no. 110

Concordance between products and industries

To define variables at the industry level, I use a National Bureau of Statistics concordance between four-digit Chinese industries and eight-digit HS products (according to the 2005 Chinese product classification) kindly provided to me by Loren Brandt, Johannes Van Biesebroeck, Luhang Wang and Yifan Zhang. After aggregating to the six-digit level, I drop any six-digit products that are concorded to more than one two-digit industry, since I cluster at the two-digit industry level in the empirical analysis. I then average the relevant data across the six-digit products concorded to each industry.

Definition of nonagricultural products and industries

I omit from the empirical analysis all eight-digit HS products defined as 'agricultural products' in China's official schedule of bound tariffs (available from the WTO web site); these are the products covered by the WTO's Agreement on Agriculture. So that I do not exclude agricultural products but include their major raw materials, I also drop fertilizers and pesticides from the analysis. I use a 2005 concordance of Chinese industries to HS products from China's National Bureau of Statistics (see above) to identify fertilizers and pesticides products in the HS data as those produced by the three-digit industries 'Fertilizer manufacture' and 'Pesticide manufacture'. I use the same concordance to classify industries into agricultural and agricultural raw materials industries, according to whether at least half of their products are agricultural goods or agricultural raw materials.

Definition of raw materials and capital goods

I define raw materials as HS products identified by the UN Broad Economic Categories (BEC) classification as neither 'consumption goods' nor 'capital goods' (according to its correspondence with the System of National Accounts, which is included in the BEC documentation), nor as 'parts and accessories'. I also divide raw materials products into primary or semiprocessed raw materials according to whether they are classified in BEC as primary goods. I then use a 2005 concordance of Chinese industries to HS products from China's National Bureau of Statistics (see above) to classify industries as raw materials industries, and then into primary or semiprocessed raw materials industries, according to whether more than half of their products are in these categories. Capital goods and capital goods industries are classified similarly, defining both final capital products and their parts and accessories as capital goods.

Downstream import tariffs

Data for 2002 to 2012 on downstream import tariffs (for the analysis of Table 1.8 in Section 1.4.1) is derived using China's 2002 input-output table. I begin by concording four-digit industries to input-output sectors using a concordance from Brandt et al. (2012b). I then classify each input-output sector concorded to at least one raw materials industry as a producer of one of nine broad categories of materials: chemicals, fuels, leather and furs, metal, nonmetallic minerals, plastic, rubber, textiles, and wood and paper (with the exception of 'Manufacture of synthetic materials', as discussed below; also, sectors producing aquatic products are dropped from this analysis). For all other nonagricultural input-output sectors, I sum the input shares (from the 2002 input-output table) of each of these groups of raw materials input-output sectors, and define the main constituent material of each sector according to the maximum of these nine input shares. This procedure generates a concordance between four-digit industries and the nine broad materials categories. However, a few industries for which the constituent material is explicitly stated in the name of the industry (including the industries concorded to the input-output sector 'Manufacture of synthetic materials', such as 'Manufacture of plastic in primary forms') are hand-concorded to that material. For each raw materials industry producing a given material, the mean downstream tariff is defined as the simple average of the tariffs of all downstream industries using that material, while the maximum downstream tariff is defined as the maximum of the tariffs of all downstream industries using that material. Fuels are not associated with any downstream industries by this procedure and so are omitted from the analysis.

Effective rates of protection

Data on effective rates of protection by industry is derived using definitions from Corden (1966) and China's 2002 input-output table. I first concord products to input-output sectors using information from a 2005 concordance of Chinese industries to HS products from China's National Bureau of Statistics (see above). Ambiguous or missing concordances are coded using a concordance of products to 2007 input-output sectors from China's 2007 input-output table, or by hand when necessary. I define export taxes (or import tariffs) for each input-output sector as the simple average of export taxes (or import tariffs) across the six-digit products in that sector. For bound tariffs, I first reassign product-level tariff rates to be equal to 1999 applied tariffs whenever bound tariffs exceed 1999 applied tariffs. I then calculate each sector's input tariff or input export tax by using the shares of each input sector in the gross output of that sector as weights. I also take information on the share of value added in gross output for each input-output sector from China's 2002 input-output table. Finally, I use a concordance of four-digit industries to input-output sectors from Brandt et al. (2012b) to assign input tariffs, input export taxes and value added shares to each four-digit industry in each year. I calculate the effective rate of protection due to tariffs for an industry as the difference between its tariff and its input tariff, divided by its value added share. Similarly, I calculate the effective rate of protection due to export taxes for an industry as the difference between its input export tax and its export tax, divided by its value added share.

Industry-level sales and export data

Data for 2002 to 2007 on industry-level exports and sales as reported by firms in current Renminbi are based on industry-level tabulations of China's annual firm-level survey of industrial production, as collected by China's National Bureau of Statistics. This data includes all non-state industrial firms with sales above five million Renminbi and all state-owned industrial firms. Exports (sales) for each industry are defined as the total of exports (sales) for all firms in the industry, excluding those reporting negative output, sales, exports or employment. Since the 2002 survey data uses a older industrial classification, I concord these sectors to industries as defined after 2002 using the concordance provided by Brandt et al. (2012b).

Trade flows

Data for 2002 to 2012 on trade flows is sourced from the UN COMTRADE database, using FOB data provided by China as the source for information on Chinese exports by value and quantity. Data on world trade flows is also sourced from the UN COMTRADE database, and is equal to the total of all export flows reported by exporters. For all trade quantity data, I use only information on net weight in kilograms where available.

Upstream import tariffs and export taxes

Data for 2002 to 2012 on upstream import tariffs and export taxes (for the analysis of Section 1.5.2) is derived in two ways. The first method uses product descriptions in the 2002 English-language six-digit HS classification and the 2002 to 2006 Chinese eight-digit product classifications (which are equivalent at the six-digit level). I first identify all primary six-digit products using the UN BEC classification, ignoring agricultural primary products and primary products in section 11 (i.e. textiles). I then identify all nonprimary HS products for which at least one of these primary raw materials is mentioned in the product description, with the goal of finding products made of that raw material. I thus exclude products with references such as 'other than (material)' and other irrelevant products such as machines for cutting the material. Using these criteria narrows the data to products made of 42 different primary raw materials. I include in the final dataset only nonprimary products whose descriptions refer to exactly one of these materials, so that I may cluster by primary raw material. I then define upstream export taxes (or import tariffs) as the average export tax (or import tariff) across the six-digit HS products associated with a particular raw material (e.g. roasted and unroasted molybdenum ores).

The second method uses China's 2002 input-output table. Products are concorded to input-output sectors using information from a 2005 concordance of Chinese industries to HS products from China's National Bureau of Statistics (see above). Ambiguous or missing concordances are coded using a concordance of products to 2007 input-output sectors from China's 2007 input-output table, or by hand when necessary. I define export taxes (or import tariffs) for each input-output sector as the simple average of export taxes (or import tariffs) across the six-digit products in that sector. I then calculate each sector's upstream tariffs by using the shares of each input sector in the total intermediate usage of the downstream sector, omitting the diagonal, as weights.

1.B Figures

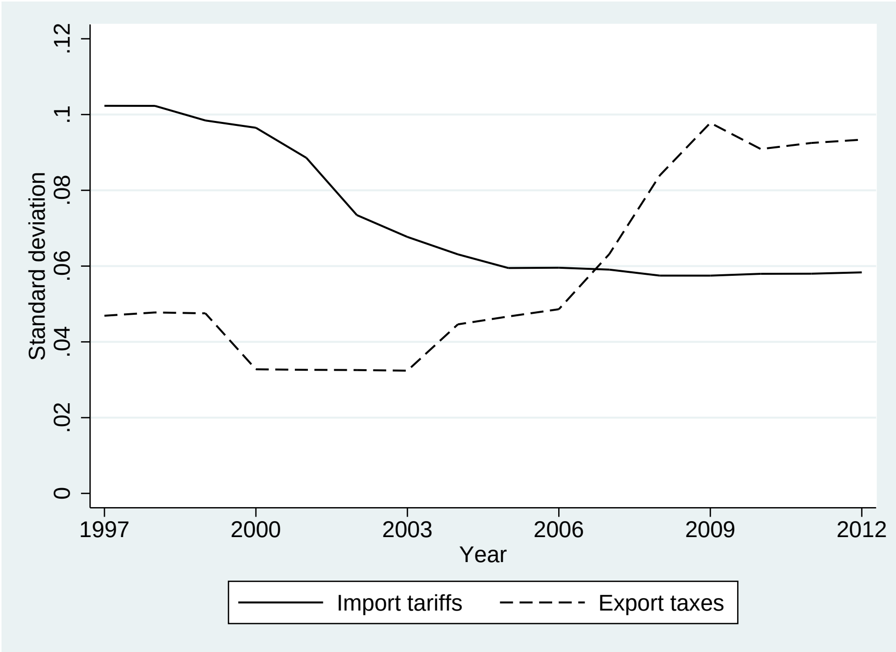


Figure 1.1: Standard deviation of China's applied import tariffs and export tax equivalents of China's export VAT rebate policies and export duties across nonagricultural products, 1997 to 2012

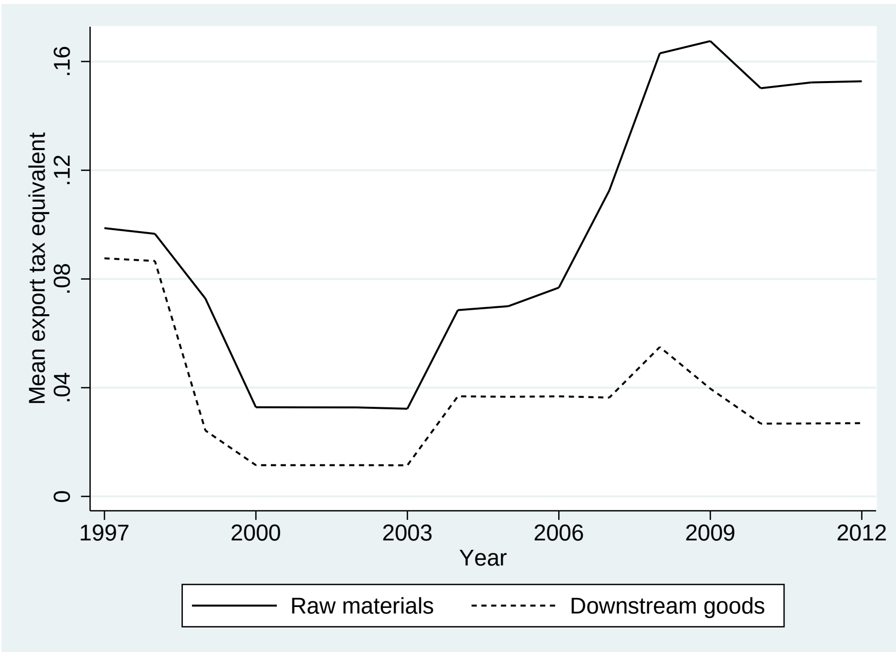


Figure 1.2: Mean of export tax equivalents of China's export VAT rebate policies and export duties across nonagricultural products by stage of production, 1997 to 2012

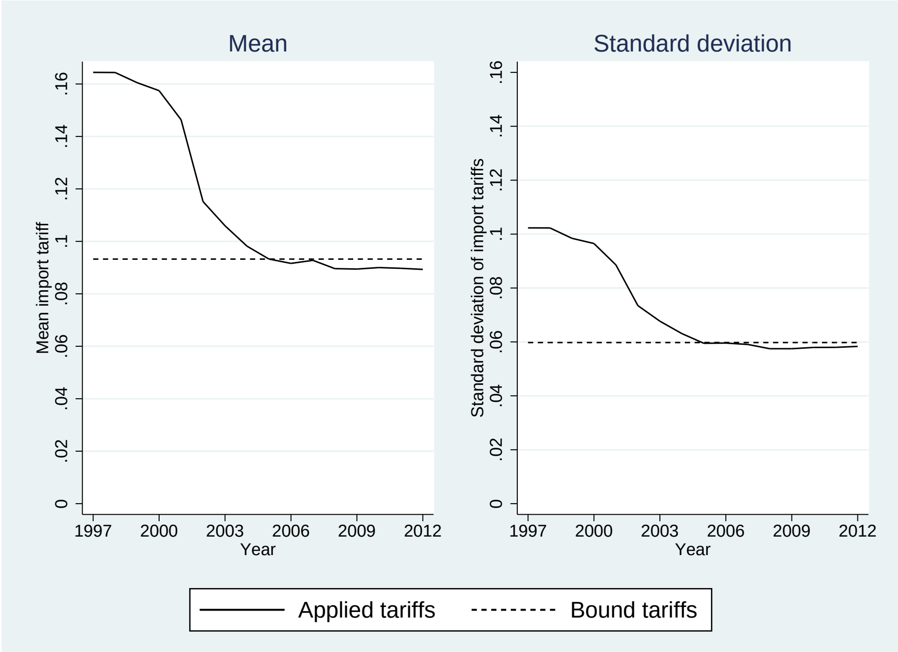


Figure 1.3: Mean and standard deviation of China's applied import tariffs across nonagricultural products, 1997 to 2012

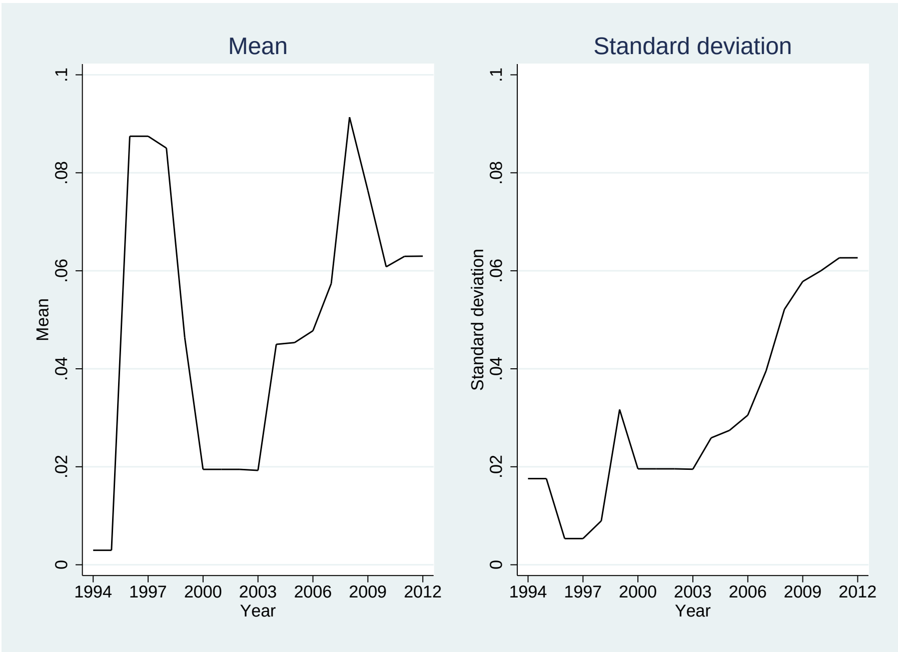


Figure 1.4: Mean and standard deviation of export tax equivalents of China's export VAT rebate policies across nonagricultural products, 1994 to 2012

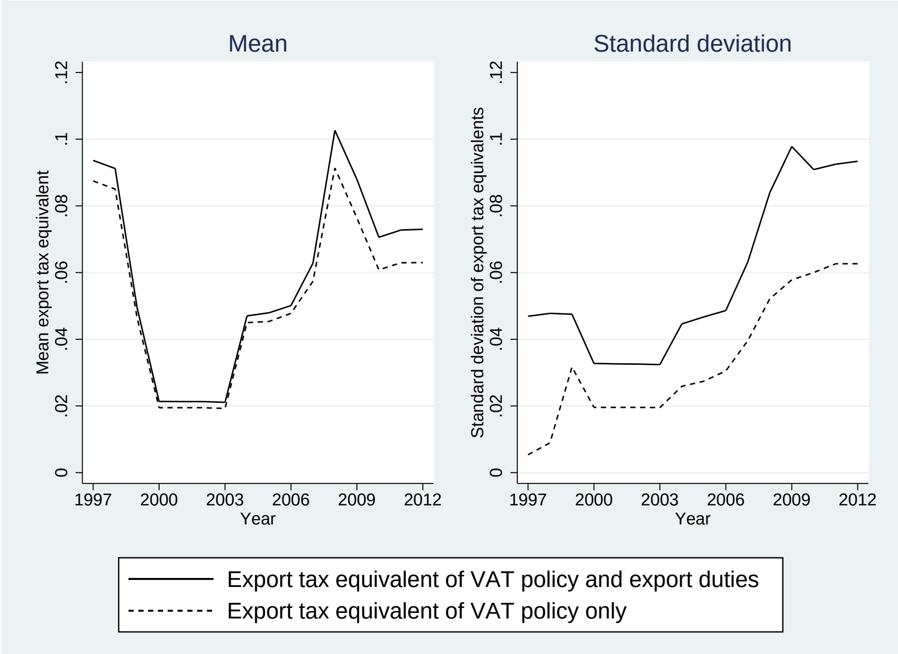


Figure 1.5: Mean and standard deviation of export tax equivalents of China's export VAT rebate policies and export duties across nonagricultural products, 1997 to 2012

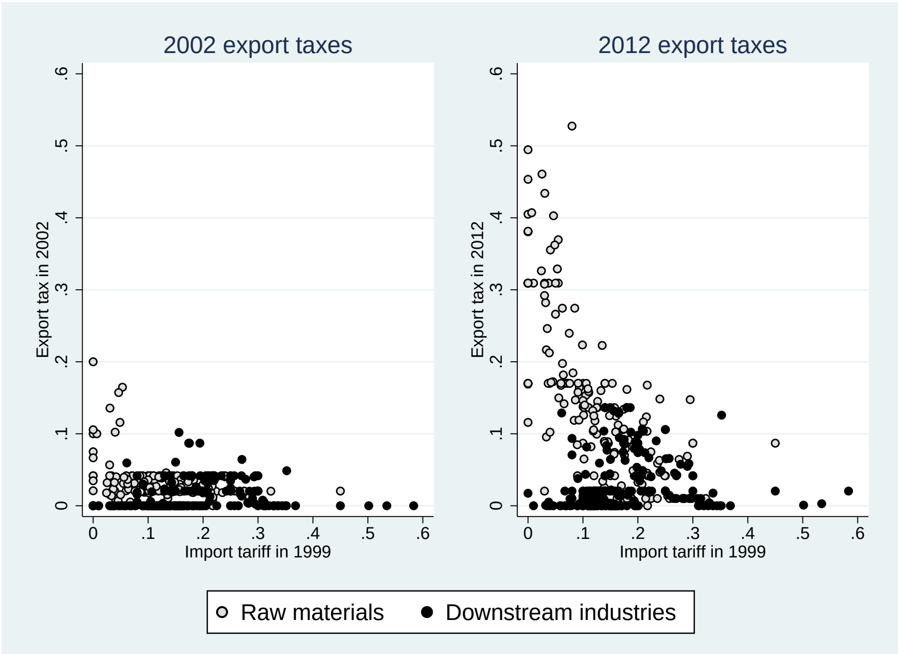


Figure 1.6: Scatter plots of 2002 and 2012 export tax equivalents of China's VAT rebate policies and export duties and 1999 applied tariffs by industry

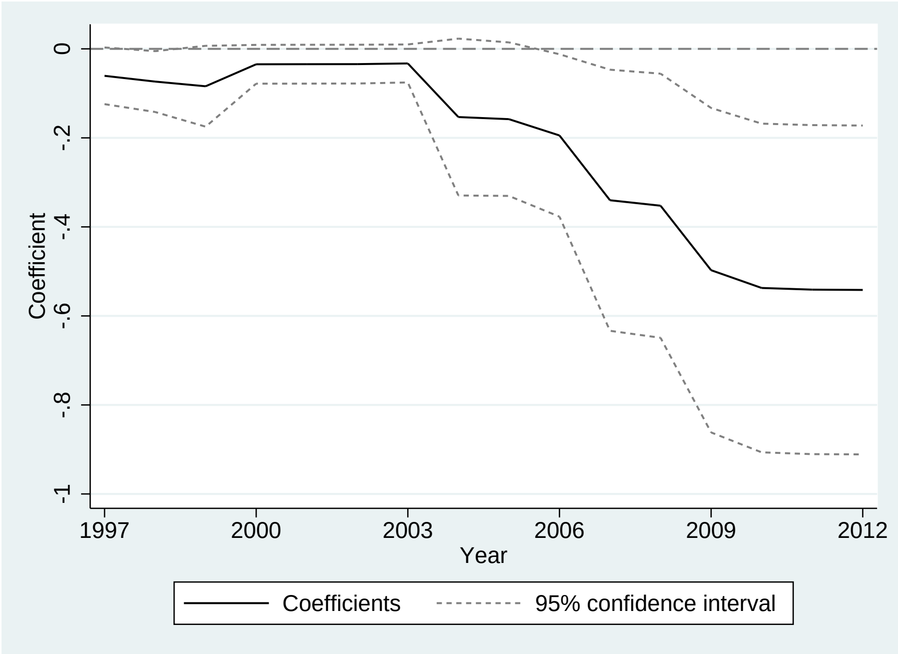


Figure 1.7: Coefficients of annual industry-level regressions of export tax equivalents of China's export VAT rebate policies and export duties on 1999 applied tariffs, 1997 to 2012

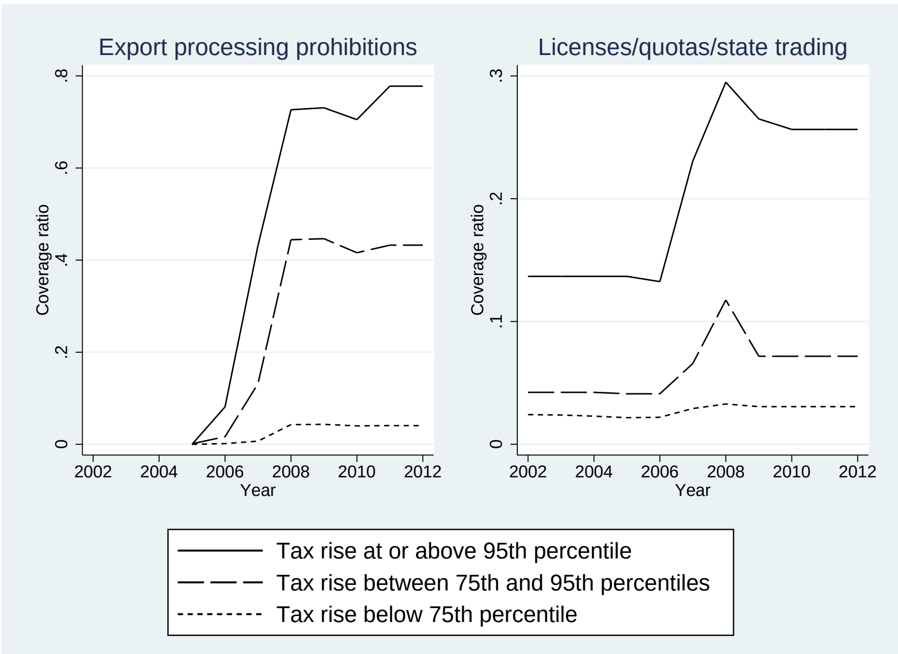


Figure 1.8: Product-level coordination between export tax rises and changes in other export policies, 2002 to 2012

1.C Tables

Table 1.1: Summary statistics of Chinese trade policies

A. Import tariffs

	1999 applied		Bound	
	Mean	Std. dev.	Mean	Std. dev.
Import tariffs	0.161	0.098	0.093	0.060

B. Export tax equivalents of VAT export rebate policies and export duties

	2002		2012	
	Mean	Std. dev.	Mean	Std. dev.
VAT export rebate policies	0.019	0.020	0.063	0.063
Export duties	0.002	0.023	0.007	0.036
Total export tax equivalent	0.021	0.033	0.073	0.093

C. Export processing prohibitions

	2005	2012
	Share of products covered	Share of products covered
Export processing prohibitions	0.0003	0.158

D. Other export policies

	2002	2012
	Share of products covered	Share of products covered
Export licenses	0.020	0.042
Export quotas	0.019	0.017
State or other designated trading	0.008	0.007
Any of the above	0.022	0.043

These summary statistics include the mean and standard deviation across nonagricultural products of the policies in Panels A and B and the proportion of six-digit nonagricultural products covered by the policies in Panels C and D. See data appendix for information on data sources for all policy variables.

Table 1.2: Export taxes and pre-WTO import tariffs by year

Dependent variable:	Export tax								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Year:	1997	1998	1999	2000	2001	2002	2003	2004	2005
Tariff 1999	-0.06*	-0.07**	-0.08	-0.03	-0.03	-0.03	-0.03	-0.15***	-0.16**
	(0.03)	(0.03)	(0.04)	(0.02)	(0.02)	(0.02)	(0.02)	(0.09)	(0.09)
	[0.09]	[0.03]	[0.11]	[0.15]	[0.15]	[0.15]	[0.16]	[0.008]	[0.014]
Observations	402	402	402	402	402	402	402	402	402
Clusters	35	35	35	35	35	35	35	35	35
R^2	0.04	0.05	0.03	0.01	0.01	0.01	0.01	0.09	0.10

Dependent variable:	Export tax						
	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Year:	2006	2007	2008	2009	2010	2011	2012
Tariff 1999	-0.19***	-0.34***	-0.35**	-0.50***	-0.54***	-0.54***	-0.54***
	(0.09)	(0.14)	(0.15)	(0.18)	(0.18)	(0.18)	(0.18)
	[0.006]	[0.004]	[0.014]	[0.004]	[0.002]	[0.002]	[0.002]
Observations	402	402	402	402	402	402	402
Clusters	35	35	35	35	35	35	35
R^2	0.13	0.19	0.14	0.20	0.23	0.23	0.23

This table displays regressions of the joint export tax equivalent of China's export VAT rebate policies and its export duties in each year between 1997 and 2012 on China's 1999 applied tariffs. The unit of observation is a four-digit industry. All regressions are estimated using ordinary least squares. Robust standard errors (in round brackets) are clustered at the two-digit industry level. p-values derived from wild bootstraps (as in Cameron et al. 2008) are in square brackets. Small p-values are represented by *** (less than 1%), ** (less than 5%) or * (less than 10%).

Table 1.3: Changes in export taxes and pre-WTO tariffs by instrument

Dependent variable:	Export tax 2012 - export tax 2002		
	(1)	(2)	(3)
Taxes calculated using:	Both policies	VAT policy only	Export duties only
Tariff 1999	-0.51***	-0.30***	-0.14***
	(0.17)	(0.10)	(0.05)
	[0.002]	[0.002]	[0.002]
Observations	402	402	402
Clusters	35	35	35
R^2	0.25	0.22	0.16

This table displays the results of regressions of changes in Chinese export taxes between 2002 and 2012 on China's 1999 import tariffs. The unit of observation is a four-digit industry. In column (1), the dependent variable is the difference between the 2012 and 2002 joint export tax equivalent of China's export VAT rebate policies and its export duties. In column (2), the dependent variable is the difference between the 2012 and 2002 export tax equivalent of China's export VAT rebate policies only. In column (3), the dependent variable is the difference between 2012 and 2002 export duties. Robust standard errors (in round brackets) are clustered at the two-digit industry level. p-values derived from wild bootstraps (as in Cameron et al. 2008) are in square brackets. Small p-values are represented by *** (less than 1%), ** (less than 5%) or * (less than 10%).

Table 1.4: Large changes in export taxes and 1999 tariffs by stage of production

	(1)	(2)	(3)
Sample:	Top 25% of 1999 tariffs	Top 25% of export tax changes	All industries
Primary raw materials	0	33	37
Semiprocessed raw materials	32	63	137
Capital goods industries	14	3	138
Other downstream industries	54	2	90
Total	100	101	402

This is a frequency table classifying industries by their stage in the value chain according to the UN Broad Economic Categories classification; see data appendix for details. Column (1) includes industries in the top quartile of China's 1999 applied tariffs. Column (2) includes industries in the top quartile of rises in the export tax equivalent of China's export VAT policy and export duties between 2002 and 2012. Column (3) includes the full sample of nonagricultural industries.

Table 1.5: Changes in export taxes and pre-WTO tariffs by stage of production

Dependent variable:	(1) Tariff 1999	(2) Export tax change
Primary raw materials	-0.19***	0.22***
	(0.02)	(0.03)
	[0.002]	[0.000]
Semiprocessed raw materials	-0.08***	0.07***
	(0.02)	(0.02)
	[0.002]	[0.000]
Capital goods industry	-0.08***	-0.01
	(0.01)	(0.01)
	[0.002]	[0.44]
Observations	402	402
Clusters	35	35
R^2	0.31	0.52

The dependent variable in column (1) is China's 1999 applied tariffs, and in column (2) it is the difference between 2012 and 2002 export taxes. Both regressions include dummies for primary raw materials industries, semiprocessed raw materials industries and capital goods industries. The omitted category is other downstream industries. The unit of observation is a four-digit industry. Both regressions are estimated using ordinary least squares. Robust standard errors (in round brackets) are clustered at the 2-digit industry level. p-values derived from wild bootstraps (as in Cameron et al. 2008) are in square brackets. Small p-values are represented by *** (less than 1%), ** (less than 5%) or * (less than 10%).

Table 1.6: Changes in export taxes and pre-WTO tariffs within stage of production

Dependent variable:	Export tax 2012 - export tax 2002				
	(1)	(2)	(3)	(4)	(5)
Sample:	All raw materials	Primary raw materials	Semiprocessed raw materials	Capital goods	Other downstream
Tariff 1999	-0.92***	-2.00**	-0.66***	-0.002	-0.04
	(0.17)	(0.14)	(0.15)	(0.02)	(0.04)
	[0.002]	[0.013]	[0.004]	[0.90]	[0.30]
Observations	174	37	137	138	90
Clusters	29	11	22	8	22
R^2	0.47	0.46	0.32	0.00	0.01

This table displays the results of regressions of the difference between 2012 and 2002 Chinese export taxes on China's 1999 applied tariffs. The unit of observation is a four-digit industry. The sample in column (1) includes all raw materials industries, in column (2) all primary raw materials industries, in column (3) all semiprocessed raw materials industries, in column (4) all capital goods industries and in column (5) all other downstream industries. All regressions are estimated using ordinary least squares. Robust standard errors (in round brackets) are clustered at the two-digit industry level. p-values derived from wild bootstraps (as in Cameron et al. 2008) are in square brackets. Small p-values are represented by *** (less than 1%), ** (less than 5%) or * (less than 10%).

Table 1.7: Changes in export taxes, stage of production and pre-WTO tariffs

Dependent variable:	Export tax 2012 - export tax 2002
	(1)
Tariff 1999	-0.001
	(0.02)
	[0.95]
Raw materials industry	0.22***
	(0.03)
	[0.000]
Raw materials * tariff 1999	-0.91***
	(0.18)
	[0.004]
Observations	402
Clusters	35
R^2	0.62

This table displays the results of a regression of the difference between 2012 and 2002 export taxes on 1999 applied tariffs, a dummy for raw materials industries and their interaction. The unit of observation is a four-digit industry. The regression is estimated using ordinary least squares. Robust standard errors (in round brackets) are clustered at the two-digit industry level. p-values derived from wild bootstraps (as in Cameron et al. 2008) are in square brackets. Small p-values are represented by *** (less than 1%), ** (less than 5%) or * (less than 10%).

Table 1.8: Changes in raw materials export taxes and downstream pre-WTO tariffs

Dependent variable:	Export tax 2012 - export tax 2002			
	(1)	(2)	(3)	(4)
Downstream tariff calculated using:	Mean tariff (incl capital)	Mean tariff (not incl capital)	Max tariff (incl capital)	Max tariff (not incl capital)
Tariff 1999	-0.82**	-0.90**	-0.81***	-0.80***
	(0.15)	(0.18)	(0.15)	(0.15)
	[0.015]	[0.015]	[0.003]	[0.003]
Downstream tariff 1999	-0.61***	0.05	0.15***	0.15***
	(0.09)	(0.08)	(0.02)	(0.03)
	[0.007]	[0.50]	[0.005]	[0.005]
Observations	164	164	164	164
Clusters	8	8	8	8
R^2	0.52	0.48	0.51	0.52

This table displays the results of regressions of changes in Chinese export taxes between 2002 and 2012 on China's 1999 import tariffs in the same industry and in downstream industries. The unit of observation is a four-digit industry. The sample includes all raw materials industries. In columns (1) and (2), downstream tariffs are calculated as the mean of the tariffs on the downstream industries associated with a given material; in column (2), capital goods industries are excluded from this calculation. In columns (3) and (4), downstream tariffs are calculated as the maximum of the tariffs on the downstream industries associated with a given material; in column (4), capital goods industries are excluded from this calculation. Robust standard errors (in round brackets) are clustered by material. p-values derived from wild bootstraps (as in Cameron et al. 2008) are in square brackets. Small p-values are represented by *** (less than 1%), ** (less than 5%) or * (less than 10%).

Table 1.9: Robustness to including share of Chinese exports in world trade

Dependent variable:	Export tax 2012 - export tax 2002			
	(1)	(2)	(3)	(4)
	OLS	IV	IV	IV
Tariff 1999	0.01		0.00	0.00
	(0.04)		(0.04)	(0.04)
Raw materials product	0.18***		0.18***	0.18***
	(0.03)		(0.03)	(0.03)
Raw materials * tariff 1999	-0.71***		-0.72***	-0.70***
	(0.13)		(0.14)	(0.13)
China share of world trade 2012		-0.04	0.01	-0.08
		(0.04)	(0.02)	(0.0614)
Square of China share of world trade 2012				0.13
				(0.08)
Observations	3,662	3,662	3,662	3,662
Clusters	76	76	76	76
KP F stat		716.6	699.6	78.6
R^2	0.43			

The dependent variable in all regressions is the difference between 2012 and 2002 export taxes. Column (1) displays the results of an OLS regression of this variable on 1999 applied tariffs, a dummy for raw materials industries and their interaction. Column (2) displays the results of an IV regression of this variable on the share of Chinese exports in total world exports by value in 2012, instrumented with the share of Chinese exports in total world exports by value in 2002. Column (3) displays the results of an IV regression incorporating all of the above independent variables and using the same instrument for China's 2012 world trade share. Column (4) displays the results of an IV regression also adding the square of the share of Chinese exports in total world exports, using China's 2002 world trade share and its square as instruments. The unit of observation is a six-digit HS product. Robust standard errors (in round brackets) are clustered at the two-digit HS product level. Small p-values are represented by *** (less than 1%), ** (less than 5%) or * (less than 10%).

Table 1.10: Export taxes, import tariffs and non-tariff barriers to imports

Dependent variable:	Export tax 2012 - export tax 2002
Tariff 1999	0.01
	(0.03)
	[0.64]
Import NTB cut	-0.02
	(0.01)
	[0.15]
Raw materials industry	0.22***
	(0.03)
	[0.000]
Raw materials * tariff 1999	-0.90***
	(0.17)
	[0.002]
Raw materials * import NTB cut	-0.10***
	(0.02)
	[0.004]
Observations	402
Clusters	35
R^2	0.64

The table displays the results of a regression of the difference between 2012 and 2002 export taxes on 1999 applied tariffs, the share of products on which China's WTO accession agreement specifies that non-tariff barriers to imports were to be removed, a dummy for raw materials industries, and the interactions of each of the first two right-hand-side variables with the raw materials dummy. The unit of observation is a four-digit industry. The regression is estimated using ordinary least squares. Robust standard errors (in round brackets) are clustered at the two-digit industry level. p-values derived from wild bootstraps (as in Cameron et al. 2008) are in square brackets. Small p-values are represented by *** (less than 1%), ** (less than 5%) or * (less than 10%).

Table 1.11: Offsetting changes in effective rates of protection

Dependent variable:	Δ ERP via export taxes
Δ ERP	-0.36***
via tariffs	(0.12)
	[0.002]
Observations	402
Clusters	35
R^2	0.07

The table displays the results of a regression of the difference in effective rates of protection (ERP) between the 2002 and 2012 schedules of Chinese export taxes on the change in ERPs between China's 1999 tariff schedule and its schedule of bound tariffs (adjusting bound tariffs to equal 1999 tariffs when 1999 tariffs exceed bound tariffs). The unit of observation is a four-digit industry. The regression is estimated using ordinary least squares. Robust standard errors (in round brackets) are clustered at the two-digit industry level. p-values derived from wild bootstraps (as in Cameron et al. 2008) are in square brackets. Small p-values are represented by *** (less than 1%), ** (less than 5%) or * (less than 10%).

Table 1.12: Export taxes and share of exports in total sales

Dependent variable:	Share of exports in total sales		
	(1) All industries	(2) All industries	(3) Raw materials only
Export tax	-0.28*	-0.27*	-0.22*
	(0.07)	(0.07)	(0.04)
	[0.07]	[0.07]	[0.054]
Tariff		-0.22	-0.32
		(0.23)	(0.36)
		[0.42]	[0.45]
Industry FE	YES	YES	YES
Year FE	YES	YES	YES
Observations	1,908	1,908	810
Clusters	30	30	26
R^2	0.05	0.05	0.11

This table displays the results of panel regressions of the share of exports in sales on export taxes and import tariffs. All regressions also include industry and year fixed effects. The unit of observation is a four-digit industry. Columns (1) and (2) display the results of regressions including the entire sample of industries, while column (3) displays the results of a regression including only raw materials industries. Textiles and apparel industries are omitted from the sample. Robust standard errors (in round brackets) are clustered at the two-digit industry level. p-values derived from wild bootstraps (as in Cameron et al. 2008) are in square brackets. Small p-values are represented by *** (less than 1%), ** (less than 5%) or * (less than 10%).

Table 1.13: Export taxes and share of exports in total sales - long-difference IV regressions

Dependent variable:	Δ Share of exports in total sales	
	(1)	(2)
Sample:	Raw materials only	Raw materials only
	OLS	IV
Δ Export tax	-0.20**	-0.26*
	(0.05)	(0.08)
	[0.01]	[0.05]
Δ Tariff	-0.33	-0.27
	(0.58)	(0.60)
	[0.58]	[0.65]
Observations	135	135
Clusters	26	26
KP F stat		50.3
R^2	0.04	

This table displays the results of long-difference regressions of the share of exports in total sales on export taxes and import tariffs using data from 2002 and 2007. The unit of observation is a four-digit industry. The sample includes raw materials industries only. Column (1) is estimated using ordinary least squares, while column (2) is estimated using two-stage least squares. In column (2), I instrument for the change in export taxes between 2002 and 2007 using import tariffs in 1999 and their square. Textiles and apparel industries are omitted from the sample. Robust standard errors (in round brackets) are clustered at the two-digit industry level. p-values derived from wild bootstraps (as in Cameron et al. 2008) are in square brackets. 'KP F stat' signifies the first-stage Kleibergen-Paap Wald F statistic. Small p-values are represented by *** (less than 1%), ** (less than 5%) or * (less than 10%).

Table 1.14: Export taxes and exports - panel regressions using HS descriptions

Dependent variable:	Log export value			
	(1)	(2)	(3)	(4)
Sample:	All products	All products	All products	Excluding iron
Export tax	-6.62***	-6.80***	-7.46***	-5.57***
	(1.15)	(1.10)	(1.03)	(1.29)
Upstream export tax	1.03**	0.82**	0.59**	0.66**
	(0.45)	(0.34)	(0.29)	(0.26)
Product FE	YES	YES	YES	YES
Year FE	YES	YES		
Section-year FE			YES	YES
Controls		YES	YES	YES
Observations	6,371	6,371	6,371	3,707
Clusters	42	42	42	41
R^2	0.35	0.38	0.41	0.32

This table displays the results of panel regressions of log export value on export taxes and upstream export taxes. The unit of observation is a six-digit product-year. All columns include product fixed effects. Columns (1) and (2) include year fixed effects and columns (3) and (4) include HS section-year fixed effects. Columns (2), (3) and (4) also include import tariffs, upstream import tariffs and log value of world exports as controls. Column (4) excludes all products with iron ore identified as the primary raw material. Upstream export taxes and import tariffs are calculated using HS product descriptions; see data appendix for details. Textiles and apparel products are omitted from the sample. All regressions are estimated using ordinary least squares. Robust standard errors (in round brackets) are clustered by primary raw material. Small p-values are represented by *** (less than 1%), ** (less than 5%) or * (less than 10%).

Table 1.15: Export taxes and exports - robustness checks

	(1)	(2)	(3)	(4)
Dependent variable:	Log export quantity	Log China share of world trade	Log export value	Log export value
Import partners:	(all)	(all)	(all)	(excl US)
Export tax	-8.30***	-7.48***	-7.07***	-7.54***
	(0.98)	(0.98)	(1.73)	(1.01)
Upstream export tax	0.58	0.57*	0.46*	0.57**
	(0.35)	(0.29)	(0.23)	(0.27)
Export processing ban			-0.46*	
			(0.24)	
Other export policy			0.95**	
			(0.37)	
Product FE	YES	YES	YES	YES
Section-year FE	YES	YES	YES	YES
Controls	YES	YES	YES	YES
Observations	6,325	6,371	6,371	6,367
Clusters	42	42	42	42
R^2	0.28	0.21	0.42	0.41

This table displays the results of panel regressions of various dependent variables on export taxes and upstream export taxes. The dependent variable in column (1) is log export quantity, the dependent variable in column (2) is China's log share of world exports, and the dependent variable in columns (3) and (4) is log export value. The unit of observation is a six-digit product-year. All columns include product and HS section-year fixed effects, and a set of controls including import tariffs and upstream import tariffs. Column (1) also controls for log quantity of world exports. Columns (3) and (4) also control for log value of world exports. Column (3) also includes indicators for whether a product is subject to a prohibition of exports via processing trade or one of the other export policies discussed in Section 4.2.3. Exports in columns (1) to (3) are calculated using all of China's trade partners, while exports in column (4) exclude exports to the US. Upstream taxes and tariffs are calculated using HS product descriptions; see data appendix for details. Textiles and apparel products are omitted from the sample. All regressions are estimated using ordinary least squares. Robust standard errors (in round brackets) are clustered by primary raw material. Small p-values are represented by *** (less than 1%), ** (less than 5%) or * (less than 10%).

Table 1.16: Export taxes and exports - long-difference IV regressions using HS descriptions

Dependent variable:	Δ Log export value	
	(1)	(2)
	OLS	IV
Δ Export tax	-10.45***	-12.37***
	(1.71)	(2.16)
Δ Upstream export tax	1.45	4.63***
	(1.02)	(0.99)
Controls	YES	YES
Observations	560	560
Clusters	40	40
KP F stat		13.7
R^2	0.23	

This table displays the results of long-difference regressions of log export value on export taxes and upstream export taxes using data from 2002 and 2012. The unit of observation is a six-digit product. Additional control variables include long differences of import tariffs, upstream import tariffs and log value of world exports. Upstream export taxes and import tariffs are calculated using HS product descriptions; see data appendix for details. Column (1) is estimated using ordinary least squares, while column (2) is estimated using two-stage least squares. In column (2), I instrument for the change in export taxes between 2002 and 2012 and the change in upstream export taxes between 2002 and 2012 using import tariffs in 1999 and their square and upstream import tariffs in 1999 and their square. Textiles and apparel products are omitted from the sample. Robust standard errors (in round brackets) are clustered by primary raw material. Small p-values are represented by *** (less than 1%), ** (less than 5%) or * (less than 10%).

Table 1.17: Export taxes and exports - panel regressions using input-output table

Dependent variable:	Log export value		
	(1)	(2)	(3)
Sample:	Products in HS descriptions sample	All products	Final goods, parts and accessories
Export tax	-7.52***	-5.10***	-4.57***
	(1.70)	(1.11)	(0.82)
Upstream export tax	6.55***	6.99***	8.22***
	(1.42)	(1.39)	(2.60)
Product FE	YES	YES	YES
Section-year FE	YES	YES	YES
Controls	YES	YES	YES
Observations	6,371	31,470	14,617
Clusters	38	69	46
R^2	0.42	0.45	0.59

This table displays the results of panel regressions of log export value on export taxes and upstream export taxes. The unit of observation is a six-digit product-year. All columns include product and HS section-year fixed effects, and a set of controls including import tariffs, upstream import tariffs and log value of world exports. The sample in column (1) is the same as the sample used in the regressions of Table 1.14. The sample in column (2) is the full set of nonagricultural products, while the sample in column (3) includes only downstream products as defined in Section 4.1; i.e. final goods and their parts and accessories. Upstream taxes and tariffs are calculated using the 2002 Chinese input-output table; see data appendix for details. Textiles and apparel products are omitted from the sample. All regressions are estimated using ordinary least squares. Robust standard errors (in round brackets) are clustered at the input-output sector level. Small p-values are represented by *** (less than 1%), ** (less than 5%) or * (less than 10%).

Chapter 2

Winners and Losers from a Commodities-for-Manufactures Trade Boom

> [W]e need to iron out distortions in the trade relationship, in which Brazil sells commodities and China manufactures.
>
> – Sergio Amaral, former Brazilian trade minister (Bloomberg 2011)

2.1 Introduction

China's recent emergence as a major force in the world economy is one of the largest economic events of recent times. The combination of China's exceptionally high rates of economic growth, its increasingly deep engagement with the rest of the world via international trade, and the sheer size of its stock of labour, land and capital has generated a set of economic shocks whose influence stretches worldwide. Much of the attention on the effects of China on the economies of other countries has focused on the import competition shock associated with the massive growth of the Chinese manufacturing sector. However, China is also an increasingly large consumer of goods produced abroad: if China has been the source of a large supply shock, it must also have been the source of a large demand shock. We will consider the heterogeneous effects of these supply-side and demand-side 'China shocks' on developing-country labour markets, by examining the case of Brazil.

For developing countries, the 'China demand shock' has taken a distinctive form: increasingly, outside of the manufacturing supply chains of East and Southeast Asia, the goods being sent to China by non-high-income countries are products of the agricultural and extractive sectors. Panel A of Figure 2.1 shows that while there has been a gradual rise in the share of agricultural and extractive sectors in the exports of non-high-income countries (excluding those in East and Southeast Asia) to destinations other than China, the importance of these industries in their exports to China has changed much more dramatically, rising from less than 20% in 1995 to nearly 70% in 2010. Meanwhile, developing countries' imports from China have become increasingly concentrated in manufactures: Panel B of Figure 2.1 shows that the share of products of the agricultural and extractive sectors in the imports of non-high-income countries from China, already small (6%) in 1995, had dwindled to 1% by 2010. This shift towards a commodities-for-manufactures trade relationship with China has coincided with a sharp increase in China's overall importance in developing countries' foreign trade (Panel A of Figure 2.2).

Just as the import side of this boom in trade with China has often been met with suspicion by policymakers and commentators concerned about effects on local industry (see e.g. Economist 2012), China's rising demand for unglamorous agricultural and mining products has similarly not always been treated with enthusiasm. Before a visit to China in 2011, Brazil's president pledged that she would be "working to promote Brazilian products other than basic commodities," amid concern that "overreliance on exports of basic items such as iron ore and soy" might result in 'de-industrialization' (LA Times 2011).

In our study of Brazil, we examine the changing labour market outcomes of regions producing manufactures affected by rising Chinese import supply and localities specializing in raw materials demanded by China. We find that while labour markets in 'loser' regions indeed appear to have suffered from Chinese import competition via slower growth in manufacturing wages and rising wage inequality, it is also the case that 'winner' regions have gained from Chinese export demand, through faster wage growth, lower takeup of social assistance and shifts in the local economy towards 'good jobs'.

Brazil provides an excellent context for a study of China's impact on developing countries' labour markets for several reasons. First, the importance of China in both the imports and exports of Brazil has risen steeply in recent years, as seen in Panel B of Figure 2.2. In 2000, Brazil received approximately 2.3% of its imports by value from China and sent 2.0% of its exports to China; by 2010, these shares were 14.5% and 15.1% respectively. Second, the pattern of Brazil-China trade has followed the broad trends outlined above for the wider set of non-high-income countries: Brazilian exports to China are increasingly products of the agricultural and extractive sectors, while Brazilian imports from China have remained concentrated in manufacturing (see Figure 2.3). Third, Brazil is particularly large and has a diverse geography, generating a set of local labour markets that are highly varied in their comparative advantages, and thus allowing for identification of the heterogeneous effects of trade with China without relying on cross-country regressions. Fourth, the Brazilian population census captures a variable of particular relevance in developing countries: informality. This is important both because the informal sector is large – in Brazil, approximately half of the employed population in 2000 were either informal salaried workers or self-employed – and because the (de-)formalization of labour markets is a potentially important but understudied effect of trade shocks affecting developing countries.

In order to identify the effects of demand and supply shocks originating from China on local labour markets in Brazil, we use the shift-share methodology of Bartik (1991), which has previously been applied to the study of trade shocks by Topalova (2007), Autor et al. (2013) and others. This method compares locations with different initial comparative advantages, tracing the fortunes of regions whose basket of industries has been faced with steeper increases in Chinese supply or demand, as compared to locations whose industries have been relatively unaffected by China's emergence. Because some agricultural, extractive and manufacturing industries have been affected more than others by China, we are able to compare regions with identical initial employment shares in each of these three broad categories. For example, our identification strategy relies on comparisons of regions with the same share of employment in agriculture in 2000 but different patterns of specialization across crops. Our measures of Chinese supply and demand shocks are based on changes in actual trade flows between China and Brazil, but we instrument for these variables to ensure that our results capture neither Brazil-specific shocks nor changes in world prices that are not directly due to China. We also run robustness checks that account for the possibility that our results are driven by other region-specific trends.

We consider the changes between 2000 and 2010 in several key characteristics of local labour markets that can be observed using Brazilian census data: wages, employment rates, in-migration rates, informality and occupational skill level, along with participation in one of the largest cash transfer programs in the world, *Bolsa Família*. We find that locations subject to larger increases in Chinese import competition experienced slower growth in manufacturing wages and in-migration rates during this period, as well as a greater rise in local wage inequality. Our estimates suggest that for a local labour market at the 80th percentile of the 'China supply shock', wage growth in manufacturing sectors was lower by 2.4 percentage points over the ten years between 2000 and 2010, while wage inequality rose by an additional 0.8% relative to average 2000 levels. On the other hand, the supply shock does not appear to have been associated with a fall in employment rates. Instead, there is some evidence of a rise in the employment rates of affected locations, though this appears to have involved a shift in the local structure of employment towards unskilled jobs in nontraded sectors and a decline in the share of the workforce in skilled manufacturing jobs.

Meanwhile, in locations more exposed to rising demand from China, average hourly wages increased more quickly during the period of study: a local labour market at the 80th percentile of the shock to Chinese demand experienced wage growth in the agricultural and extractive sectors that was four percentage points higher over the course of the decade. This wage effect appears to have spilled over to workers in other local industries, and to have occurred without an associated increase in wage inequality. *Bolsa Família* takeup rates were also lower in 2010 in regions benefiting more from Chinese demand. Moreover, while there is little evidence of an effect of demand from China on local employment rates, we do observe positive effects on job quality: an increase in the share of formal employment at the expense of informal jobs, and a rise in the proportion of the local workforce in skilled agricultural or extractive sector occupations.

This chapter contributes to a growing literature on the worldwide effects of the rise of China. This includes papers that have studied the impact of Chinese import competition on economic variables such as manufacturing employment (Pierce and Schott 2013, Autor et al. 2013), worker earnings (Pessoa 2014), skill upgrading (Hsieh and Woo 2005, Mion and Zhu 2013), firm and product selection (Iacovone et al. 2013) and innovation (Bloom et al. 2011). There are a much smaller number of papers which, like this chapter, also take account of demand-side effects. Dauth et al. (2014) take a reduced-form approach, examining the impact of rising imports from and exports to China and Eastern Europe on local labour market variables in Germany. Dauth et al. study a developed-country context in which agricultural and extractive sectors are relatively unimportant, and so focus on the effects of these trade shocks on the manufacturing and services sectors. General equilibrium analyses of China's effect on the world economy (such as Hsieh and Ossa 2011 and di Giovanni et al. 2014) also take account of both the supply and demand effects of China on other countries, but these studies summarize the impact of China on aggregate welfare rather than distinguishing between the potentially heterogeneous impacts of rising Chinese import competition and export demand.

Our work also relates to the wider literature studying the impact of trade shocks on labour markets. Several other papers investigate the effect of trade on workers in Brazil (e.g. Gonzaga et al. 2006, Menezes-Filho and Muendler 2011, Helpman et al. 2012, Kovak 2013, Dix-Carneiro 2014), with particular attention given to Brazil's early 1990s trade liberalization. Most research on trade and labour markets, including much of the literature on Brazil, is limited to studying workers in formal employment. Our work also fits into the smaller literature on trade and informality, including Goldberg and Pavcnik (2003), Nataraj (2011), McCaig and Pavcnik (2014) and Paz (2014). Finally, the chapter contributes to the literature on the local labour market effects of shocks involving nonmanufacturing sectors; one particularly relevant study is Aragón and Rud (2013), who examine the local economic impact of a Peruvian gold mine.

The chapter is organized as follows: we first describe our data sources and present our identification strategy in Section 2.2. We then discuss the results of our empirical analysis in Section 2.3, and draw conclusions in Section 2.4. Additional figures and tables are included in an attached appendix.

2.2 Data and empirical strategy

This section describes the data used in the study and outlines our empirical strategy, discussing our baseline OLS specification, instrumental variables and robustness checks.

2.2.1 Data sources

We use individual-level labour market and socioeconomic data from the long form Brazilian Demographic Census (*Censo Demográfico*) for 2000 and 2010, sourced from the Brazilian Institute of Geography and Statistics (IBGE); some specifications also use individual-level data from the 1991 census. The data contains a number of labour market variables, including employment status, monthly income from employment and hours worked per week, along with information on migration and other demographic variables; we will discuss the variables we use in our analysis in greater depth below. We restrict our sample to the subpopulation most likely to participate in the labour market, defining the workforce as every individual between 18 and 60 years old. We then aggregate the data to the geographical unit 'microregion', a level of aggregation that has been constructed by IBGE by grouping Brazilian municipalities according to information on integration of local economies. Our sample includes all of the 558 Brazilian microregions, each of which contains an average of 10 municipalities.

We draw information on informality from a question in the census asking employed individuals about their job type: government worker; employee registered at the Brazilian Ministry of Labour and Employment (*com carteira assinada*); employee not registered at the Ministry of Labour and Employment (*sem carteira assinada*); self-employed; or in unpaid work. We include the final three categories in our definition of the informal sector.[1] We also use information on individuals' occupations from the 2000 and 2010 censes, defining 'skilled occupations' and 'unskilled occupations' using the definition of occupational skill level from the 2008 International Standard Classification of Occupations (ISCO-08). In particular, we define a skilled occupation as one associated with skill level 3 or 4 in the ISCO-08 classification; this covers managers, professionals, technicians and associate professionals. While the occupational classification in the 2010 Brazilian census is almost identical to ISCO-08, we need to use publicly available concordances between the Brazilian occupational classification CBO-02 and ISCO-88, and between ISCO-88 and ISCO-08, to classify the occupations observed in the 2000 census into skilled and unskilled occupations.

Our data on international trade in goods is from the BACI database developed by Centre d'Etudes Prospectives et d'Informations Internationales (CEPII), which reconciles the data separately reported by importers and exporters in the United

[1] Although a self-employed worker could be registered with the federal government, these cases constitute a small fraction of all self-employed individuals. Publicly available administrative data from the *Relaçao Anual de Informaçoes Sociais* (RAIS) database – the official records of the Ministry of Labour and Employment – show that only 0.9% and 0.8% of the workforce were registered as self-employed in 2000 and 2010, respectively. We observe total rates of self-employment of 18.3% and 15.7% of the workforce in these two years' censes.

Nations Statistical Division's COMTRADE database. CEPII BACI contains the total annual value of bilateral trade at the 6-digit level of the Harmonized System classification for more than 200 countries from 1995 to 2010; we use data for 2000 and 2010 in the analysis below. The CEPII data is denominated in thousands of current US dollars; we convert 2000 values to 2010 US dollars using the US GDP deflator from the US Bureau of Economic Analysis.

Our empirical strategy requires us to classify employed individuals in the 2000 census data and products in the 2000 and 2010 trade data into sectors. In the 2000 Brazilian census, individuals are asked to state their sector of activity according to the 5-digit *CNAE Domicílio* classification.[2] We thus construct a concordance assigning products in the trade data to *CNAE Domicílio* sectors, which requires us to combine some of the traded goods sectors in *CNAE Domicílio* when these cannot be separately identified in the trade data. We are left with a total of 82 traded goods sectors, including 32 agricultural and extractive sectors (22 agricultural sectors, 8 mining sectors, forestry and fishing/aquaculture) and 50 manufacturing sectors; see Table 2.1 for a full list.[3]

2.2.2 Baseline specification

To estimate the heterogeneous impacts of supply and demand shocks at the microregion level, we first create sector-level measures of each shock and then define exposure to a shock according to local comparative advantage across sectors, as measured by the sectoral composition of employment in each microregion in 2000. This is the 'shift-share' methodology of Bartik (1991), as applied to trade shocks by Topalova (2007) and to the effect of China on US labour markets by Autor et al. (2013). Given the existence of migration across microregions, which we will show is correlated with the trade shocks we study, our regression results should be interpreted as identifying effects of China on local labour markets as geographical units varying in their initial comparative advantages, rather than effects on the set of workers present in those labour markets in the year 2000.

[2] This is defined as the main sector of activity of the firm or other institution of an employed person or the nature of the activity of a self-employed person.

[3] Several products from the Harmonized System classification, mostly waste or scrap (e.g. scrap metal, used clothing) could not be concorded to the *CNAE Domicílio* classification; these products make up less than 1% of Brazilian trade by value.

Our baseline specification is as follows:

$$\Delta y_m = \beta_I IS_m + \beta_X XD_m + W_m^{'}\gamma + \epsilon_m. \tag{2.1}$$

Here, Δy_m is the change in a given labour market outcome between 2000 and 2010 in microregion m, IS_m and XD_m are microregion-level measures of the import supply and export demand shocks due to China between 2000 and 2010, and W_m is a set of controls.

To construct IS_m and XD_m, we first define an import (export) shock in sector k as the difference in the value of Brazilian imports (exports) from China in sector k between 2000 and 2010, $\Delta I_k = I_{k,2010} - I_{k,2000}$ and $\Delta X_k = X_{k,2010} - X_{k,2000}$, denominated in thousands of 2010 US dollars. We then allocate each shock across microregions according to the fraction of Brazil's workers in sector k sited in a given microregion m in 2000; i.e. $\frac{L_{km,2000}}{L_{k,2000}}\Delta I_k$ and $\frac{L_{km,2000}}{L_{k,2000}}\Delta X_k$, where $L_{km,2000}$ is the number of workers in sector k and microregion m in year 2000, and $L_{k,2000} = \sum_m L_{km,2000}$.[4] Since microregions differ in size, which affects each sector's relevance for the local labour market, we normalize the trade shock by the number of employed workers in each microregion in 2000 (excluding workers employed outside the private sector), giving us the expressions $\frac{L_{km,2000}}{L_{k,2000}}\frac{\Delta I_k}{L_{m,2000}}$ and $\frac{L_{km,2000}}{L_{k,2000}}\frac{\Delta X_k}{L_{m,2000}}$.[5] Finally, we define the total local exposure per worker to each trade shock as the sum of these expressions across sectors, so that our microregion-level measures of the import supply and export demand shocks are, respectively:

$$IS_m = \sum_k \frac{L_{km,2000}}{L_{k,2000}}\frac{\Delta I_k}{L_{m,2000}}$$
$$XD_m = \sum_k \frac{L_{km,2000}}{L_{k,2000}}\frac{\Delta X_k}{L_{m,2000}}.$$

As measured by IS_m and XD_m, the average Brazilian microregion received an import competition shock from China of US$225 per worker and an export demand shock of US$594 per worker.[6] The dispersion of the export demand shock is also

[4]The underlying assumption here is that the trade shock is distributed uniformly across workers in each sector.

[5]The means across microregions of the distributions of these sector-microregion-level variables are shown in columns (3) and (5) of Table 2.1.

[6]These two figures differ in magnitude even though trade between China and Brazil was approximately in balance in both 2000 and 2010; this is because both measures include a microregion-level per-worker normalization.

larger (with a standard deviation of 1.31 for XD_m as compared to 0.27 for IS_m), though both distributions are highly skewed to the right, as shown in Figure 2.4. The microregion at the 20th percentile of IS_m received an import supply shock of US\$73 per worker, while the supply shock to the microregion at the 80th percentile of IS_m was US\$313 per worker. The corresponding figures for XD_m are US\$38 and US\$647, respectively. Figure 2.5 shows that the two shocks affected different sets of microregions, as the unconditional distributions of the two measures are nearly orthogonal, with a correlation of 0.07.

Table 2.2 charts the characteristics of microregions in the top 20% of IS_m and XD_m in 2000, while the geographical distribution of microregions in the top 20% of each of the two measures are plotted in Figure 2.6. Table 2.2 shows that the microregions most exposed to Chinese imports tended to have a lower proportion of workers engaged in agriculture and a higher proportion working in manufacturing in 2000 as compared to the average region, as well as a much smaller share of rural residents. On average, these regions also had a larger working-age population, a higher share of the workforce in private sector employment and a greater proportion of workers in skilled occupations than the mean microregion. The average wage in these regions in 2000 was also relatively high.[7]

Table 2.2 also suggests that the microregions most affected by Chinese export demand were somewhat less populous than the mean microregion and much smaller in population than high-IS_m microregions in 2000. At the same time, microregions with large values of XD_m had an average share of the workforce employed in the private sector, share of workers in formal jobs and average hourly wage somewhat higher than that of the mean microregion, though again smaller than the top quintile of IS_m. They were relatively more rural than the high-IS_m regions as of 2000, and slightly less rural on average than the mean microregion. Unsurprisingly, the average share of workers in the extractive sector was particularly high in these microregions, though the overall size of the extractive sector relative to total local employment was very small even in these locations. In terms of most other labour market variables, regions in the top 20% of XD_m were similar on average to the mean Brazilian microregion in 2000, and in general they were more similar to the

[7]Unsurprisingly, the three microregions with the highest IS_m are all major industrial centers: Manaus, São José dos Campos and Santa Rita do Sapucaí. The last of these regions is sometimes referred to as the 'Electronic Valley' due to the size of its electronics industry.

average microregion than were the locations in the top quintile of IS_m.[8]

Our baseline specifications also include a set of microregion-level controls W_m; key among these are the share of each microregion's workforce employed in agricultural sectors, extractive sectors and manufacturing sectors in 2000.[9] This means that our results depend on comparisons between microregions with the same initial economic structure (in terms of the distribution of local employment across these three broadly defined categories) but specialized in different particular agricultural, extractive and manufacturing sectors.

This strategy is feasible because the distribution of Brazil-China trade growth is skewed across sectors on both the import and export sides. Approximately 40% of the total growth in Brazil's imports from China between 2000 and 2010 (i.e. $\sum_k \Delta I_k$) is accounted for by electronics (19%), machinery (13%) and electrical equipment (8%). Meanwhile, just three sectors, all of which are agricultural or extractive sectors, were responsible for 82% of the growth in Brazil's exports to China between these two years: mining of nonprecious metals (45%), soybeans (23%) and oil and gas (14%).[10] This breakdown actually understates the level of concentration of Brazil's exports to China, since its exports in the 'mining of nonprecious metals' sector are almost exclusively made up of exports of iron ore. This high degree of concentration in a few commodities is a typical pattern of exports to China among developing countries for whom trade with China is important.[11]

The controls in our baseline regressions also include the workforce size, the share of the workforce employed in nontraded sectors, the share employed in informal

[8]The three microregions with the largest values of XD_m include a major center for the offshore oil industry (Macaé), an important outpost of the iron ore mining complex (Itabira) and a small microregion specialized in soybean production (Não-me-Toque, Rio Grande del Sul).

[9]Forestry and fisheries/aquaculture are defined here as agricultural sectors.

[10]To calculate these measures, we take the difference between the 2010 and 2000 values of Brazil's imports from China (or exports to China) in each sector and divide by the aggregate difference between 2010 and 2000 Brazilian imports from China (or exports to China). The resulting figures for each of the 82 traded goods sectors may be found in columns (1) and (2) of Table 2.1. The value of imports from China actually decreased in several sectors, but their total decline constitutes a tiny proportion of the total difference in imports, so that the total of all positive values only slightly exceeds 1; the same is true of exports to China. As noted above, some Harmonized System codes (mostly waste and scrap) are not concorded to any sector; trade in these products is included in the denominator but not listed in Table 2.1.

[11]According to the CEPII BACI data, in all 27 non-high-income countries outside East and Southeast Asia for whom exports to China constituted a minimum of 10% of total exports by value in 2010, at least 80% of exports to China were concentrated in three or fewer of the sectors defined in this chapter (82 sectors plus a residual 'waste and scrap' category). In 16 of these 27 countries (including Brazil), at least 80% of exports to China were in agricultural and/or extractive sectors; in a further five, at least 80% of exports were concentrated in up to two agricultural or extractive sectors and either the 'basic metals' manufacturing sector or scrap metal.

jobs, and the proportion of rural residents, all measured at the microregion level for the year 2000, along with a cubic polynomial of 2000 microregion-level income per capita. In all regressions, in order to allow for spatial correlation of errors across microregions, we cluster standard errors at the level of the mesoregion. Like the microregion, this geographical unit has been defined by IBGE according to measures of local market integration; there are 138 mesoregions in Brazil. Also, in order to prevent our regression results from being driven by outliers or very small microregions, we assign values of IS_m and XD_m below the 1st and above the 99th percentiles to the values of the 1st and 99th percentiles, and weight all regressions by the share of the national workforce in each microregion. We include all 558 Brazilian microregions in all regressions.

2.2.3 Instrumental variables and robustness checks

Our goal is to identify the causal effect of the two 'China shocks' on local labour market dynamics in Brazil. However, regression equation (2.1) does not capture causality in the presence of any additional shocks that are both relevant for our dependent variables and correlated with our exposure measures IS_m and XD_m. In particular, given the sector-level variation that underlies our identification strategy, one potential issue would be the existence of Brazil-specific supply or demand shocks in sectors in which Brazil also experienced a relatively large change in trade with China. For example, changes in Brazil-China trade patterns might be capturing sector-specific productivity growth or Engel effects in Brazil rather than changes in China.

Several other studies of the cross-country transmission of shocks have addressed this concern by using an instrumental variables strategy that exploits information on trade between the shocks' country of origin (in this case, China) and countries *other* than the 'destination' country of interest (Brazil).[12] For instance, one might instrument our microregion-level import supply and export demand variables with measures calculated in the same way as IS_m and XD_m, but using the change between 2000 and 2010 in imports from China (or exports to China) for a set of countries that does not include Brazil. A key assumption underlying this approach is that the changes in the pattern of trade between China and these other countries are

[12] This is a standard approach in the 'China shock' literature; see e.g. Bloom et al. (2011), Autor et al. (2013) and Iacovone et al. (2013).

unrelated to Brazil-specific shocks.

The main issue with this strategy is that it does not account for changes in *world* prices or quantities traded that are not due to China: if the world price of a given product rises due to other factors, or all countries trade more intensively in the products of some sector due to a worldwide technology or demand shock, this will be reflected in the trade flows of all countries. This is a particular issue for our study given its focus on commodities, whose world prices were on an upward trajectory over the course of the decade we study. If, for instance, the share of oil by value increased in the import baskets of all countries between 2000 and 2010 due to rises in its world price, both our baseline regression specification and the IV strategy described above would assign this effect to China. However, while China likely played a pivotal role in changes in world prices in many sectors during this period, we do not want to ascribe world price or quantity changes to China when these actually resulted from other factors.

We thus adapt the IV approach described above by considering changes in China's sector-level imports and exports *relative* to those of other countries. To do this, we first define $\tilde{I}_{ikt}$ and $\tilde{X}_{ikt}$ to be the total imports (exports) of country i in sector k in year t from (to) all countries other than Brazil. We then run the following auxiliary regressions, using data on $\tilde{I}_{ikt}$ and $\tilde{X}_{ikt}$ in 2000 and 2010 for all countries available in the CEPII trade data except Brazil:

$$\frac{\Delta \tilde{I}_{ik}}{\tilde{I}_{ik,2000}} = \alpha_k + \psi_{China,k} + \nu_{ik}$$
$$\frac{\Delta \tilde{X}_{ik}}{\tilde{X}_{ik,2000}} = \gamma_k + \delta_{China,k} + \mu_{ik}$$

The left-hand side of the two regressions above is the growth rate of the imports (exports) of a country in a given sector, net of its imports from (exports to) Brazil. The sector fixed effect α_k (or γ_k) then captures the mean growth rate, across countries, of net-of-Brazil imports (or exports) in that sector. The regressions are weighted by 2000 import (export) volumes, so that the values of these fixed effects are not driven by large positive or negative growth rates in countries with small shares of world trade. This means that the China-specific dummies $\psi_{China,k}$ and $\delta_{China,k}$ represent the deviation in the growth rates of China's imports and exports in sector k excluding trade with Brazil, as compared to this weighted cross-country average.

We then relate the resulting estimates $\hat{\psi}_{China,k}$ and $\hat{\delta}_{China,k}$ to the microregion-level shock measures defined in Section 2.2.2. We first multiply these estimates by the values of Brazil-China imports and exports in 2000, redefining the sector-level 'China shocks' as $\Delta\hat{I}_k \equiv I_{k,2000}\hat{\delta}_{China,k}$ and $\Delta\hat{X}_k \equiv X_{k,2000}\hat{\psi}_{China,k}$. Our instrumental variables are then constructed at the microregion level using these new shock measures in the same way as for IS_m and XD_m:[13]

$$ivIS_m = \sum_k \frac{L_{km,2000}}{L_{k,2000}} \frac{\Delta\hat{I}_k}{L_{m,2000}}$$
$$ivXD_m = \sum_k \frac{L_{km,2000}}{L_{k,2000}} \frac{\Delta\hat{X}_k}{L_{m,2000}}.$$

If Chinese trade with the rest of the world (excluding Brazil) had evolved in the same way as that of the (weighted) average country in each sector, all of these shocks would be equal to zero. In practice, however, this is not the case: the two vectors $\Delta\hat{I}_k$ and $\Delta\hat{X}_k$, like the 'raw' measures ΔI_k and ΔX_k, vary widely across sectors. Indeed, the raw shocks and these IV shock measures are highly correlated, with correlation coefficients of 0.93 for the sector-level import supply shocks ΔI_k and $\Delta\hat{I}_k$ and 0.86 for the export demand shocks ΔX_k and $\Delta\hat{X}_k$. Scatter plots of IS_m against $ivIS_m$ and XD_m against $ivXD_m$ are shown in Figure 2.7.

Even if these instrumental variables were to fully capture the sectoral mix of Chinese supply and demand shocks, it is naturally still possible that these shocks were correlated to supply and demand shocks in Brazil during this period. The variable $ivXD_m$ might be particularly vulnerable to this problem, since it is driven mainly by export growth in two nonmanufacturing sectors (soybeans and iron ore).[14] It could bias our results, for example, if Brazil discovered major new sources of iron ore just as China began importing it in much larger quantities. Reassuringly, however, there is evidence that the rise in Brazil-China exports in these two sectors was mainly due to a Chinese demand shock. First, the share of Brazil in world trade by value in the two sectors changed relatively little between 2000 and 2010:

[13] The averages across microregions of the sector-microregion-level variables analogous to those in Section 2.2, but constructed using $\Delta\hat{I}_k$ and $\Delta\hat{X}_k$, may be found in columns (4) and (6) of Table 2.1.

[14] While the oil and gas sector was responsible for 14% of the growth in exports from Brazil to China between 2000 and 2010 (as noted in Section 2.2), its importance is greatly diminished in the IV shock measure, since $\Delta\hat{X}_{oil}$ accounts for only 2% of $\sum_k \Delta\hat{X}_k$. The point in the upper left of the scatter plot of XD_m against $ivXD_m$ (see Figure 2.7) is the offshore oil center (Macaé) mentioned in Footnote 8.

Brazil accounted for 23% of world exports of soybeans in 2000 and 27% in 2010, and for 13% of world exports of nonprecious metal ores in 2000 and 17% in 2010. Meanwhile, China's share of world imports in these two sectors rose much more steeply during this period: from 21% to 56% for soybeans, and from 10% to 45% for nonprecious metal ores. Exports to China accounted for 98% of the growth in the total quantity of soybeans exported from Brazil, and 87% of the growth in the quantity of Brazil's exports of nonprecious metal ores, between the two years.[15]

It is also possible that the outcomes we observe were driven by other circumstances specific to individual Brazilian regions. Indeed, the maps in Figure 2.6 suggest that the incidence of Chinese trade shocks is spatially correlated within Brazil. We thus run a robustness check in which we add fixed effects for Brazil's five regions to our IV specification, so as to check whether the results are robust to accounting for contemporaneous region-specific trends in the dependent variable Δy_m. That is, in this specification we investigate the within-region effects of the two 'China shocks'.

Finally, we also conduct an additional robustness check to address the concern that any results we observe simply represent the continuation of local labour market trends that began in years before our period of study. For example, Brazil underwent a major trade liberalization episode in the late 1980s and early 1990s that is known to have had a significant impact on affected local labour markets (see e.g. Menezes-Filho and Muendler 2011, Kovak 2013); adjustments resulting from this shock might still have been occurring between 2000 and 2010. Thus, in order to account for pre-sample-period trends, we use data from the 1991 Brazilian census to add a lagged dependent variable to the right-hand side of specifications for which this data is available; that is, we control for microregion-level changes between 1991 and 2000 in the outcome of interest. Because of likely correlation between the lagged dependent variable and the residual ϵ_m, we instrument for this variable using 1991 levels, as suggested by Anderson and Hsiao (1981).[16]

[15]Notably, Bustos et al. (2013) present evidence of non-Brazil-specific technological change in the soybean sector via the development in the US of a genetically modified soybean variety in 1996, and suggest that the adoption in Brazil of this technology in the early 2000s led to increases in agricultural productivity per worker, decreases in the labour intensity of agricultural production, rising manufacturing employment shares and declining manufacturing wages in affected locations. Bustos et al. also discuss a Brazil-specific technological change in the maize sector (*milho safrinha*) which they find is associated with rises in labour intensity, declines in manufacturing employment shares and increases in wages.

[16]Note that the consistency of our estimates then depends on the assumption that 1991 levels are uncorrelated with ϵ_m.

2.3 Results

In this section, we provide empirical evidence of the heterogeneous effects of the import supply shock and export demand shock from China on local labour markets across Brazil. We begin by considering the effects of these shocks on average hourly wages, wage inequality within local labour markets and takeup of the cash transfer program *Bolsa Família*. We then look at the impact of the 'China shocks' on migration, employment rates and the pattern of employment across sectors. Finally, we examine the evolution of 'good jobs' and 'bad jobs' in local labour markets affected by the shocks, considering the proportion of the local workforce in formal and informal jobs, and in skilled and unskilled occupations. The coefficients and standard errors in all tables are normalized by multiplying by 100, so that they may generally be interpreted as the effect of a US$1000 increase in imports or exports per worker on changes in the dependent variable in percentage points.[17]

2.3.1 Wages and wage inequality

Table 2.3 displays the results of microregion-level regressions of differences in log average hourly wages between 2000 and 2010 on IS_m, XD_m and controls. In Panel A, the sample of wage-earners includes workers in all sectors, while Panels B, C and D only consider workers in the agricultural and extractive, manufacturing and nontraded sectors respectively. The OLS estimates in column (1) of Panel A suggest that larger export demand shocks are associated with higher growth in wages over these ten years, and that this effect is statistically significant. Columns (2) through (5) of Panel A show that the result is qualitatively unchanged by our instrumental variables strategy and robustness checks, including specifications with region fixed effects (column (3)), a lagged dependent variable (column (4)) and both of these two additional controls (column (5)). In our preferred specification, column (2), a US$1000 per worker increase in exports to China is associated with higher decadal growth in wages of approximately 1.76 percentage points.

Panels B through D suggest that the largest effect of rising export demand from China was on the set of industries most directly affected by this shock: the agricultural and extractive sectors. The baseline IV specification in column (2) of

[17] This interpretation is, of course, approximate when the dependent variable is measured as a long difference of logarithms, but exact when the dependent variable is in long differences of shares.

Panel B indicates that a microregion subject to the average demand shock of US$594 per worker saw wage growth in these sectors that was higher by 3.7 percentage points over the course of the decade. Given that the average wage in agricultural and extractive sectors increased by 52% during this period, a back-of-the-envelope calculation would suggest that the estimated effect of the 'China demand shock' is equal to 7.2% of the observed wage increase in these sectors. Panels C and D indicate that growth in wages in agricultural and extractive sectors also spilled over to other industries, as average wages in the manufacturing and nontraded sectors also grew faster in microregions more exposed to Chinese export demand, though only the result for manufacturing is statistically significant in our preferred specification.

Meanwhile, while the results in Panel A suggest that the Chinese import supply shock is not associated with statistically significant changes in average wages overall, Panel C indicates that it did have an effect for manufacturing, the sector most directly affected by Chinese import competition. The IV results in column (2) of Panel C indicate that a microregion exposed to the average import supply shock of US$225 per worker experienced growth in manufacturing wages that was smaller by 1.7 percentage points over this period.

Table 2.4 breaks down the effects of the shocks on the growth in average wages of workers in formal and informal jobs (Panels A and B), and in skilled and unskilled occupations (Panels C and D). The wage effects of IS_m appear to be concentrated in the formal sector; the estimated coefficient on IS_m is negative for the subcategory of formal jobs and positive (though insignificant) for informal jobs. Also, although the wage effect of Chinese import competition on workers in skilled occupations remains insignificantly different from zero, higher values of IS_m are significantly associated with slower average wage growth for workers in unskilled occupations in the baseline IV specification in Panel D. This result becomes smaller and loses statistical significance after controlling for region-specific trends. Meanwhile, the export demand shock is associated with positive wage growth for all four of these categories – for both skilled and unskilled occupations, and for both formal and informal jobs.

These heterogeneous effects of IS_m on different subgroups of the workforce imply that Chinese import competition may have affected levels of inequality. Indeed, when we consider effects on local wage inequality in Panel A of Table 2.5, we find that import shocks but not export shocks are associated with relatively higher growth in wage inequality, as measured by the microregion-level wage Gini coefficient. Since we multiply all coefficients by 100, the estimate in column (2) implies that in locations experiencing an import competition shock that was greater by US$1000, the wage Gini coefficient rose by an additional 0.014 between 2000 and 2010; this is equivalent to a 2.6% increase in wage inequality relative to average 2000 levels. The coefficient on XD_m is economically and statistically indistinguishable from zero in each of the specifications; that is, we find no evidence that the demand-side shock contributed to rises in local wage inequality.

In Panel B of Table 2.5, we consider the impact of the 'China shocks' on social assistance in Brazil, by examining the distribution of takeup of the cash transfer program *Bolsa Família* across microregions in 2010. While participation in *Bolsa Família* was on a very large scale in 2010 – according to the census data, more than 7% of the Brazilian workforce received *Bolsa Família* in this year – the program was implemented only after 2002. Thus, in this case, we use levels rather than long differences on the left-hand side of our regressions, so that the dependent variable is the proportion of the local workforce receiving *Bolsa Família* in 2010.[18] The results suggest that a larger export demand shock is associated with lower takeup of *Bolsa Família* in 2010; according to the baseline IV specification, in a microregion experiencing the average export demand shock of US$594, the proportion of the local workforce receiving *Bolsa Família* in 2010 was lower by 0.15 percentage points. The estimated effects of Chinese import competition on participation in *Bolsa Família* are statistically insignificant in all three specifications.

2.3.2 Migration and employment

We next consider whether the two 'China shocks' are also associated with changes in the pattern of migration across microregions, and microregion-level employment rates. In Table 2.6, we display the results of regressions whose dependent variable is the long difference in the proportion of the workforce that migrated into the microregion within the five years before the census.[19] Column (2) reports that the change in the share of recent migrants in the local workforce was 0.89 percentage

[18]As of 2000, Brazil had a similar program on a much smaller scale, *Bolsa Escola*, with a Brazil-wide participation rate of less than 1%. The results are not affected if we instead use differences between *Bolsa Escola* takeup rates in 2000 and *Bolsa Família* takeup rates in 2010 as the left-hand-side variable.

[19]These regressions thus examine changes in the microregion-level pattern of migration in the five years before 2010 as compared to the five years before 2000.

points lower on average in microregions experiencing a $1000 per worker higher import supply shock; these results are robust across all five specifications. This suggests that in-migration grew by 4.9% less in a microregion exposed to the average increase in import supply from China. The analogous estimate for XD_m is positive, but much smaller in magnitude and statistically insignificant in each of the four IV specifications. The slowdown in local in-migration rates associated with Chinese import competition is reminiscent of the findings of Kovak (2011), who observes a migration response to the Brazilian trade liberalization of the early 1990s using 2000 census data.

Brazilians' willingness to migrate – the census data indicates that the average share of recent migrants across microregions was 8.3% in 2000 and 12.4% in 2010 – might have served to dampen the effects of the trade shocks on microregion-level employment rates. Indeed, while the damaging impact of Chinese import competition on employment status has been an important finding of studies of high-income countries (e.g. Autor et al. 2013 for the US), Panel A of Table 2.7 shows that we do not observe a negative correlation between IS_m and changes in private sector employment rates of Brazilian microregions from 2000 to 2010. On the contrary, our preferred specification yields a positive coefficient that is marginally statistically significant. The estimate is magnified and becomes significant at the 1% level in the specifications with region fixed effects; this is a puzzling result. Meanwhile, the effect of the 'China demand shock' on the change in the proportion of the local workforce employed in the private sector is very small and statistically insignificant in all five specifications.[20]

Panels B to D of Table 2.7 provide a breakdown of the changes in employment structure associated with the two 'China shocks', using the difference between 2000 and 2010 in the share of a microregion's working-age population employed in the agricultural and extractive, manufacturing and nontraded sectors as the dependent variables. This analysis yields few statistically significant coefficient estimates. However, Panel D suggests that the finding of rising employment rates in locations competing with Chinese imports appears to have been driven by growth in the share of the workforce employed in nontraded sectors. This result is similar to the findings of Menezes-Filho and Muendler (2011), who observe movement of Brazilian

[20]When comparing these results to our findings on takeup of *Bolsa Família* in Table 2.5, it is important to note that eligibility for *Bolsa Família* is not directly conditional on employment status.

formal sector workers from manufacturing into services after the early 1990s trade liberalization.

2.3.3 Job quality

We now examine the effects of China's emergence on the prevalence of 'good jobs' in affected microregions, using two measures of job quality: informality and occupational skill level. We first consider informality, which is widespread in the Brazilian economy: in 2000, more than half of private sector workers were working in the informal sector as defined in this chapter. Being part of the informal sector brings disadvantages for workers and firms, since they are not granted some legal rights, such as property rights, and do not benefit from some public services linked to employment.

Table 2.8 shows that shocks to export demand from China are associated with a shift towards 'good jobs' by this measure: a rise in formal-sector jobs at the expense of the informal sector. The baseline IV results in Panels A and B suggest that a rise in exports to China of US$1000 is associated with an average increase in the proportion of a microregion's workforce in formal jobs that is larger by 0.31 percentage points and an average decline in the share of informal jobs that is greater by 0.24 percentage points, though the result for the informal share is statistically insignificant. The size of these effects is similar across all of the regression specifications in each case.[21]

As discussed in Section 2.2.1, our measure of occupational skill level, which is based on an international definition, is a dummy variable broadly distinguishing between managerial, professional and technical workers and workers directly involved in production. Panel B of Table 2.11 shows that the proportion of the workforce in skilled occupations in the agricultural and extractive sectors rose more quickly in areas more affected by Chinese demand, while this was not the case for unskilled occupations in these sectors. Our estimates suggest that a microregion subject to the mean Chinese export demand shock experienced 18.6% higher growth in the share of the workforce employed in skilled agricultural or extractive sector jobs. The results in Panel A indicate that this led to a positive effect of XD_m on the share of workers

[21] Tables 2.9 and 2.10 show that the estimated effect of XD_m on the proportion of the workforce in formal agricultural or extractive sector jobs is positive in all five specifications, while the estimated impact of XD_m on the share of the workforce in informal jobs in agricultural or extractive sectors is negative in all five specifications. None of these results is statistically significant.

in skilled occupations overall, though this estimate is not statistically significant.

Meanwhile, Panel C of Table 2.11 shows that the proportion of the working-age population employed in skilled manufacturing occupations saw a statistically significant decline in locations with higher IS_m: an increase of US$1000 in Chinese imports was associated with a reduction of approximately 0.28 percentage points in this share between 2000 and 2010 in the baseline IV specification. Given that the average share of the workforce employed in skilled occupations in manufacturing grew from 0.8% in 2000 to 1% in 2010, a back-of-the-envelope counterfactual exercise suggests that the share of skilled jobs in the manufacturing sector would have grown 31% more on average if it were not for rising import competition from China. Taken together with the results in Table 2.4, it thus appears that local labour markets were affected by the 'China supply shock' through declines in both average unskilled wages and skilled manufacturing employment shares.

Tables 2.8 and 2.11 also provide additional insight on the nature of the shift towards the nontraded sector in locations more affected by Chinese import competition, as documented in Table 2.7. Table 2.11 indicates that growth in the share of nontraded sector employment mainly occurred in relatively unskilled occupations, while Table 2.8 suggests that these jobs were primarily in the formal sector. This conclusion is supported by the results of regressions with the share of the workforce in formal or informal agricultural/extractive, manufacturing or nontraded jobs on the left-hand side, which may be found in Tables 2.9 and 2.10. Across all of the IV specifications, only the regressions for formal jobs in nontraded sectors yield statistically significant coefficient estimates for IS_m.

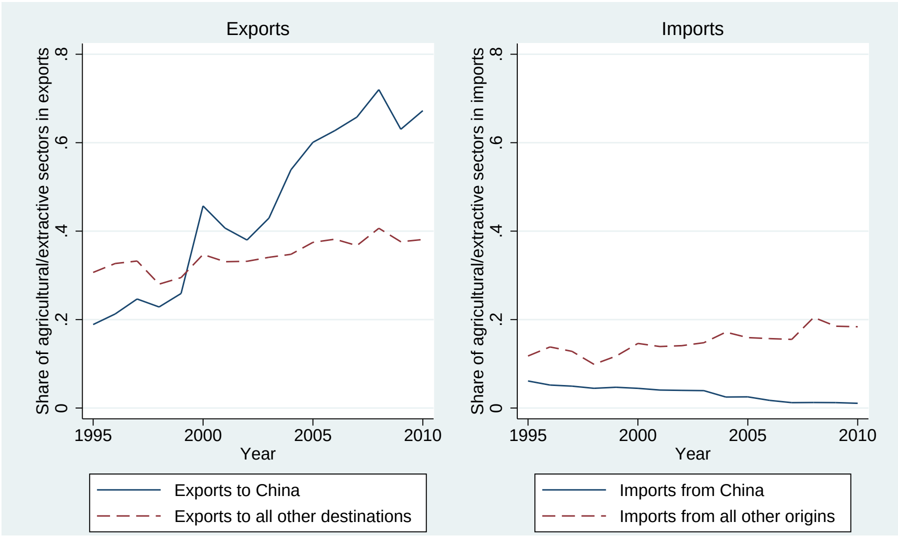
2.4 Conclusion

In this chapter, we investigate the effects of China's ascent into one of the world's largest economies on local labour markets in Brazil. As in other developing countries, Brazil's imports from China are dominated by manufactures while most of the growth in its exports to China has been concentrated in agricultural and extractive sectors. We use data from the Brazilian demographic censes of 2000 and 2010 to provide empirical evidence of the heterogeneous effects on Brazilian labour markets of shocks to both Chinese import supply and export demand. Using a shift-share methodology, we compare trends in local labour markets with a similar initial employment structure (proportion of workers in agricultural, extractive and manufacturing sectors) but differently exposed to these two 'China shocks' due to specialization in different specific industries.

We find that local labour markets more affected by Chinese import competition experienced slower growth in manufacturing wages, greater increases in wage inequality and a relative decline in the share of the workforce employed in skilled manufacturing jobs. However, imports from China do not appear to have led to either a fall in employment rates or higher takeup of social assistance (as measured by participation in the *Bolsa Família* program of cash transfers) in affected regions. Meanwhile, in local labour markets experiencing larger growth in Chinese export demand, average hourly wages increased more quickly and without an accompanying increase in wage inequality, while 2010 *Bolsa Família* participation rates were lower. While there is little evidence of an effect of Chinese demand on local employment rates, we do observe positive effects on job quality: an increase in the share of formal employment at the expense of informal jobs, and a rise in the share of the local workforce in skilled agricultural or extractive sector occupations.

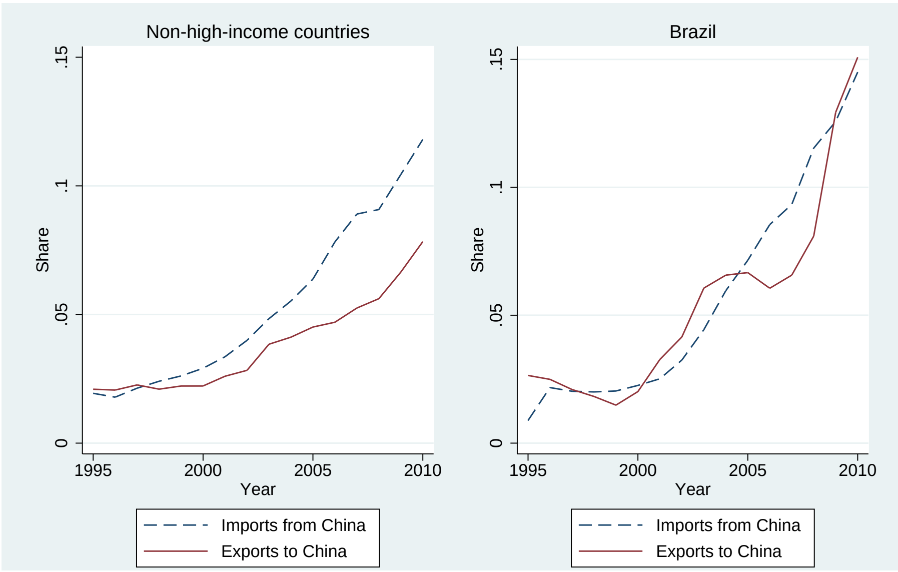
Overall, our findings suggest that growth in commodities-for-manufactures trade spurred by the rise of China has created winners as well as losers. Even though the increase in export demand from China has mainly involved the relatively unglamorous agricultural and extractive sectors, local labour markets specialized in these industries appear to have flourished in the presence of this commodity export boom. Moreover, while areas specialized in manufacturing sectors do seem to have suffered from rising Chinese import supply, our findings of slower growth of in-migration rates in more affected regions, along with shifts in the structure of local employment towards nontraded industries, also provide evidence of adjustment in response to competition from China.

2.A Figures



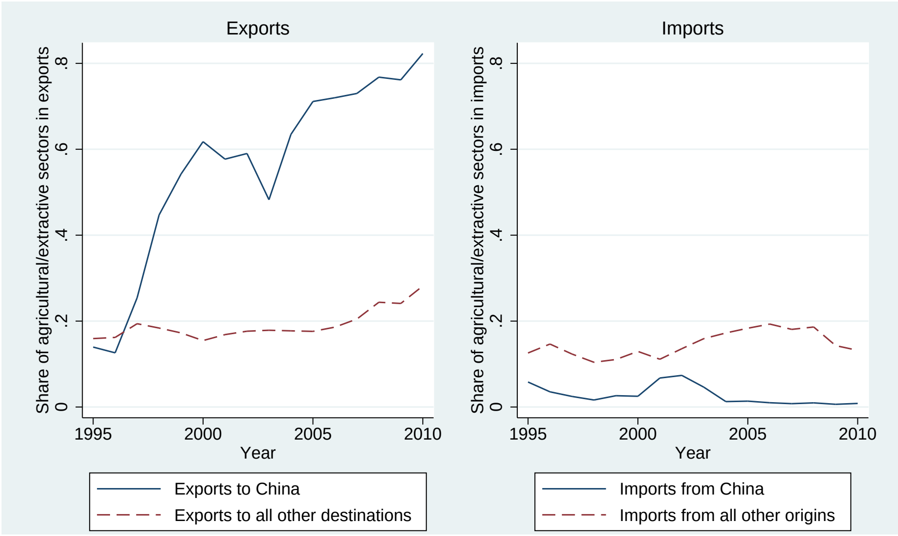
Panel A Panel B

Figure 2.1: Evolution of the share of agricultural and extractive sectors in the exports and imports of non-high-income countries



Panel A Panel B

Figure 2.2: Evolution of the share of China in the imports and exports of non-high-income countries and Brazil



Panel A Panel B

Figure 2.3: Evolution of the share of agricultural and extractive sectors in the exports and imports of Brazil

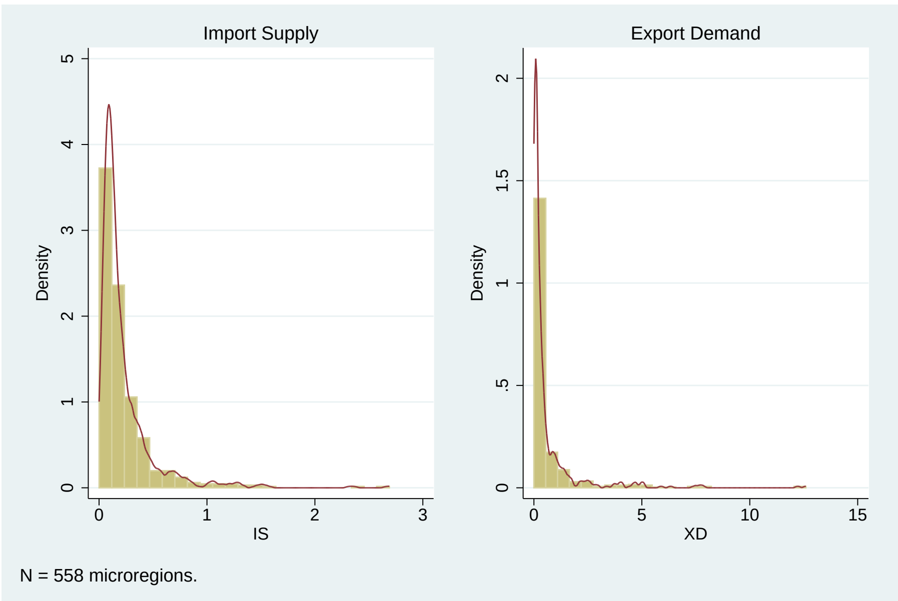


Figure 2.4: Distributions of import supply and export demand measures

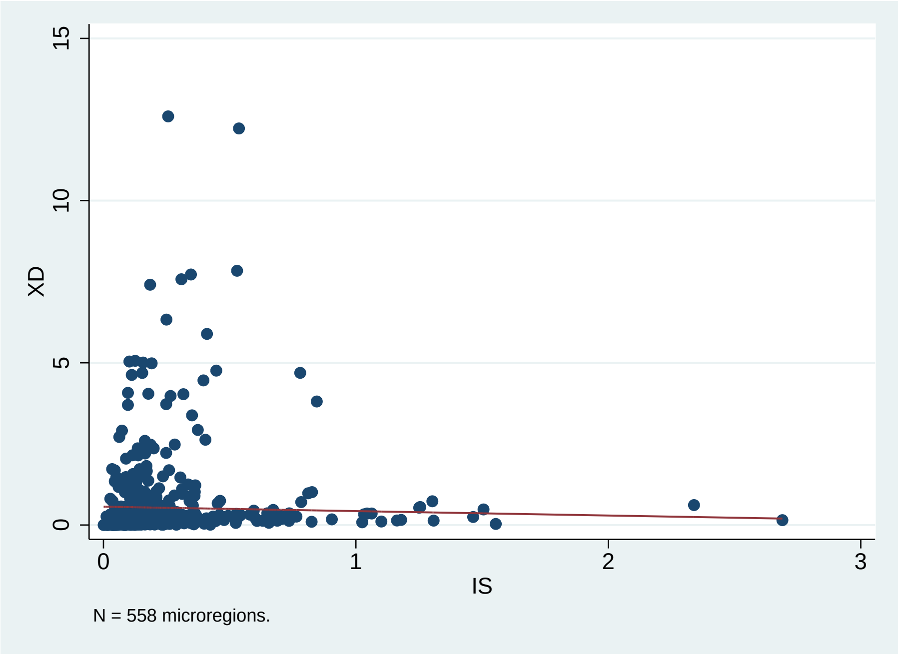
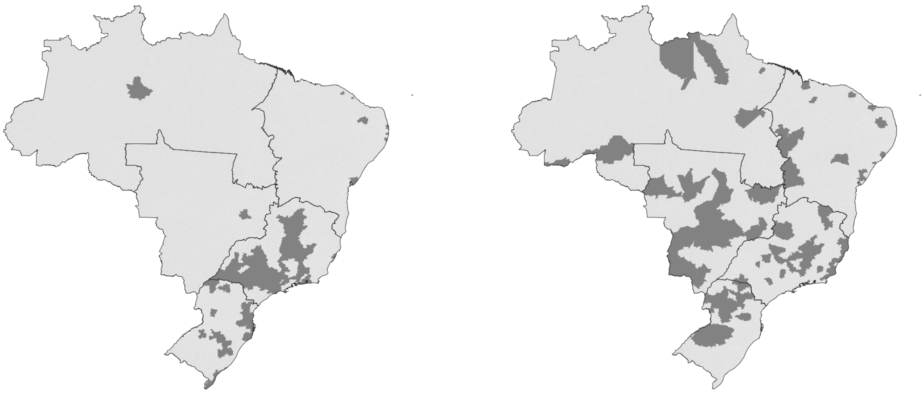


Figure 2.5: Import supply vs export demand measures



Panel A - Import supply

Panel B - Export demand

Figure 2.6: Geographical distributions of top quintile of import supply and export demand measures

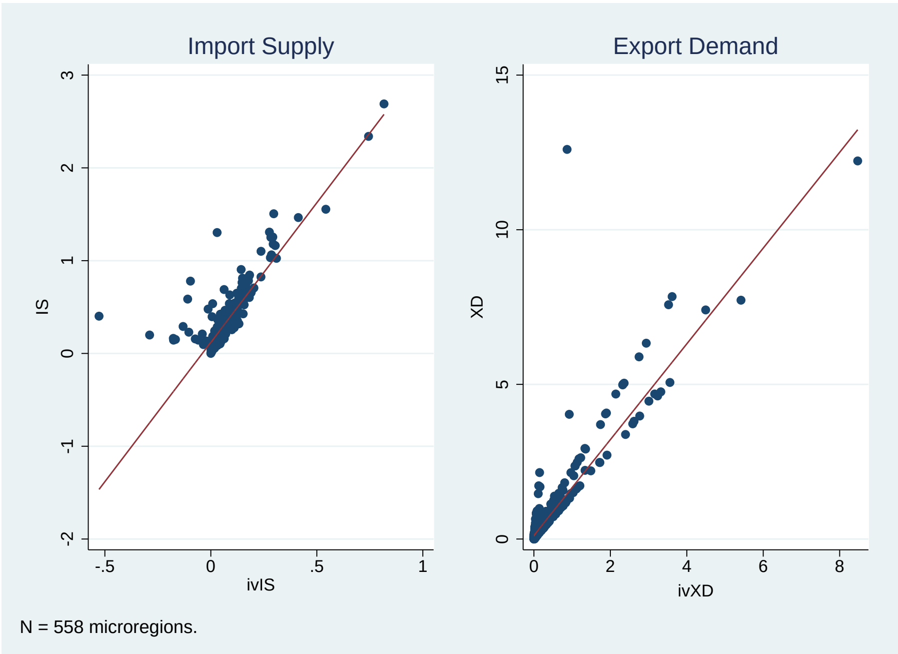


Figure 2.7: Raw measures vs instrumental variables measures

The lines depict the results of simple regressions of IS_m on $ivIS_m$ (coefficient 1.286, s.e. 0.021 and t-statistic 60.09) and XD_m on $ivXD_m$ (coefficient 2.076, s.e. 0.053 and t-statistic 39.16).

2.B Tables

Table 2.1: List of sectors and additional summary statistics

	(1) Import share	(2) Export share	(3) Import supply from China: Mean	(4) Import supply from China: IV	(5) Export demand to China: Mean	(6) Export demand to China: IV
Agriculture: rice	-	-	-	-	-	-
Agriculture: maize	-	0.000	-	-	0.000	-
Agriculture: other cereals	0.000	-	0.000	0.000	-	-
Agriculture: cotton	0.000	0.005	0.000	0.000	0.013	-
Agriculture: sugar cane	-	-	-	-	-	-
Agriculture: tobacco	0.000	0.010	0.000	0.000	0.022	0.015
Agriculture: soya	-	0.229	-	-	0.555	0.259
Agriculture: manioc	-	-	-	-	-	-
Agriculture: flowers and ornamentals	0.000	0.000	0.000	0.000	0.000	-
Agriculture: citrus fruits	-	0.000	-	-	0.000	0.000
Agriculture: coffee	-	0.000	-	-	0.000	0.000
Agriculture: cocoa	-	-	-	-	-	-
Agriculture: grapes	-	-	-	-	-	-
Agriculture: bananas	-	-	-	-	-	-
Agriculture: other	0.007	0.000	0.006	0.000	0.000	0.000
Agriculture: bovine animals	-	-	-	-	-	-
Agriculture: sheep	-	-	-	-	-	-
Agriculture: pigs	-	-	-	-	-	-
Agriculture: birds	-	-	-	-	-	-
Agriculture: beekeeping	0.000	0.000	0.000	-	0.000	0.000
Agriculture: silk	0.000	-	0.000	-	-	-
Agriculture: other animals	0.000	0.000	0.000	0.000	0.000	-
Forestry	0.000	0.000	0.000	0.000	0.000	0.000
Fishing and aquaculture	-	0.000	-	-	0.000	0.000
Mining: coal	-0.001	0.000	-0.002	-0.018	0.000	-
Mining: oil and gas	-	0.137	-	-	0.219	0.015
Mining: radioactive metals	-	-	-	-	-	-
Mining: precious metals	-	-	-	-	-	-
Mining: other metals	0.000	0.453	0.000	-0.001	0.917	0.649
Mining: nonmetals for construction	0.000	0.001	0.000	0.000	0.001	0.002
Mining: precious stones	0.000	0.000	0.000	0.000	0.001	0.001
Mining: other nonmetals	0.000	0.000	0.001	0.000	0.000	0.001
Manuf: meat and fish	0.004	0.008	0.002	0.000	0.005	0.001
Manuf: fruits and vegetables	0.002	0.003	0.002	0.000	0.003	0.000
Manuf: oils and fats	0.000	0.026	0.000	0.000	0.045	0.015
Manuf: dairy products	0.000	0.000	0.000	-	0.000	0.000
Manuf: sugar	0.000	0.018	0.000	0.000	0.019	-
Manuf: coffee	0.000	0.000	0.000	-	0.000	0.000
Manuf: other food	0.003	0.000	0.001	0.000	0.000	0.000
Manuf: beverages	0.000	0.000	0.000	0.000	0.000	0.000
Manuf: tobacco	0.000	-	0.000	0.000	-	-

Continued on next page.

Table 2.1: List of sectors and additional summary statistics (continued)

	(1) Import share	(2) Export share	(3) Import supply from China Mean	(4) Import supply from China IV	(5) Export demand to China Mean	(6) Export demand to China IV
Manuf: spinning and weaving	0.026	0.000	0.009	0.000	0.000	0.000
Manuf: other textile products	0.029	0.000	0.014	0.001	0.000	0.000
Manuf: apparel	0.025	0.000	0.008	0.001	0.000	0.000
Manuf: leather processing	0.000	0.011	0.000	0.000	0.014	0.000
Manuf: leather products	0.001	0.000	0.000	0.000	0.000	0.000
Manuf: footwear	0.003	0.000	0.001	0.001	0.000	0.000
Manuf: wood products	0.001	0.001	0.001	0.000	0.001	0.002
Manuf: pulp and paper	0.003	0.039	0.003	0.000	0.041	0.002
Manuf: paper products	0.001	0.000	0.000	0.000	0.000	0.000
Manuf: printing and recording	0.003	0.000	0.001	0.000	0.000	0.000
Manuf: coke	0.003	-	0.040	-0.119	-	-
Manuf: refined petroleum	0.002	0.000	0.001	0.000	0.000	0.000
Manuf: nuclear fuel	-	-	-	-	-	-
Manuf: paints and varnishes	0.000	0.000	0.000	0.000	0.000	0.000
Manuf: pharmaceuticals	0.018	0.001	0.004	0.002	0.000	0.000
Manuf: cleaning and hygiene products	0.001	0.001	0.000	0.000	0.000	0.000
Manuf: other chemicals	0.065	0.008	0.026	0.014	0.004	0.003
Manuf: rubber products	0.014	0.000	0.004	0.001	0.000	0.000
Manuf: plastic products	0.025	0.000	0.007	0.001	0.000	0.000
Manuf: glass products	0.006	0.000	0.002	0.001	0.000	0.000
Manuf: ceramic products	0.009	0.000	0.006	0.000	0.000	0.000
Manuf: other nonmetallic mineral products	0.003	0.000	0.001	0.000	0.000	0.000
Manuf: basic metals	0.064	0.026	0.027	0.002	0.013	0.003
Manuf: metal products	0.029	0.002	0.007	0.001	0.000	0.000
Manuf: machinery	0.133	0.005	0.038	0.010	0.002	0.002
Manuf: domestic appliances	0.019	0.000	0.009	0.001	0.000	0.000
Manuf: computing	0.073	0.000	0.033	0.017	0.000	0.000
Manuf: electrical equipment	0.080	0.001	0.023	0.005	0.000	0.000
Manuf: electronics	0.192	0.001	0.065	0.024	0.000	0.001
Manuf: medical instruments	0.006	0.000	0.002	0.000	0.000	0.000
Manuf: measuring instruments	0.008	0.000	0.004	0.001	0.000	0.000
Manuf: optical equipment	0.061	0.000	0.030	0.006	0.000	0.002
Manuf: watches and clocks	0.002	0.000	0.002	0.000	0.000	0.000
Manuf: motor vehicles	0.009	0.000	0.002	0.000	0.000	0.001
Manuf: motor vehicle bodies and parts	0.011	0.002	0.003	0.000	0.001	0.001
Manuf: shipbuilding	0.018	-	0.016	0.000	-	-
Manuf: railway products	0.000	0.000	0.000	0.000	0.000	-
Manuf: aircraft	0.000	0.011	0.000	-	0.012	0.005
Manuf: other transport	0.009	0.000	0.007	0.001	0.000	-
Manuf: furniture	0.005	0.000	0.002	0.000	0.000	0.000
Manuf: other	0.026	0.001	0.008	0.001	0.000	0.000

This table displays the share of each sector in the total growth of Brazil's imports and exports to China between 2000 and 2010 in columns (1) and (2), the means across microregions of the sector-microregion-level variables used to calculate IS_m and XD_m in columns (3) and (5), and the means across microregions of the sector-microregion-level variables used to calculate $ivIS_m$ and $ivXD_m$ in columns (4) and (6).

Table 2.2: Brazilian microregion-level summary statistics 2000

	(1) All	(2) Top quintile of IS_m	(3) Top quintile of XD_m
Workforce (thousands)	170.952	417.095	138.593
Private sector workers	0.589	0.624	0.608
Agriculture	0.167	0.078	0.161
Extractive	0.002	0.002	0.004
Manufacturing	0.068	0.123	0.069
Nontraded	0.352	0.421	0.375
Formal jobs	0.177	0.299	0.205
Informal jobs	0.412	0.326	0.403
Skilled occupations	0.094	0.124	0.099
Unskilled occupations	0.496	0.501	0.509
Rural residents	0.313	0.137	0.271
In-migrated in the last 5 years	0.083	0.084	0.088
Average hourly wage (R$)	2.21	3.14	2.46
Skilled occupations	5.07	6.72	5.55
Unskilled occupations	1.70	2.28	1.92
Wage inequality (Gini)	0.542	0.528	0.556

This table displays descriptive statistics of the Brazilian labour market in 2000, averaged at the microregion level. Column (1) includes all microregions, column (2) includes only microregions among the top 20% of IS_m, and column (3) includes only microregions in the top 20% of XD_m. All figures are shares of the total workforce, except as indicated. The workforce is defined here as the total number of citizens between 18 and 60 years old. Average hourly wage is in current Real.

Table 2.3: Log average hourly wages

	(1) OLS	(2) IV	(3) IV	(4) IV	(5) IV
Panel A. All sectors					
IS_m	-3.46	-3.19	-0.70	-3.57	-1.06
	(2.90)	(2.87)	(2.48)	(2.84)	(2.40)
XD_m	1.98***	1.76**	2.26***	1.84***	2.33***
	(0.62)	(0.74)	(0.73)	(0.71)	(0.71)
Panel B. Agricultural/extractive sectors					
IS_m	1.15	-0.92	2.40	-6.39	0.36
	(6.31)	(7.61)	(7.82)	(6.94)	(7.26)
XD_m	5.98***	6.31***	6.74***	7.02***	6.96***
	(1.93)	(2.29)	(2.08)	(1.93)	(1.93)
Panel C. Manufacturing sectors					
IS_m	-7.84***	-7.69***	-7.19***	-8.51***	-7.16***
	(1.42)	(1.24)	(1.42)	(1.43)	(1.42)
XD_m	2.93***	2.95***	3.22***	2.78***	3.23***
	(0.61)	(0.64)	(0.68)	(0.62)	(0.69)
Panel D. Nontraded sectors					
IS_m	-4.23	-3.85	-1.70	-4.72*	-1.69
	(2.62)	(2.47)	(2.04)	(2.45)	(2.03)
XD_m	0.94*	0.61	0.95*	0.93*	0.94*
	(0.49)	(0.50)	(0.55)	(0.51)	(0.53)
Region FE	NO	NO	YES	NO	YES
Lag dep. var.	NO	NO	NO	YES	YES
KP F stat		334.7	250.3	245.2	195.3

This table displays estimated effects of Chinese import and export shocks on changes between 2000 and 2010 in log average hourly wages, as captured by β_I and β_X from equation (1). Panel A presents results for all sectors, Panel B for agricultural and extractive sectors, Panel C for manufacturing sectors, and Panel D for nontraded sectors. Each column corresponds to a different regression with specification indicated. In the columns marked with IV, we instrument imports from (exports to) China using a measure based on growth in Chinese exports to (imports from) all countries, excluding Brazil, relative to a weighted cross-country average. The unit of observation is a microregion (N=558). Coefficients and standard errors are multiplied by 100, so that the unit of the coefficients is roughly percentage increase. All regressions include a constant and the following controls: 2000 workforce, 2000 share of workforce in agricultural sectors, 2000 share of workforce in extractive sectors, 2000 share of workforce in manufacturing, 2000 share of workforce in nontraded sectors, 2000 share of workforce in informal jobs, 2000 share of workforce in rural areas, and a cubic polynomial of income per capita in 2000. Regressions in columns (3) and (5) include region fixed effects, and in columns (4) and (5) include the lag of the dependent variable for the period 1991-2000, instrumented with 1991 levels. All regressions are weighted by share of national workforce. Standard errors are clustered by mesoregion, 138 clusters. Small p-values are represented by *** (less than 1%), ** (less than 5%) or * (less than 10%).

Table 2.4: Log average hourly wages by formality and occupation

	(1) OLS	(2) IV	(3) IV	(4) IV	(5) IV
Panel A. Formal jobs					
IS_m	-6.37***	-5.83***	-3.46*	-4.67***	-2.77
	(1.74)	(1.60)	(1.91)	(1.38)	(1.74)
XD_m	1.45***	1.12**	1.40***	0.91**	1.23***
	(0.48)	(0.47)	(0.43)	(0.46)	(0.42)
Panel B. Informal jobs					
IS_m	2.47	3.24	6.00	2.55	5.20
	(5.31)	(5.50)	(5.20)	(5.43)	(5.02)
XD_m	2.34**	2.14*	2.64**	2.24**	2.76***
	(1.03)	(1.17)	(1.08)	(1.13)	(1.03)
Panel C. Skilled occupations					
IS_m	-0.62	-0.85	0.71		
	(3.13)	(3.36)	(3.15)		
XD_m	1.13*	0.72	1.16**		
	(0.60)	(0.64)	(0.59)		
Panel D. Unskilled occupations					
IS_m	-5.22***	-5.14***	-2.22		
	(1.79)	(1.76)	(2.01)		
XD_m	2.33***	2.24***	2.47***		
	(0.72)	(0.81)	(0.67)		
Region FE	NO	NO	YES	NO	YES
Lag dep. var.	NO	NO	NO	YES	YES
KP F stat		334.7	250.3	245.2	195.3

This table displays estimated effects of Chinese import and export shocks on changes between 2000 and 2010 in log average hourly wages, as captured by β_I and β_X from equation (1). Panel A presents results for workers in formal jobs, Panel B for workers in informal jobs, Panel C for workers in skilled occupations, and Panel D for workers in unskilled occupations. A skilled occupation is defined as an occupation of skill level 3 or 4 according to the ISCO-08 classification. Each column corresponds to a different regression with specification indicated. In the columns marked with IV, we instrument imports from (exports to) China using a measure based on growth in Chinese exports to (imports from) all countries, excluding Brazil, relative to a weighted cross-country average. The unit of observation is a microregion (N=558). Coefficients and standard errors are multiplied by 100, so that the unit of the coefficients is roughly percentage increase. All regressions include a constant and the following controls: 2000 workforce, 2000 share of workforce in agricultural sectors, 2000 share of workforce in extractive sectors, 2000 share of workforce in manufacturing, 2000 share of workforce in nontraded sectors, 2000 share of workforce in informal jobs, 2000 share of workforce in rural areas, and a cubic polynomial of income per capita in 2000. Regressions in columns (3) and (5) include region fixed effects, and in columns (4) and (5) include the lag of the dependent variable for the period 1991-2000, instrumented with 1991 levels. All regressions are weighted by share of national workforce. Standard errors are clustered by mesoregion, 138 clusters. Small p-values are represented by *** (less than 1%), ** (less than 5%) or * (less than 10%).

Table 2.5: Inequality and social assistance

	(1) OLS	(2) IV	(3) IV	(4) IV	(5) IV
Panel A. Wage inequality (Gini coefficient)					
IS_m	1.34***	1.40***	1.12**	1.40***	1.11**
	(0.39)	(0.41)	(0.46)	(0.41)	(0.46)
XD_m	0.07	0.06	0.09	0.06	0.09
	(0.11)	(0.10)	(0.12)	(0.10)	(0.12)
Panel B. Bolsa Família					
IS_m	-0.20	-0.15	0.07		
	(0.30)	(0.33)	(0.19)		
XD_m	-0.25*	-0.25**	-0.14*		
	(0.14)	(0.13)	(0.07)		
Region FE	NO	NO	YES	NO	YES
Lag dep. var.	NO	NO	NO	YES	YES
KP F stat		334.7	250.3	245.2	195.3

This table displays estimated effects of Chinese import and export shocks, as captured by β_I and β_X from equation (1), on two outcomes. In Panel A, the dependent variable is the change in microregion-level wage inequality, as measured by the wage Gini coefficient, between 2000 and 2010. In Panel B, the dependent variable is the share of workforce participating in *Bolsa Família* in 2010. Each column corresponds to a different regression with specification indicated. In the columns marked with IV, we instrument imports from (exports to) China using a measure based on growth in Chinese exports to (imports from) all countries, excluding Brazil, relative to a weighted cross-country average. The unit of observation is a microregion (N=558). Coefficients and standard errors in both panels are multiplied by 100, so that the coefficients in Panel B are in percentage points. All regressions include a constant and the following controls: 2000 workforce, 2000 share of workforce in agricultural sectors, 2000 share of workforce in extractive sectors, 2000 share of workforce in manufacturing, 2000 share of workforce in nontraded sectors, 2000 share of workforce in informal jobs, 2000 share of workforce in rural areas, and a cubic polynomial of income per capita in 2000. Regressions in columns (3) and (5) include region fixed effects, and in columns (4) and (5) include the lag of the dependent variable for the period 1991-2000, instrumented with 1991 levels. All regressions are weighted by share of national workforce. Small p-values are represented by *** (less than 1%), ** (less than 5%) or * (less than 10%).

Table 2.6: In-migration

	(1) OLS	(2) IV	(3) IV	(4) IV	(5) IV
IS_m	-0.86*	-0.89*	-0.83**	-0.92*	-0.83**
	(0.44)	(0.46)	(0.35)	(0.54)	(0.41)
XD_m	0.21**	0.11	0.17	0.13	0.17
	(0.09)	(0.10)	(0.12)	(0.10)	(0.11)
Region FE	NO	NO	YES	NO	YES
Lag dep. var.	NO	NO	NO	YES	YES
KP F stat		334.7	250.3	245.2	195.3

This table displays estimated effects of Chinese import and export shocks on changes between 2000 and 2010 in the share of the workforce that in-migrated to the microregion in the previous five years, as captured by β_I and β_X from equation (1). Each column corresponds to a different regression with specification indicated. In the columns marked with IV, we instrument imports from (exports to) China using a measure based on growth in Chinese exports to (imports from) all countries, excluding Brazil, relative to a weighted cross-country average. The unit of observation is a microregion (N=558). Coefficients and standard errors are multiplied by 100, so that the coefficients represent percentage point changes. All regressions include a constant and the following controls: 2000 workforce, 2000 share of workforce in agricultural sectors, 2000 share of workforce in extractive sectors, 2000 share of workforce in manufacturing, 2000 share of workforce in nontraded sectors, 2000 share of workforce in informal jobs, 2000 share of workforce in rural areas, and a cubic polynomial of income per capita in 2000. Regressions in columns (3) and (5) include region fixed effects, and in columns (4) and (5) include the lag of the dependent variable for the period 1991-2000, instrumented with 1991 levels. All regressions are weighted by share of national workforce. Standard errors are clustered by mesoregion, 138 clusters. Small p-values are represented by *** (less than 1%), ** (less than 5%) or * (less than 10%).

Table 2.7: Private sector employment

	(1) OLS	(2) IV	(3) IV	(4) IV	(5) IV
Panel A. All sectors					
IS_m	0.56*	0.67*	1.24***	0.28	0.92***
	(0.33)	(0.34)	(0.33)	(0.38)	(0.34)
XD_m	0.07	0.08	0.07	0.07	0.08
	(0.11)	(0.10)	(0.10)	(0.12)	(0.11)
Panel B. Agricultural/extractive sectors					
IS_m	-0.39	-0.25	-0.16	-0.01	0.06
	(0.26)	(0.28)	(0.32)	(0.25)	(0.28)
XD_m	0.07	0.06	-0.01	0.11	0.06
	(0.18)	(0.18)	(0.15)	(0.14)	(0.13)
Panel C. Manufacturing sectors					
IS_m	-0.20	-0.29	0.05	0.34	0.65
	(0.52)	(0.55)	(0.67)	(0.56)	(0.71)
XD_m	-0.06	-0.12	-0.10	-0.16	-0.15
	(0.10)	(0.10)	(0.09)	(0.10)	(0.10)
Panel D. Nontraded sectors					
IS_m	1.18*	1.21*	1.34*	1.39*	1.43*
	(0.63)	(0.67)	(0.73)	(0.72)	(0.78)
XD_m	0.11	0.18	0.22	0.04	0.11
	(0.15)	(0.16)	(0.15)	(0.12)	(0.14)
Region FE	NO	NO	YES	NO	YES
Lag dep. var.	NO	NO	NO	YES	YES
KP F stat		334.7	250.3	245.2	195.3

This table displays estimated effects of Chinese import and export shocks on changes between 2000 and 2010 in the share of the workforce employed in the private sector, as captured by β_I and β_X from equation (1). Panel A presents results for all sectors, Panel B for agricultural and extractive sectors, Panel C for manufacturing sectors, and Panel D for nontraded sectors. Each column corresponds to a different regression with specification indicated. In the columns marked with IV, we instrument imports from (exports to) China using a measure based on growth in Chinese exports to (imports from) all countries, excluding Brazil, relative to a weighted cross-country average. The unit of observation is a microregion (N=558). Coefficients and standard errors are multiplied by 100, so that the coefficients represent percentage point changes. All regressions include a constant and the following controls: 2000 workforce, 2000 share of workforce in agricultural sectors, 2000 share of workforce in extractive sectors, 2000 share of workforce in manufacturing, 2000 share of workforce in nontraded sectors, 2000 share of workforce in informal jobs, 2000 share of workforce in rural areas, and a cubic polynomial of income per capita in 2000. Regressions in columns (3) and (5) include region fixed effects, and in columns (4) and (5) include the lag of the dependent variable for the period 1991-2000, instrumented with 1991 levels. All regressions are weighted by share of national workforce. Standard errors are clustered by mesoregion, 138 clusters. Small p-values are represented by *** (less than 1%), ** (less than 5%) or * (less than 10%).

Table 2.8: Informality

	(1) OLS	(2) IV	(3) IV	(4) IV	(5) IV
Panel A. Formal jobs					
IS_m	0.83***	0.80***	1.16***	0.88**	1.25***
	(0.29)	(0.29)	(0.37)	(0.36)	(0.44)
XD_m	0.36**	0.31**	0.31**	0.32**	0.32***
	(0.14)	(0.15)	(0.12)	(0.15)	(0.12)
Panel B. Informal jobs					
IS_m	-0.28	-0.13	0.08	0.11	0.30
	(0.38)	(0.43)	(0.48)	(0.39)	(0.45)
XD_m	-0.28**	-0.24	-0.24	-0.21	-0.21
	(0.14)	(0.16)	(0.16)	(0.16)	(0.16)
Region FE	NO	NO	YES	NO	YES
Lag dep. var.	NO	NO	NO	YES	YES
KP F stat		334.7	250.3	245.2	195.3

This table displays estimated effects of Chinese import and export shocks on changes between 2000 and 2010 in the share of the workforce employed in formal and informal private sector jobs, as captured by β_I and β_X from equation (1). Panel A presents results for formal jobs and Panel B for informal jobs. Each column corresponds to a different regression with dependent variable and specification indicated. In the columns marked with IV, we instrument imports from (exports to) China using a measure based on growth in Chinese exports to (imports from) all countries, excluding Brazil, relative to a weighted cross-country average. The unit of observation is a microregion (N=558). Coefficients and standard errors are multiplied by 100, so that the coefficients represent percentage point changes. All regressions include a constant and the following controls: 2000 workforce, 2000 share of workforce in agricultural sectors, 2000 share of workforce in extractive sectors, 2000 share of workforce in manufacturing, 2000 share of workforce in nontraded sectors, 2000 share of workforce in rural areas, and a cubic polynomial of income per capita in 2000. Regressions in columns (3) and (5) include region fixed effects, and in columns (4) and (5) include the lag of the dependent variable for the period 1991-2000, instrumented with 1991 levels. All regressions are weighted by share of national workforce. Standard errors are clustered by mesoregion, 138 clusters. Small p-values are represented by *** (less than 1%), ** (less than 5%) or * (less than 10%).

Table 2.9: Formal private sector employment

	(1) OLS	(2) IV	(3) IV	(4) IV	(5) IV
Panel A. Agricultural/extractive sectors					
IS_m	0.09	-0.00	0.06	-0.01	0.05
	(0.12)	(0.10)	(0.12)	(0.11)	(0.12)
XD_m	0.17	0.17	0.17	0.15	0.17
	(0.12)	(0.13)	(0.11)	(0.12)	(0.11)
Panel B. Manufacturing sectors					
IS_m	-0.27	-0.28	-0.16	0.45	0.53
	(0.55)	(0.57)	(0.62)	(0.65)	(0.73)
XD_m	-0.00	-0.06	-0.06	-0.10	-0.11
	(0.08)	(0.08)	(0.09)	(0.08)	(0.10)
Panel C. Nontraded sectors					
IS_m	1.04**	1.09**	1.26***	0.75	1.00**
	(0.45)	(0.50)	(0.43)	(0.57)	(0.45)
XD_m	0.20*	0.21	0.21	0.09	0.11
	(0.12)	(0.13)	(0.13)	(0.16)	(0.14)
Region FE	NO	NO	YES	NO	YES
Lag dep. var.	NO	NO	NO	YES	YES
KP F stat		334.7	250.3	245.2	195.3

This table displays estimated effects of Chinese import and export shocks on changes between 2000 and 2010 in the share of the workforce employed in formal private sector jobs, as captured by β_I and β_X from equation (1). Panel A presents results for agricultural and extractive sectors, Panel B for manufacturing sectors, and Panel C for nontraded sectors. Each column corresponds to a different regression with specification indicated. In the columns marked with IV, we instrument imports from (exports to) China using a measure based on growth in Chinese exports to (imports from) all countries, excluding Brazil, relative to a weighted cross-country average. The unit of observation is a microregion (N=558). Coefficients and standard errors are multiplied by 100, so that the coefficients represent percentage point changes. All regressions include a constant and the following controls: 2000 workforce, 2000 share of workforce in agricultural sectors, 2000 share of workforce in extractive sectors, 2000 share of workforce in manufacturing, 2000 share of workforce in nontraded sectors, 2000 share of workforce in informal jobs, 2000 share of workforce in rural areas, and a cubic polynomial of income per capita in 2000. Regressions in columns (3) and (5) include region fixed effects, and in columns (4) and (5) include the lag of the dependent variable for the period 1991-2000, instrumented with 1991 levels. All regressions are weighted by share of national workforce. Standard errors are clustered by mesoregion, 138 clusters. Small p-values are represented by *** (less than 1%), ** (less than 5%) or * (less than 10%).

Table 2.10: Informal private sector employment

	(1) OLS	(2) IV	(3) IV	(4) IV	(5) IV
Panel A. Agricultural/extractive sectors					
IS_m	-0.48**	-0.24	-0.22	-0.12	-0.10
	(0.23)	(0.23)	(0.28)	(0.22)	(0.26)
XD_m	-0.10	-0.11	-0.18	-0.07	-0.13
	(0.12)	(0.14)	(0.14)	(0.12)	(0.13)
Panel B. Manufacturing sectors					
IS_m	0.07	-0.01	0.20	-0.00	0.21
	(0.12)	(0.10)	(0.13)	(0.11)	(0.14)
XD_m	-0.06*	-0.06*	-0.04	-0.06*	-0.04
	(0.03)	(0.03)	(0.03)	(0.04)	(0.03)
Panel C. Nontraded sectors					
IS_m	0.14	0.11	0.08	0.28	0.27
	(0.35)	(0.38)	(0.47)	(0.36)	(0.46)
XD_m	-0.09	-0.04	0.01	-0.05	-0.02
	(0.14)	(0.15)	(0.12)	(0.15)	(0.12)
Region FE	NO	NO	YES	NO	YES
Lag dep. var.	NO	NO	NO	YES	YES
KP F stat		334.7	250.3	245.2	195.3

This table displays estimated effects of Chinese import and export shocks on changes between 2000 and 2010 in the share of the workforce employed in informal private sector jobs, as captured by β_I and β_X from equation (1). Panel A presents results for agricultural and extractive sectors, Panel B for manufacturing sectors, and Panel C for nontraded sectors. Each column corresponds to a different regression with specification indicated. In the columns marked with IV, we instrument imports from (exports to) China using a measure based on growth in Chinese exports to (imports from) all countries, excluding Brazil, relative to a weighted cross-country average. The unit of observation is a microregion (N=558). Coefficients and standard errors are multiplied by 100, so that the coefficients represent percentage point changes. All regressions include a constant and the following controls: 2000 workforce, 2000 share of workforce in agricultural sectors, 2000 share of workforce in extractive sectors, 2000 share of workforce in manufacturing, 2000 share of workforce in nontraded sectors, 2000 share of workforce in informal jobs, 2000 share of workforce in rural areas, and a cubic polynomial of income per capita in 2000. Regressions in columns (3) and (5) include region fixed effects, and in columns (4) and (5) include the lag of the dependent variable for the period 1991-2000, instrumented with 1991 levels. All regressions are weighted by share of national workforce. Standard errors are clustered by mesoregion, 138 clusters. Small p-values are represented by *** (less than 1%), ** (less than 5%) or * (less than 10%).

Table 2.11: Occupational skill level

	(1)	(2)	(3)	(4)	(5)	(6)
	Skilled occupations			Unskilled occupations		
	OLS	IV	IV	OLS	IV	IV
Panel A. All sectors						
IS_m	-0.21	-0.04	0.10	0.77*	0.71	1.14**
	(0.22)	(0.33)	(0.38)	(0.41)	(0.50)	(0.55)
XD_m	0.05	0.07	0.07	0.02	0.01	0.00
	(0.06)	(0.07)	(0.08)	(0.13)	(0.13)	(0.14)
Panel B. Agricultural/extractive sectors						
IS_m	-0.03	-0.04*	-0.04	-0.36	-0.21	-0.12
	(0.02)	(0.02)	(0.02)	(0.25)	(0.27)	(0.30)
XD_m	0.06**	0.05*	0.05*	0.01	0.00	-0.06
	(0.03)	(0.03)	(0.03)	(0.16)	(0.17)	(0.14)
Panel C. Manufacturing sectors						
IS_m	-0.30**	-0.28**	-0.26*	0.09	-0.00	0.30
	(0.12)	(0.13)	(0.13)	(0.43)	(0.48)	(0.60)
XD_m	0.01	0.01	0.02	-0.08	-0.13	-0.11
	(0.02)	(0.02)	(0.02)	(0.09)	(0.09)	(0.08)
Panel D. Nontraded sectors						
IS_m	0.11	0.27	0.38	1.07**	0.94*	0.96*
	(0.20)	(0.31)	(0.35)	(0.54)	(0.56)	(0.58)
XD_m	-0.02	0.00	0.01	0.13	0.17	0.21
	(0.05)	(0.06)	(0.06)	(0.16)	(0.18)	(0.17)
Region Fixed Effects			YES			YES
KP F stat		334.7	250.3		334.7	250.3

This table displays estimated effects of Chinese import and export shocks on changes between 2000 and 2010 in the share of the workforce employed in skilled and unskilled occupations, as captured by β_I and β_X from equation (1). Panel A presents results for all sectors, Panel B for agricultural and extractive sectors, Panel C for manufacturing sectors, and Panel D for nontraded sectors. Each column corresponds to a different regression with dependent variable and specification indicated. The dependent variable in columns 1 to 3 is the change in the share of workforce in skilled occupations, and in columns 4 to 6 it is the change in the share of workforce in unskilled occupations. A skilled occupation is defined as an occupation of skill level 3 or 4 according to the ISCO-08 classification. In the columns marked with IV, we instrument imports from (exports to) China using a measure based on growth in Chinese exports to (imports from) all countries, excluding Brazil, relative to a weighted cross-country average. The unit of observation is a microregion (N=558). Coefficients and standard errors are multiplied by 100, so that the coefficients represent percentage point changes. All regressions include a constant and the following controls: 2000 workforce, 2000 share of workforce in agricultural sectors, 2000 share of workforce in extractive sectors, 2000 share of workforce in manufacturing, 2000 share of workforce in nontraded sectors, 2000 share of workforce in informal jobs, 2000 share of workforce in rural areas, and a cubic polynomial of income per capita in 2000. Regressions in columns (3) and (6) include region fixed effects. All regressions are weighted by share of national workforce. Standard errors are clustered by mesoregion, 138 clusters. Small p-values are represented by *** (less than 1%), ** (less than 5%) or * (less than 10%).

Chapter 3

Access to Raw Materials and Local Comparative Advantage: The Effects of India's Freight Equalization Policy

> In order that industrialisation may benefit the economy of the country as a whole, it is important that disparities in levels of development between different regions should be progressively reduced. The lack of industries in different parts of the country is very often determined by factors such as the availability of the necessary raw materials....
>
> – Industrial Policy Resolution, Government of India, 1956

3.1 Introduction

Access to raw materials is a potentially important determinant of industrial location and the geography of economic development. Proximity to stocks of natural resources or other industrial raw materials might give a region a comparative advantage in industries whose products are intensive in locally available intermediates. Conversely, the competitiveness of firms in locations distant from their material inputs might suffer from the disadvantage of the additional freight costs associated with transporting those materials to their plants for processing. In this chapter, we examine the effects of a policy that aimed to 'level the playing field' for regions near and far from essential raw materials. India's Freight Equalization Policy, adopted in 1956, was designed to ensure that long-distance and short-haul shipments of steel, cement and fertilizers were subject to identical total freight costs, equalizing prices of those commodities for downstream firms across the country.

We focus here on steel, which was mainly produced in the 'iron and steel belt' of Eastern India at the time of the policy's adoption. Some sources (discussed in the next section) have suggested that this region was deprived of its comparative advantage in steel-intensive downstream industries due to the Freight Equalization Policy. Below, we assess the evidence for this hypothesis in three steps, using data from the period around the policy's adoption. We first examine whether iron and steel prices were actually equalized across states after the imposition of the policy, using input data as reported by firms in downstream industries. We then use data on interstate trade to consider whether quantities shipped of iron and steel became less responsive to distances between exporters and importers in the years after the policy was adopted. Finally, we directly assess whether the location of steel-intensive industries was influenced by the policy, using data on manufacturing output across industries and states.

The evidence presented here does not make a strong case that the Freight Equalization Policy was effective in changing the spatial pattern of India's industrial output. In particular, regressions comparing trends across states in the output of the steel-using engineering industry to changes in other industries' output do not suggest that steel-intensive industries moved further away from steel mills as a consequence of the policy. Moreover, estimation of gravity equations suggests that there was little or no change in the distance elasticity of trade in iron and steel after the adoption of freight equalization.

However, rather than suggesting that access to raw materials was unimportant for industrial development in India, this might be because the policy did not succeed in eliminating differences in access to raw materials. Our results suggest that prices of iron and steel increased with a state's distance to the nearest steel mill before 1956, but that these price differences were only partially offset after the introduction of freight equalization. It is thus difficult to draw confident conclusions about the effect of access to steel on industrial location in India from the results of this study.

This chapter fits into a literature (also discussed in the first chapter) studying the link between advantageous access to raw materials and manufacturing performance (e.g. Wright 1990, Irwin 2003). The question of whether proximity to raw materials affects the location of industries has also sometimes been studied in concert with the influence of access to other inputs (such as skilled labour) in the literature on industrial agglomeration. Ellison and Glaeser (1999) find that 'natural advantages' of these kinds are able to partly explain the present-day geographic concentration of industries in the United States. On the other hand, Klein and Crafts (2012) suggest that natural advantages, including better access to coal, helped determine the location of manufacturing within the US in the late 19th century, but that their influence faded out in the early 20th century. The effect of proximity to coal on economic development is also examined by Fernihough and O'Rourke (2014), who conclude that access to coal had a substantial effect on the growth of European cities between 1750 and 1900.

Our study also contributes to the literature assessing the effects of industrial policy. Other studies of the myriad industrial policies of post-independence India often focus on the effect of these policies' removal rather than their imposition: for example, Chari (2011) examines the effect of entry and size restrictions imposed on firms by India's licensing requirements by studying the impact of a 1985 episode of liberalization. Finally, our results may help inform the study of the dramatic differences in regional performance in India since its independence. Lahiri and Yi (2009) point out that the fortunes of West Bengal (a state within India's 'iron and steel belt') and Maharashtra diverged dramatically between 1960 and 1993, and attempt to explain West Bengal's far inferior income gains using a multi-sector growth model.

The chapter now proceeds as follows: Section 3.2 provides further background on the Freight Equalization Policy. Section 3.3 then presents empirical results regarding the policy's effects on iron and steel prices, interstate trade in iron and steel and the output of steel-intensive industries. The data used by the study is also introduced over the course of this section. Finally, Section 3.4 provides concluding remarks.

3.2 Background

As indicated in the quotation at the beginning of this chapter, India's Industrial Policy Resolution of 1956 set out the aim of reducing economic inequality between the country's regions, and identified interregional differences in access to raw materials as one cause of this inequality. By mid-1956, the Indian government had instituted a system of 'freight pooling', often referred to as the Freight Equalization Policy, for three important raw materials – steel, cement and fertilizers – and was considering implementing such a system for coal (Economic Weekly 1956).[1] In the case of steel, according to the annual report of the Ministry of Commerce and Industry for 1956-57:

> With effect from the 11th June 1956 uniform prices have been fixed for all Rail Head Stations in India, and the prices of both steel and pig iron have been increased to meet the extra costs of transport involved, which are now met out of the equalisation funds. This step, it is hoped, would result in better geographical distribution of industries and also stimulate the dispersal of industries all over the country.[2]

To accomplish the fixation of iron and steel prices across India, the difference between the consumer price and the ex-factory 'retention price' was paid into a self-financing equalization fund, which covered the cost of freight (Singh 1989). This system required the expected average distance travelled by shipments of steel to be estimated in advance, so that payments into the equalization fund were sufficient to cover the total cost of all shipments (Raza and Aggarwal 1986). Ex-factory prices were initially set by the Indian government's Tariff Commission, but starting in 1964, an institution specific to the steel sector (the Joint Plant Committee) took over the setting of ex-factory and consumer prices and administration of the freight equalization fund (Singh 1989). Freight equalization for steel continued until 1992 and was replaced with a 'freight ceiling' policy setting a maximum freight rate; this was in turn removed in 2001 (Hindu Business Line 2001). Below, we will limit our consideration of the effects of the Freight Equalization Policy to the years immediately after its implementation.

Various sources have claimed that the Freight Equalization Policy was effective in changing patterns of trade and industrial output. For example, Mills and Becker (1986) stated that the policy "leads to excessive transport of the commodities, because users have no incentive to buy from the nearest source", while Mohan (1983)

[1] We could find no evidence that freight equalization was actually implemented for coal, though several secondary sources suggest that this was the case. For example, Chakravorty and Lall (2007) note that "[t]he Freight Equalization Policy of 1956 equalized the prices for 'essential' items such as coal, steel and cement nationwide.". The 1977 report of the Inter-Ministerial Group on Freight Equalisation of Commodities lists only pig iron, steel, cement and fertilizers as subject to freight equalization schemes at that time (Government of India Planning Commission 1977).

[2] The report also notes that the maximum freight rate for shipments of steel had previously been fixed at 60 rupees per ton as of May 1954 (Ministry of Commerce and Industry 1957). Here, we use 1956, the year in which prices were to be fully equalized across regions, as the date of the initiation of the Freight Equalization Policy for steel.

argues that price equalization of commodities "robbed the producing areas... of their comparative advantage in industries using these products". A 2008 World Bank report on Orissa suggests that recent growth in that state was partly due to the end of the Freight Equalization Policy, which "had annulled the state's comparative advantage as the location for metal industries" (World Bank 2008).

However, an inter-ministerial task force charged with assessing the feasibility of extension of the Freight Equalization Policy to raw cotton reported in 1977 that the effect of steel freight equalization on regional comparative advantage was probably very limited (Government of India Planning Commission 1977). Using data on the input consumption of steel-intensive industries, the task force calculated the relative cost savings due to freight equalization for firms relatively more distant from steel mills. These were found to be small: for example, producers of machine tools 2000 km away from their steel suppliers were found to have reaped a cost advantage from the policy of just 0.7% of the price of final output as compared to firms located 250 km from a steel mill.

3.3 Empirical analysis

3.3.1 Iron and steel input prices

Because the Freight Equalization Policy was designed to equalize iron and steel prices across locations in India, we first examine its effect on these prices. To do so, we use information on input data from the Census of Indian Manufactures, a statutory census of manufacturing firms that was conducted in India annually between 1946 and 1958 and was the predecessor to the present-day Annual Survey of Industries. This census asked firms about the quantity and value of various material inputs consumed in production, and reported this data by state and industry in published volumes. Most of the manufacturing firms for which iron and steel was intensively used in production were included in the broadly defined 'General Engineering and Electrical Engineering' industry, and so we focus our analysis on materials usage data for this industry. In particular, we define the average unit value for a given iron and steel product (such as 'pig iron') in each state and year as the total value of that product used in the engineering industry in rupees, divided by the total quantity used in tons.

Using Indian manufacturing data from this period presents some challenges. First, states with small numbers of firms in a given industry are consolidated into a residual 'other states' category in the published data, and in the earliest years of the Census of Manufactures, this results in relatively fewer observations associated with individual states. We begin our analysis in 1951, since before this year information from firms in Uttar Pradesh and Rajasthan is not separately identified in data on the engineering industry.[3] Second, there were major changes in India's state borders in 1956, which makes it difficult to concord state-level observations over time. However, we are able to construct a dataset of eleven states whose borders stay relatively consistent – though far from perfectly so – over the period studied. Finally, so that our results are not driven by outliers in the unit value data, we drop observations for which unit values are particularly distant from the product-year median.[4]

We then examine the hypothesis that the Freight Equalization Policy eliminated the gap in steel prices between locations close to steel mills and locations distant from steel mills. At the beginning of the period of study, India had only two integrated steel plants – in Jamshedpur, Bihar and Burnpur, West Bengal – and although three other integrated steel plants set up operations in the late 1950s, only one of these had begun producing steel by 1958, and this was less than 50 km away from the existing Burnpur mill.[5] We define the distance between a state and the nearest steel mill as the distance between the state's largest city (according to the 1951 Census of India) and the nearer of the two plants in Jamshedpur and Burnpur; this variable is therefore defined at the state level and is invariant across time.[6] Column (1) of Table 3.1 demonstrates the large variation in the distances of each state to the nearest steel mill by this measure: while Calcutta in West Bengal was less than 200 km from the nearest mill as of 1950, Amritsar in Punjab was nearly 1500 km from either of these integrated steel plants.

[3]Note that this sample excludes Mysore (later Karnataka) and Travancore-Cochin (later Kerala), since these two states do not join the dataset until 1954.

[4]In particular, we drop the top 5% and bottom 5% of observations, across all iron and steel products, according to observed unit value divided by product-year median unit value.

[5]These three plants were in Durgapur, West Bengal; Rourkela, Orissa; and Bhilai, Madhya Pradesh.

[6]Because the largest city in Madhya Pradesh in 1951 (Nagpur) was absorbed into Maharashtra as of 1956, we use the state's second largest city in 1951 (Jabalpur) for this exercise instead.

We begin by running the following regression:

$$unitvalue_{pst} = \alpha + \beta dist_s + \gamma dist_s * policy_t + \phi_{pt} + \epsilon_{pst} \tag{3.1}$$

The estimated parameters of primary interest, $\hat{\beta}$ and $\hat{\gamma}$, reveal whether steel prices rose with distance to integrated steel mills $dist_s$, and the extent to which this was offset in the three years following adoption of the Freight Equalization Policy (1956 to 1958). Distance enters the equation linearly on the assumption that freight rates are charged in rupees per ton-kilometer. Product-time fixed effects ensure that identification relies on across-state variation in unit values in each year for each of the nine iron and steel products for which data is available.

The results of this regression are displayed in column (1) of Table 3.2. The estimated $\hat{\beta}$ suggests that states whose largest cities were 100 km farther from the nearest integrated steel mill paid an average of 5 rupees more for a ton of iron and steel products; this estimate is statistically significant at the 5% level. The average unit value of iron or steel products across all states before 1956 was 536 rupees per ton, and the effect of moving a firm from West Bengal to Punjab is predicted to correspond to a change in unit iron and steel input value of 62.5 rupees per ton, or 11.7% of this average.

However, while the estimated $\hat{\gamma}$ from this regression is negative as predicted, it is only one-third of the magnitude of $\hat{\beta}$, and statistically insignificant. This finding does not support the conclusion that the imposition of the Freight Equalization Policy led immediately to the full offset of differences in unit values of iron and steel inputs resulting from distance from steel mills, though it suggests that these differences may have been partially offset. Of course, some of the differences in unit values throughout the period of study might result from different usage patterns of steel inputs by state; for example, firms in states more distant from steel mills might happen to have used more expensive types of steel within product categories throughout the period. The substitution of product-state fixed effects for the $\beta dist_s$ term in regression (3.1) results in estimates for $\hat{\gamma}$ that remain negative (and of similar magnitude) but statistically insignificant (column (2) in Table 3.2).

Columns (3) and (4) of Table 3.2 show results from identical regressions to those in columns (1) and (2), but for all other metal inputs to the engineering industry (e.g. 'brass castings').[7] Reassuringly, column (3) shows that distance from steel plants does not seem to drive unit values for metal products other than iron and steel. The small positive estimated coefficient for the interaction term in columns (3) and (4) suggests that a 'triple-difference'-type specification, comparing unit values of iron and steel to those of other metals by distance before and after 1956, would yield an estimated effect of the Freight Equalization Policy slightly larger than that in column (1) or (2). This is confirmed by column (5), which displays the results of the following specification (where $ironsteel_p$ is a dummy for iron and steel products):

$$unitvalue_{pst} = \alpha + \gamma ironsteel_p * dist_s * policy_t + \phi_{pt} + \psi_{st} + \theta_{ps} + \epsilon_{pst} \tag{3.2}$$

In practice, the integrated steel mills in West Bengal and Bihar produced a very large share of India's iron and steel during the 1950s, but not all of its steel. According to the Census of Indian Manufactures, these two states produced 91.0% of iron and steel products by value in 1951 and 80.8% in 1958. Much steel was produced in smaller plants across India using scrap as an input. However, some products appear to have been produced almost exclusively by the vertically integrated steel mills: while just 61% of steel bars and rods were produced in West Bengal and Bihar in 1958, these two states were the origin of 99.8% of steel plates and sheets. As discussed by Collard-Wexler and De Loecker (2015) in their study of the US steel industry, this was due to technological constraints: historically, only the furnaces of vertically integrated plants could produce the higher-quality steel required for steel sheet, while smaller plants dependent on scrap metal produced lower-quality steel used for products such as steel bars.

I thus rerun regression (3.1) separately for the two steel product categories 'Plates, sheets and strips' and 'Bars and rods', using either $dist_s$ or state fixed effects as covariates. As shown in columns (1) and (3) of Table 3.3, before 1956, both products' unit values increased with distance from an integrated steel mill at a rate of approximately 10 rupees per 100 km. However, while there was no change in this pattern for bars and rods after the adoption of the Freight Equalization Policy (see columns (3) and (4)), the distance effect was almost entirely offset from 1956 for plates, sheets and strips. Moreover, the estimated $\hat{\gamma}$ for steel plates, sheets and

[7] As with iron and steel products, we drop the top 5% and bottom 5% of observations across all products of other metals according to observed unit value divided by product-year median unit value.

strips is statistically significant in the specifications with and without state fixed effects (columns (1) and (2)). Figure 3.1 shows the evolution of the estimated distance effect over time for steel plates, sheets and strips, from a regression similar to (3.1) but with a full set of interactions between distance from a steel plant and year.

One possible explanation for these results is that firms throughout India may already have had access to nearby producers of steel bars and rods, so that the Freight Equalization Policy did not change the pattern of prices available to firms across states. In this case, the significant differences between the prices of steel bars and rods across provinces might be due to persistent factors unrelated to freight costs. Alternatively, it might be that freight costs were relevant for both sets of goods – of which West Bengal and Bihar were the largest producers in both cases – but that only products of vertically integrated steel plants were actually subject to the Freight Equalization Policy. While most sources discussing the Freight Equalization Policy do not specify which firms were subject to the policy, a document from India's National Council of Applied Economic Research (1964) suggests that:

> The main producers, viz. Hindustan Steel, Tata Iron and Steel and Indian Iron and Steel charge the lowest price (i.e. Column I) f.o.r. destination (i.e. freight paid) and this price is uniform at all railheads in India. Other producers, i.e. re-rolling mills, sell at Column I rate f.o.r. works (i.e. freight to be paid by consumer).

Notably, these results do not seem to be driven by something special about demand for plates and sheets across states. Columns (5) and (6) of Table 3.3 reproduce the regressions in columns (1) and (2) for the product category 'circles, plates, sheets and strips' for brass, copper and aluminum; these produce very small and statistically insignificant estimates of $\hat{\beta}$ and $\hat{\gamma}$.

3.3.2 Internal trade in iron and steel

We next examine the hypothesis that equalization of freight rates across locations reduced the elasticity of trade in steel to distance between exporter and importer. For this, we use annual data on trade by rail and river between Indian states published by India's Department of Commercial Intelligence and Statistics. This source includes information on the quantity of 'iron and steel bars, sheets, girders and other commercial forms of iron and steel' traded by rail or river between locations in India in each year.

Conveniently, the major changes in the borders of Indian states in 1956 are not reflected in this dataset until 1961, which means that it is possible to conduct an analysis of the effect of the Freight Equalization Policy using identical spatial units through 1960. We thus digitized data on trade in iron and steel for each year between 1950 and 1960 (with the exception of 1952, for which data was not readily available). Sixteen locations are represented in all of these years, but we drop three small and/or remote locations for which a high proportion of observations are zeroes (Assam, Goa and Jammu and Kashmir), leaving thirteen states.[8]

In order to identify changes in distance elasticities due to the Freight Equalization Policy, we estimate a series of gravity equations. Following the advice of Head and Mayer (2015), we do so using a variety of empirical specifications in order to assess the robustness of our estimates to possible biases due to heteroskedasticity (Santos Silva and Tenreyro 2006). We begin by estimating a standard gravity equation for trade between exporters i and importers j using ordinary least squares:

$$\ln quantity_{ijt} = \alpha + \delta \ln dist_{ij} + \phi_{it} + \psi_{jt} + \epsilon_{ijt} \tag{3.3}$$

Here, $\hat{\delta}$ is the estimated elasticity of quantity traded with respect to geographic distance $dist_{ij}$. We then proceed to estimate analogous gravity regressions using Poisson pseudo-maximum-likelihood (PML) and Gamma PML.[9]

Column (1) of Table 3.4 shows that these three methods result in estimated distance elasticities for interstate trade in iron and steel ranging from -1.55 to -2.60.[10] In column (2), an interaction between distance and the post-1956 period is added to specification (3.3), in order to assess the extent to which the distance elasticity falls after the adoption of the Freight Equalization Policy. None of the three estimates indicate that the distance elasticity moved substantially towards zero after 1956; only the OLS estimate is both positive and statistically significant, and

[8] Data is reported separately for some Indian ports, such as Calcutta; we add these quantities to the quantities reported for the rest of the state (in this case, West Bengal).

[9] Head and Mayer (2015) suggest that the choice of the preferred estimate among these three should be guided in part by the outcome of a test of the distribution of the error term proposed by Manning and Mullahy (2001). We run this test using residuals from the OLS regression and find that the result supports the Poisson model.

[10] Notably, the estimate from the Poisson PML regression is substantially smaller in absolute value than the other two estimates; Head and Mayer (2015) suggest that this might be due to small-sample bias or distance elasticities that decrease with trade volume.

this is an order of magnitude smaller in absolute value than the estimated pre-policy elasticity. These estimated effects of the policy change little when exporter-importer fixed effects are substituted for the $\delta \ln dist_{ij}$ term in column (3).

Of course, the very small measured effect of freight equalization on iron and steel flows might be due to the fact that the policy may have been targeted to products of the large vertically integrated plants, as suggested in the previous section. We thus also run a 'triple-difference' regression in which the effect of the policy is instead identified by comparing distance elasticities of iron and steel exports from Bihar and West Bengal, before and after the policy, to exports from other states whose steel-producing plants may have been unaffected by freight equalization. This is accomplished with the following specification, in which $steelstate_i$ is a dummy for Bihar and West Bengal:

$$\ln quantity_{ijt} = \alpha + \delta \ln dist_{ij} * steelstate_i * policy_t + \phi_{it} + \psi_{jt} + \theta_{ij} + \epsilon_{ijt} \quad (3.4)$$

The results of this regression may be found in column (4) of Table 3.4. These provide little evidence that the Freight Equalization Policy had a short-run effect on the distance elasticity of trade in steel: all three estimates of $\hat{\delta}$ are statistically insignificant and none of the three are of the predicted sign. One important caveat to this conclusion is that as noted earlier, vertically integrated steel plants started production in Orissa and Madhya Pradesh in 1959. If this led to a decline (in absolute value) in the distance elasticity of steel exports from these two provinces, the triple-difference estimates might be biased downwards. However, dropping all trade involving either of these two states from the dataset results in estimated coefficients that are very similar to those in column (4).

The Indian rail and river trade data also allows for distance elasticities to be estimated for other commodities; we have digitized this data for the full set of commodities tracked by these publications for six years between 1951 and 1960.[11] In particular, we may estimate these elasticities for another commodity to become subject to freight equalization in 1956: cement. One complication of estimating gravity equations for interstate trade in cement is that there are many more observed flows of zero trade between states in the matrix of interstate cement trade (32% of all observations, as compared to 3.5% for iron and steel). We thus add a fourth

[11] These are 1951, 1953, 1955, 1956, 1958 and 1960.

estimation methodology to the menu of gravity regressions for this case, a Tobit strategy proposed by Eaton and Kortum (2001), again based on a recommendation by Head and Mayer (2015). This approach replaces the zero flows to a given importer with the minimum nonzero observed flow to that importer in the same year.

Applying the specification of column (2) of Table 3.4 – which includes log distance and its interaction with the post-1956 period – to interstate trade in cement yields the results in column (1) of Table 3.5. The estimated distance elasticities are again negative, though substantially larger in magnitude than those for iron and steel, but the largest positive estimate for $\hat{\delta}$ is again an order of magnitude smaller than the estimated pre-policy distance elasticity.

Of course, it is possible that the estimates of $\hat{\delta}$ are being biased downward by some contemporaneous shock correlated to bilateral distance. In this case, we might expect to see more negative estimates of $\hat{\delta}$ for 'placebo' products to which the Freight Equalization Policy did not apply. We thus repeat the regression of Table 3.5 column (1) for the three nonsteel products with the lowest proportion of observed zero trade flows in the period covered by the data: glass, pulses (excluding gram) and timber (excluding teak). This exercise provides little support for the hypothesis of a negative bias due to a correlated shock: all twelve estimates of $\hat{\delta}$ in columns (2) to (4) are positive, several of them statistically significant.

3.3.3 Output of steel-intensive industries

We now consider evidence on whether the location of steel-intensive industries was affected by the Freight Equalization Policy, by examining changes in the pattern of manufacturing output across industries and states around the time of the policy's adoption. For this exercise, we combine annual output data by state and industry from the Census of Indian Manufactures, which ended in 1958, with similar data for 1959 to 1970 from its successor, the Annual Survey of Industries. We use the same concordance of pre-1956 and post-1956 states introduced in the section on steel prices; however, we must now also construct a concordance of industries between the two datasets. Eleven states and sixteen industries are continuously represented in the data starting from 1950. We drop the industries directly affected by the policy – iron and steel and cement – and so fourteen industries remain in the dataset we use here. The list of these industries may be found in Table 3.6.

To quantify the steel intensity of the fourteen industries in the sample, we calculated the share of iron and steel in total input costs for each of these industries using data from the 1949 Census of Indian Manufactures. This suggests that while 42% of intermediate input value is accounted for by iron and steel products in the engineering industry, no other industry in the sample has a steel input share greater than 1%. Therefore, in the analysis below, we simply compare the engineering industry to all other industries in the sample.

We must now return to the issue that some states' output is assigned to a residual 'other states' category in the Census of Manufactures, wherever an industry is represented by only a small number of firms in those states. Here, we divide this output equally across the relevant states, potentially resulting in some measurement error. The issue of measurement is further complicated by the fact that in the 1959-70 Annual Survey of Industries data, output of states with only one firm in a given industry is not reported. Whenever our state and/or industry concordances require us to incorporate a missing observation between 1959 and 1970 into a wider state-industry cell, we assume that the missing output observation is equal to zero.

Notably, the share of zeroes and missing values in the resulting dataset is quite large: 30% of 3234 possible nonzero observations. This is due to the inclusion of states with relatively small manufacturing sectors (such as Assam) as well as relatively unimportant industries (such as 'Manufacture of paints and varnishes'). We thus also create an alternative dataset in which only states and industries with a number of nonzero observations at or above the median (by state and industry, respectively) are kept in the data. This six-state, seven-industry dataset has only a 1.5% share of zeroes and missing values.[12]

We begin the analysis of these datasets by summarizing the broad trends for the two states with integrated steel mills as of 1950, Bihar and West Bengal, as compared to all other states in the data. To do so, we first chart the share of Bihar and West Bengal in the total India-wide output of the engineering industry over time, as well as the evolution of the share of these two states in total output across the other thirteen industries in the sample.[13] Figure 3.2 shows that while this region

[12]The states remaining in this sample are Bihar, Bombay, Madras, Punjab, Uttar Pradesh and West Bengal. The industries in this sample are marked with stars in Table 3.6.

[13]Recall that Travancore-Cochin (later Kerala) and Mysore (later Karnataka) are not in the sample and thus not included in 'India-wide output', because they do not enter the Census of Manufactures data until 1954.

produced almost half of engineering output by value at the beginning of the sample (mainly due to the contribution of West Bengal), its share had dropped to just over 20% by 1970. This trend coincided with convergence of the two states' share of output in engineering and their share of the total output of other manufacturing industries, suggesting that the region's comparative advantage in the engineering industry relative to other Indian states fell sharply during this time. The figure also provides suggestive visual evidence that the beginning of the gradual decline of the share of engineering output in the region coincided with the imposition of the Freight Equalization Policy in 1956.

Of course, the decline in the importance of Bihar and West Bengal in India's engineering output might be due to the opening of two additional integrated steel mills in other states during this period. Both of these plants began operations in 1959, and like the Bihar and West Bengal plants, were located close to the rich sources of coal and iron ore in Eastern India's 'iron and steel belt': in Rourkela, Orissa and Bhilai, Madhya Pradesh. However, Figure 3.3 shows that when the exercise above is conducted instead with the pooled output of all four of these states, there is little effect on the trends discussed above.

We now directly test the hypothesis that the Freight Equalization Policy led to a shift in the location of the engineering industry within India, using a 'triple-difference' identification strategy. We begin by comparing the output in engineering industries in West Bengal and Bihar relative to other states to output in nonengineering industries in these two states relative to others, before and after the imposition of the Freight Equalization Policy. To do so, we use the following regression specification, where $engineering_i$ is a dummy variable for the engineering industry:

$$\ln output_{ist} = \alpha + \eta engineering_i * steelstate_s * policy_t + \phi_{is} + \psi_{st} + \theta_{it} + \epsilon_{ist} \quad (3.5)$$

The estimated $\hat{\eta}$ from this regression may be found in column (1) of Table 3.7. This is negative (as predicted by the hypothesis that the comparative advantage of Bihar and West Bengal in engineering industries eroded after the Freight Equalization Policy), but the result is not statistically significant; the relevant t statistic is -0.42. Moreover, when the regression is instead conducted using the smaller dataset discussed above, resulting in a much lower proportion of missing values for the dependent variable, the coefficient switches sign (column (2)), while its t statistic remains very small in absolute value (0.26).

We next generalize the triple-difference analysis to a comparison of locations closer to integrated steel mills to those that were farther away. By expanding the 'treated' group beyond West Bengal and Bihar, this strategy takes account of the fact that the 1959 startup of new steel mills outside these states brought other locations nearer to an integrated steel mill.[14] In particular, we estimate the following specification:

$$\ln output_{ist} = \alpha + \zeta engineering_i * dist_{st} * policy_t + \phi_{is} + \psi_{st} + \theta_{it} + \epsilon_{ist} \qquad (3.6)$$

Based on the hypothesis that the comparative disadvantage of being farther from a steel mill grew less important in the location of engineering output after the Freight Equalization Policy, the predicted sign for ζ is positive. Column (3) of Table 3.7, which displays the estimate for $\hat{\zeta}$ using the full sample, confirms that this estimate is of the correct sign. However, it is again statistically insignificant, and switches sign and remains insignificant when the narrower sample is used instead, as shown in column (4).

3.4 Conclusion

This chapter has sought to provide evidence about whether access to raw materials is an important determinant of the pattern of industrial development across locations. We have investigated the effects of India's Freight Equalization Policy, which was designed to equalize prices of steel and other key raw materials across Indian states. According to the results of the previous section, the evidence that this policy affected the spatial distribution of steel-intensive downstream industries is weak. While a decline in the share of the steel-producing region in India-wide output of the engineering industry appears to have begun at the same time as the policy's imposition, a triple-difference regression analysis across states, industries and time provides no indication that this relationship is causal.

However, this might be because the policy itself did not have a significant impact on access to steel across India. We have shown evidence that before the 1956 adoption of the Freight Equalization Policy, the iron and steel input prices facing

[14]Table 3.1 displays a comparison of these distances by state in 1950 and 1970.

downstream firms increased with their distance to the nearest integrated steel mill. But in the first three years after the policy took effect, these differences appear to have been only partly offset. Also, the elasticity of interstate trade in iron and steel to the distance between importer and exporter does not seem to have declined appreciably after the policy was imposed.

Although the results above do not yet provide significant insights into the effect of access to raw materials on industrial location in India, a promising way forward for research on the Freight Equalization Policy could be the closer examination of trends associated with specific steel product categories. We have found evidence that the policy had an impact on certain steel products exclusively produced by Eastern India's large integrated steel mills, as the positive relationship between prices of steel plates and sheets and distance from these steel mills was almost eliminated after the policy's introduction. The analysis of output data on downstream firms intensively using these specific products, and/or data on their internal trade, might reveal further insights about the impact of the Freight Equalization Policy on the pattern of India's industrial development.

3.A Figures

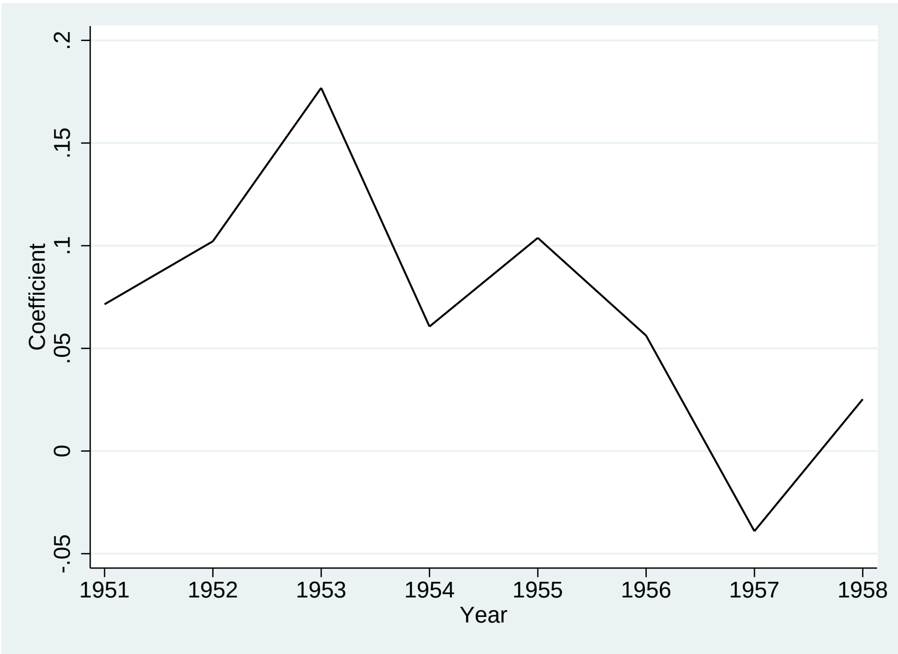


Figure 3.1: Coefficients from regressions of unit values of steel plates, sheets and strips on distance from nearest integrated steel mill, 1951 to 1958

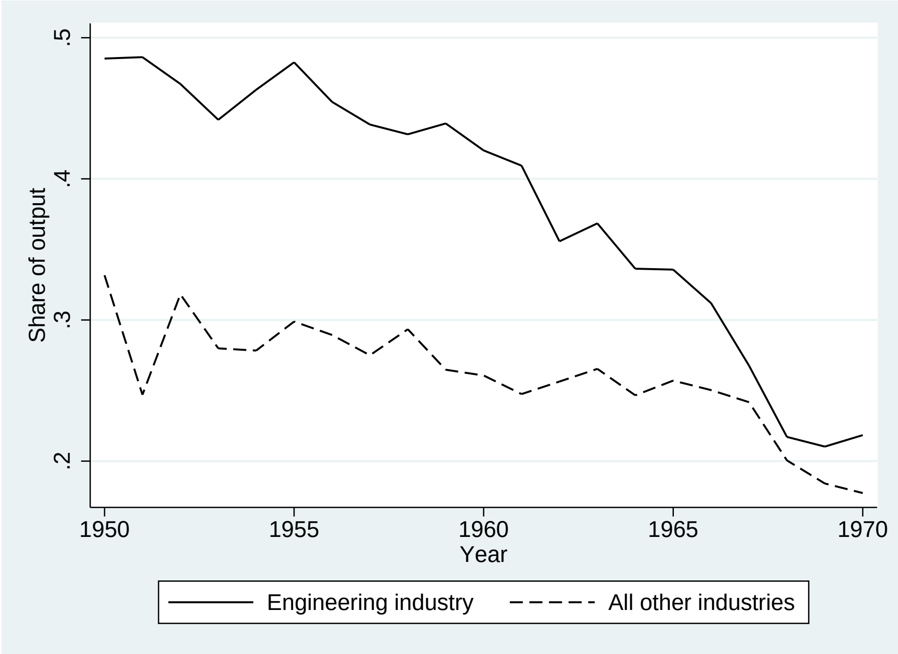


Figure 3.2: Share of Bihar and West Bengal in engineering and other manufacturing output, 1950 to 1970

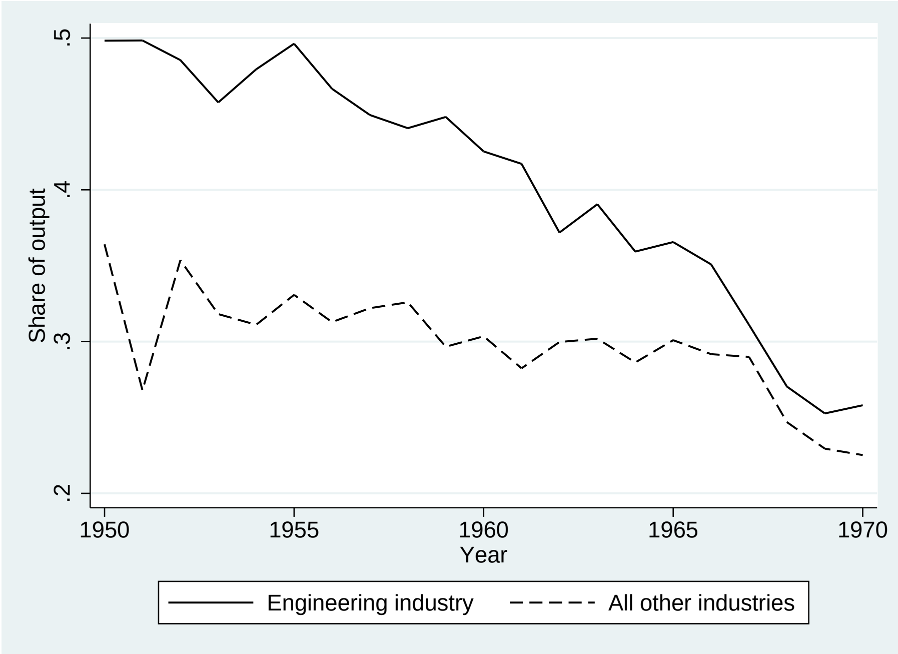


Figure 3.3: Share of Bihar, Madhya Pradesh, Orissa and West Bengal in engineering and other manufacturing output, 1950 to 1970

3.B Tables

Table 3.1: Distances of states from nearest steel mills

State	City	(1) 1950 distance	(2) 1970 distance
Assam	Shillong	543.3	515.4
Bihar	Patna	283.5	283.5
Bombay	Bombay	1449.7	921.1
Delhi	Delhi	1109.1	928.6
Madhya Pradesh	Jabalpur	642.5	264.6
Madras	Madras	1254.2	911.9
Orissa	Cuttack	263.0	224.3
Punjab	Amritsar	1481.8	1330.2
Rajasthan	Jaipur	1144.8	851.4
Uttar Pradesh	Kanpur	735.8	596.8
West Bengal	Calcutta	190.4	148.1

This table shows the distance in kilometers between the largest city in each state as of 1950 and the nearest integrated steel mill in 1950 and 1970. Steel mills in 1950 were located in Jamshedpur, Bihar and Burnpur, West Bengal. Additional steel mills in 1970 were in Durgapur, West Bengal; Rourkela, Orissa; and Bhilai, Madhya Pradesh. Data on city size is from the Census of India, 1951. Because the largest city in Madhya Pradesh in 1951 (Nagpur) was absorbed into Maharashtra as of 1956, the state's second largest city in 1951 (Jabalpur) is used instead.

Table 3.2: Unit values of inputs to engineering industry

Dependent variable:	Unit value				
Sample:	Iron and steel products		Other metal products		All metal products
	(1)	(2)	(3)	(4)	(5)
Distance to steel mill	0.048**		-0.007		
	(0.020)		(0.006)		
Distance * period of policy	-0.015	-0.018	0.013*	0.009	
	(0.021)	(0.022)	(0.007)	(0.008)	
Distance * period of policy * steel					-0.024
					(0.023)
Product-year FE	YES	YES	YES	YES	YES
Product-state FE	NO	YES	NO	YES	YES
State-year FE	NO	NO	NO	NO	YES
Observations	671	671	974	974	1645
Clusters	96	96	142	142	238
R^2	0.84	0.92	0.86	0.91	0.95

This table displays the results of regressions relating unit values of inputs to the engineering industry (in Rs/ton) to distance to the nearest integrated steel mill (in km). The unit of observation is a product-state-year. The sample in columns (1) and (2) includes all iron and steel products, in columns (3) and (4) all other metal products, and in column (5) all metal products. All regressions are estimated using ordinary least squares. Robust standard errors (in round brackets) are clustered at the product-state level. Small p-values are represented by *** (less than 1%), ** (less than 5%) or * (less than 10%).

Table 3.3: Unit values of inputs to engineering industry by specific product

Dependent variable:	Unit value					
Sample:	Steel plates, sheets and strips		Steel bars and rods		Other metal circles, plates, sheets and strips	
	(1)	(2)	(3)	(4)	(5)	(6)
Distance to steel mill	0.103***		0.087***		-0.001	
	(0.027)		(0.026)		(0.008)	
Distance * period of policy	-0.089*	-0.089**	0.006	0.010	0.001	-0.002
	(0.049)	(0.036)	(0.053)	(0.033)	(0.013)	(0.011)
Year FE	YES	YES	YES	YES	NO	NO
State FE	NO	YES	NO	YES	NO	NO
Product-year FE	NO	NO	NO	NO	YES	YES
Product-state FE	NO	NO	NO	NO	NO	YES
Observations	88	88	86	86	232	232
R^2	0.60	0.85	0.49	0.85	0.41	0.62

This table displays the results of regressions relating unit values of inputs to the engineering industry (in Rs/ton) to distance to the nearest integrated steel mill (in km). The unit of observation is a state-year in columns (1) to (4) and a product-state-year in columns (5) and (6). The sample in columns (1) and (2) includes the steel plates, sheets and strips product category only, in columns (3) and (4) the steel bars and rods product category only, and in column (5) the circles, plates, sheets and strips category for metals other than iron and steel. All regressions are estimated using ordinary least squares. Robust standard errors are in round brackets. Small p-values are represented by *** (less than 1%), ** (less than 5%) or * (less than 10%).

Table 3.4: Distance elasticity of interstate iron and steel trade

	(1)	(2)	(3)	(4)
Panel A: OLS				
Log distance	-2.60***	-2.76***		
	(0.15)	(0.18)		
Log distance * period of policy		0.39**	0.41**	
		(0.17)	(0.17)	
Log distance * period of policy * steel state				-0.32
				(0.26)
Observations	1505	1505	1505	1505
Panel B: Poisson PML				
Log distance	-1.55***	-1.50***		
	(0.14)	(0.16)		
Log distance * period of policy		-0.10	-0.01	
		(0.09)	(0.11)	
Log distance * period of policy * steel state				-0.11
				(0.14)
Observations	1560	1560	1560	1560
Panel C: Gamma PML				
Log distance	-2.50***	-2.57***		
	(0.16)	(0.17)		
Log distance * period of policy		0.18	0.29*	
		(0.16)	(0.16)	
Log distance * period of policy * steel state				-0.17
				(0.28)
Observations	1560	1560	1560	1560
Exporter-year FE	YES	YES	YES	YES
Importer-year FE	YES	YES	YES	YES
Exporter-importer FE	NO	NO	YES	YES

This table displays the results of regressions relating quantity traded of iron and steel to log distance between states. The unit of observation is an exporter-importer-year. In Panel A, regressions are estimated using ordinary least squares with log quantity as the dependent variable. In Panel B, regressions are estimated using Poisson pseudo-maximum-likelihood estimation with quantity as the dependent variable. In Panel C, regressions are estimated using Gamma pseudo-maximum-likelihood estimation with quantity as the dependent variable. Robust standard errors (in round brackets) are clustered at the exporter-importer level. Small p-values are represented by *** (less than 1%), ** (less than 5%) or * (less than 10%).

Table 3.5: Distance elasticity of other products' interstate trade

	(1)	(2)	(3)	(4)
Product:	Cement	Glass	Pulses	Timber
Panel A: OLS				
Log distance	-4.28***	-2.55***	-2.15***	-3.35***
	(0.37)	(0.20)	(0.25)	(0.25)
Log distance * period of policy	-0.97**	0.52**	0.77**	0.32
	(0.40)	(0.18)	(0.24)	(0.21)
Observations	636	851	811	801
Panel B: Poisson PML				
Log distance	-3.48***	-1.64***	-1.68***	-2.18***
	(0.33)	(0.14)	(0.19)	(0.22)
Log distance * period of policy	-0.33	0.23*	0.54***	0.13
	(0.58)	(0.14)	(0.17)	(0.11)
Observations	936	936	936	936
Panel C: Gamma PML				
Log distance	-8.26***	-2.72***	-2.78***	-3.70***
	(1.00)	(0.24)	(0.26)	(0.29)
Log distance * period of policy	0.61	0.27	1.12***	0.24
	(0.78)	(0.22)	(0.17)	(0.25)
Observations	936	936	936	936
Panel D: Tobit				
Log distance	-8.87***	-3.17***	-3.34***	-4.64***
	(0.56)	(0.21)	(0.34)	(0.31)
Log distance * period of policy	0.13	0.68***	1.03***	0.41
	(0.57)	(0.18)	(0.24)	(0.27)
Observations	936	936	936	936
Exporter-year FE	YES	YES	YES	YES
Importer-year FE	YES	YES	YES	YES
Exporter-importer FE	NO	NO	NO	NO

This table displays the results of regressions relating quantity traded of various products to log distance between states. The unit of observation is an exporter-importer-year. In Panel A, regressions are estimated using ordinary least squares with log quantity as the dependent variable. In Panel B, regressions are estimated using Poisson pseudo-maximum-likelihood estimation with quantity as the dependent variable. In Panel C, regressions are estimated using Gamma pseudo-maximum-likelihood estimation with quantity as the dependent variable. In Panel D, regressions are estimated using the Tobit methodology of Eaton and Kortum (2001) with log quantity as the dependent variable. Robust standard errors (in round brackets) are clustered at the exporter-importer level. Small p-values are represented by *** (less than 1%), ** (less than 5%) or * (less than 10%).

Table 3.6: Industries in output dataset

*Grain milling
Manufacture of bakery products
Fruit and vegetable processing
*Sugar processing
Distilling and brewing
Manufacture of paints and varnishes
Leather tanning
*Manufacture of glass and glass products
*Manufacture of ceramics
Manufacture of paper and paperboard
*Textile manufacturing
*Manufacture of chemical products
Manufacture of non-ferrous basic metals
*General and electrical engineering

This table lists the industries included in the output dataset. Industries marked with a star are also in the version of the dataset designed to minimize zeroes and missing values.

Table 3.7: Output of engineering and other industries

Dependent variable:	Log output			
Sample:	All states and industries	States and industries with few obs missing	All states and industries	States and industries with few obs missing
	(1)	(2)	(3)	(4)
Engineering * period of policy * steel state	-0.13 (0.31)	0.10 (0.37)		
Engineering * period of policy * distance to steel mill			0.0001 (0.0004)	-0.0002 (0.0004)
Industry-year FE	YES	YES	YES	YES
Industry-state FE	YES	YES	YES	YES
State-year FE	YES	YES	YES	YES
Observations	2258	869	2258	869
Clusters	137	42	137	42
R^2	0.95	0.96	0.95	0.96

The dependent variable in all regressions is log output value and the unit of observation is an industry-state-year. Distance to the nearest steel mill is measured in km. The sample in columns (1) and (3) includes the full concorded sample of states and industries, while the sample in columns (2) and (4) includes only states and industries with a number of nonzero observations at or above the median (by state and industry, respectively). All regressions are estimated using ordinary least squares. Robust standard errors (in round brackets) are clustered at the industry-state level. Small p-values are represented by *** (less than 1%), ** (less than 5%) or * (less than 10%).

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