Trade Liberalization with Idiosyncratic Distortions: Theory and Evidence from India

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November 12, 2010

Abstract

We study the effects of a trade liberalization on trade patterns, the skill premium, and welfare in a multi-sector economy with heterogeneous firms, in which firms are potentially subject to size-dependent idiosyncratic distortions, i.e. firm-specific distortions that constrain large/highly productive firms while favoring small ones. We argue that this type of distortions reduces the perceived degree of productivity heterogeneity across firms. We formally show that within-sector heterogeneity is a determinant of comparative advantage, and thus contributes to shaping the pattern of specialization and relative factor prices. We then explore a quantitative application using India’s 1991 trade liberalization episode. India’s economy was opened up for trade without completely removing the numerous micro distortions in the manufacturing sector. A calibrated model with idiosyncratic distortions inferred from firm-level data is successful in reproducing several key facts of India’s development path, namely reversal of endowment-based comparative advantage trade patterns, increased inequality after trade liberalization, and a structural change process that is uniquely driven by services. Finally, our quantitative exercise shows that the welfare costs of idiosyncratic distortions are magnified by trade openness.

*E-mail: giangho@ucla.edu. I am grateful to Lee Ohanian, Ariel Burstein, and especially Francisco Buera, for their invaluable guidance and support throughout this project. I also thank Javier Cravino, Matthias Doepke, Christian Hellwig, Vaidyanathan Venkateswaran, Jonathan Vogel, Mark Wright, and participants in the Macro Seminar at UCLA for many helpful comments. All errors are mine.
1 Introduction

Increasing openness to international trade is a key feature transforming developing economies. However, trade liberalization efforts have produced a wide range of outcomes, not all of which conform to predictions of classical workhorse models of trade.\(^1\) Many scholars and policymakers have argued that existing frictions, such as labor market rigidities, generate distortions in the domestic economy and thus contribute to shaping the outcomes of trade openness. Despite the central importance of the issue for policy and welfare, little attention has been devoted to studying the interaction between trade liberalization and these micro-level distortions.\(^2\) The types of distortions considered have been limited, as are analyses that rigorously quantify them.

This paper integrates firm-level distortions in a standard Heckscher-Ohlin (H-O) model of trade with heterogeneous firms to study the implications of trade reform in a distorted environment. We build on two important strands of literature, namely the trade literature with firm heterogeneity pioneered by Melitz (2003), and the recent literature emphasizing the role of firm-level distortions (e.g. Baily, Hulten, and Campbell (1992), Restuccia and Rogerson (2008), Hsieh and Klenow (2009), Bartelsman, Haltiwanger, and Scarpetta (2009), etc.). We refer to these distortions as "idiosyncratic," since they potentially vary across individual firms. Specifically, we focus on the interesting and empirically relevant case where distortions are positively correlated with firm productivity, such as those resulting from policies that constrain large firms while favoring small ones.\(^3\) In an experiment with a closed economy, Restuccia and Rogerson (2008) find that this specification of idiosyncratic distortions leads to particularly large losses in aggregate TFP and output. With trade openness, these costs can be magnified, since trade generates reallocation of resources from the least efficient firms to the highly productive firms, who are the primary targets of these distortions. If, in addition, idiosyncratic distortions display some sector-specific pattern, they potentially affect the trade-induced process of resource reallocation towards the economy’s sector of comparative advantage. This may result in unexpected patterns of sectoral specialization or movements of relative factor prices.

India’s trade reform experience offers an empirical case in point. A major trade liberalization effort in the early 1990s was followed by a trade pattern that defies traditional endowment-based comparative advantage, in which India specializes in modern services (e.g. IT, telecommunications, finance and insurance) as opposed to unskilled labor-intensive manufacturing despite being relatively abundant in low-cost labor. Further, inequality has increased after the economy opened up for trade, while per capita income over the two decades after trade reform has not enjoyed a

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\(^1\)See, for example, Rodriguez and Rodrik (2001), Bajona, Gibson, Kehoe, and Ruhl (2010) for discussion of the tenuous empirical and theoretical relationship between trade openness and income growth, and Goldberg and Pavcnik (2007) for evidence on the link between trade and inequality in developing countries.

\(^2\)A few recent exceptions are, for example, Cosar (2010), Cosar, Guner, and Tybout (2010), Helpman and Itskhoki (2007), and Kambourov (2009), who focus on the role of labor market regulations and/or search frictions.

\(^3\)Throughout the paper, we refer to firm size and firm productivity interchangeably, as in models with productivity heterogeneity, more productive firms are monotonically larger.
significant boost to the extent observed in miracle economies such as China or South Korea. These facts do not conform to the predictions of standard economic theory, such as in a classical H-O framework. Perhaps a related phenomenon is the fact that India’s process of structural transformation stands in contrast to that in most developing economies; its industrialization had never fully materialized before the services sector started taking on a prominent role in the composition of output.\(^4\) India therefore presents an ideal case to study the nuances of economic development and trade liberalization by identifying the obstacles that may interact with or hinder this process.

Our emphasis on sector-specific idiosyncratic distortions is particularly relevant for India, who is well-known for having numerous regulations designed to target large firms in manufacturing industries. An apt example is a policy that reserves hundreds of manufactured products to be exclusively produced by small-scale firms, i.e. firms having fixed assets below a certain limit. We argue that the presence of distortions has important implications for the economy’s responses to increased exposure to international trade. To the extent that these distortions are quantitatively significant, they contribute to undermine the ex-ante comparative advantage of the distorted sector, thereby possibly reversing the patterns of specialization and reducing the gains from trade.

We formulate our theory in a standard H-O trade model featuring heterogeneous firms and endogenous entry and selection. Specifically, we consider a multi-sector, multi-factor extension of Melitz (2003); in this respect, the model closely resembles that in Burstein and Vogel (2010b) and Bernard, Redding and Schott (2007). We allow for two exogenous sources of comparative advantage that result from sectoral productivity differences, as in the Ricardian model, and factor endowment differences, as in the Heckscher-Ohlin model. We model idiosyncratic distortions as firm-specific taxes or subsidies on firm revenue, as in Restuccia and Rogerson (2008) and Hsieh and Klenow (2009), who study the impacts of idiosyncratic distortions on aggregate productivity in a closed economy setting. We also allow for the extent of distortions to vary across countries and across sectors within a country. The model offers a simple framework to intuitively analyze the channels through which idiosyncratic distortions interact with exogenous comparative advantage to affect the patterns of trade, as well as inequality via movements of relative factor prices (the skill premium).

We first use the model to theoretically investigate the effects of idiosyncratic distortions. We argue that the presence of idiosyncratic distortions is isomorphic to a reduction in the within-sector productivity heterogeneity across firms, making firms appear more "alike." In other words, with distortions it is as if the distribution of firms were skewed away from the most productive firms and towards the least productive firms. This has important implications for the extent of specialization and the skill premium, since heterogeneity is a determinant of comparative advantage. Specifically, in a simple specification of the model with no entry and no selection into markets (i.e. all firms produce and export), we formally show that lower heterogeneity in any sector is equivalent to a

\(^4\)India’s "service-led growth" has been widely documented, for example, see Kochhar, Kumar, Rajan, and Subramanian (2006), Panagariya (2008), and Mazumdar (2010).
decrease in that sector's Ricardian advantage. Intuitively, competitiveness of a sector is shaped by not only the average firm productivity but also the presence of extremely productive firms in the sectoral distribution. Eaton and Kortum (2002) formulated essentially the same idea, although in a different framework.

Our analysis applies a key insight from Burstein and Vogel (2010b) to think about comparative advantage as interaction of different sources, among which some are exogenous such as factor endowment differences, and some are endogenous, originating from entry and production decisions of heterogeneous firms. We extend their framework to allow for potential cross-sector and cross-country differences in the degree of firm heterogeneity. In our model, the degree of heterogeneity is governed by a parameter of the productivity distribution. We argue that it is instructive to view heterogeneity as a potential source of comparative advantage in addition to the traditional H-O and Ricardian sources, and that studying the implications of heterogeneity is a key step to understanding the main mechanisms through which idiosyncratic distortions affect trade patterns and the skill premium.

We then explore a quantitative analysis of the 1991 trade liberalization episode in India, using the model calibrated to aggregate and micro data from India’s pre- and post-reform periods. To capture the sector-specificity of India’s policy regime, we assume that idiosyncratic distortions apply to the manufacturing sector. We measure the distortions from firm-level data following the approach in Hsieh and Klenow (2009), and use the calibrated model to quantify their effects on trade patterns and inequality as the economy opens up for trade. This experiment suggests that idiosyncratic distortions are quantitatively important. In particular, the model with distortions predicts a reversed comparative advantage pattern of specialization, in which India specializes in modern services instead of manufacturing. It also predicts a rise in the skill premium after trade liberalization. These two features characterize the observed response of India’s economy to the removal of trade barriers. They arise as natural consequences from the interaction between micro distortions and trade reform, and thus are exactly what should be expected to occur in a classical H-O trade model once we allow for the possibility that the domestic economy may not be frictions-free even after barriers to trade have been eliminated.

The reversed specialization pattern has implications for structural change, since in an open economy the between-sector reallocation of resources induced by trade plays an important role in the structural change process. India’s distorted trade patterns thus partially explain the limited industrialization and the premature rise of services compared to economies at similar level of development. Consistent with this prediction, Kochhar et al. (2006) document that India’s abnormally high value added share of services in GDP is a relatively recent phenomenon, occurring around the 1980-2000 period, which coincides with the opening up of the economy for foreign investment and trade. In this respect, the model highlights the importance of understanding structural transformation in the context of an open economy, which has been the focus of work by Buera and Kaboski (2009), Matsuyama (2009), Yi and Zhang (2010), among others.
As mentioned, our focus on idiosyncratic distortions is motivated by the recent large literature that emphasizes the importance of allocative efficiency for aggregate outcomes. This literature builds on the premise that production units are heterogeneous in their productivity, and policies that prevent resources from being allocated to the more efficient producers may have substantial effects on aggregate output and measured TFP. In the context of India, Hsieh and Klenow (2009) find evidence of large misallocation of labor and capital across manufacturing establishments, and that moving to U.S. level of efficiency would improve manufacturing TFP by 40 to 60 percent. In addition, firm-level distortions vary systematically with firm productivity. More productive firms are subject to higher taxes, while less productive firms tend to be subsidized. We capture this empirical relationship by assuming a parametric form for the idiosyncratic distortions, with a parameter governing the correlation between distortions and productivity that can be estimated using firm-level data. In this form, our distortions potentially embody the effects of an array of micro policies, such as financial frictions, labor market regulations, and of course size-dependent policies.

Our calibrated model allows us to precisely quantify each margin of comparative advantage and therefore isolate the effects of idiosyncratic distortions. Specifically, we find that while abundance of unskilled labor gives India’s manufacturing sector an overwhelming Heckscher-Ohlin based comparative advantage, there is a slight Ricardian disadvantage due to lower sectoral TFP compared to tradable services industries. However, it is the presence of idiosyncratic distortions in manufacturing that reverses the patterns of trade. This operates primarily through lowering the perceived heterogeneity across firms in the manufacturing sector, as argued above, but also through the endogenous determinants of comparative advantage such as entry and selection. Our results provide a clear decomposition of these margins, showing that endogenous entry and selection work to magnify the impacts of idiosyncratic distortions. We also show that with endogenous selection, idiosyncratic distortions contribute to shaping the trade elasticity by encouraging entry of marginal exporters (the extensive margin).

Finally, we use the quantitative model to explore the welfare implications of idiosyncratic distortions and to study whether these welfare costs are ameliorated or exacerbated by international trade. First, we find that international trade magnifies the welfare loss from idiosyncratic distortions; in other words, welfare loss is increasing in the openness of the economy. This is because trade shifts more weight to the largest and most productive firms, who are precisely the targets of idiosyncratic distortions. Second, in our model the welfare gain from trade is a non-monotonic function of the extent of distortions; in other words, distortions could reduce or increase the gains from trade, depending on the level of distortions. Our welfare findings highlight the importance of understanding the implications of trade liberalization in an environment with frictions, as well as the implications of distortions in the context of an open economy. The multifaceted interaction between trade and distortions potentially generates interesting effects.

5See Buera, Burstein and Cravino (2010, in progress) for a theoretical analysis of the welfare implications of idiosyncratic distortions in a one-sector framework.
As noted above, our model has predictions for the response of inequality in India, as measured by the skill premium, to trade liberalization. Thus our analysis contributes to the extensive debate on the link between inequality and globalization (see, for example, Goldberg and Pavcnik (2007) for a survey). This debate originates from the overwhelming empirical evidence that inequality in many developing countries has worsened after they opened up for trade. The list of country episodes include post-NAFTA Mexico, most Latin American countries in the 1980s and 1990s, as well as India in the 1990s. These findings contrast predictions of a standard H-O trade model, by which openness should raise the returns of the locally abundant factor, which is unskilled labor in the case of developing economies. Numerous theories have been advanced to explain this contradiction, including skill-biased technological change and outsourcing. Our model offers a distortions-based explanation for the rise in inequality in post-reform India, confirming Goldberg and Pavcnik (2007)’s conclusion that the mechanism via which globalization impacts inequality is likely to be case-specific and depends on the prevailing circumstances of the domestic economy at the time of trade liberalization.

The rest of the paper is organized as follows. The next section documents in more details the key facts of India’s trade liberalization episode that motivate our empirical analysis. Section 3 develops the model. Section 4 examines the relationship between idiosyncratic distortions, heterogeneity, and comparative advantage. Section 5 presents a quantitative experiment of India’s trade reform, where we describe model calibration, discuss our methodology to measure idiosyncratic distortions from firm-level data, and evaluate the model implications for trade patterns, inequality, and welfare. Section 6 concludes.

2 Facts of India’s Trade Liberalization Episode

This section documents the key empirical facts motivating our analysis. We first describe India’s pattern of sectoral specialization and discuss evidence of the change in inequality in the post-liberalization period. Second, we relate trade openness to the process of structural change. Finally, we briefly review the policy environment in India at the time of trade liberalization, and argue that this gives rise to micro distortions which have a particularly large impact in the manufacturing sector.

2.1 Facts

Trade Patterns: Attempts to open up India’s economy started in the early 1980s, particularly in terms of removing non-tariff barriers. For example, the Open General Licensing (OGL) list, which specified products that could be imported without a license, was steadily expanded during the 1980s. Several measures to promote exports were introduced, such as Export Processing Zones (EPZ) and 100% Export Oriented Units (EOU). However, tariffs were actually escalated in the late 1980s. Tariff revenue as percentage of imports rose from 27 percent in 1978 to 62 percent in 1988.
Facing an imminent balance of payment crisis, India initiated a major trade liberalization in 1991. Import licensing ended for all but a few intermediate and capital goods items. The number of products subject to export controls (prohibition, licensing, quantitative ceilings) were reduced from 439 items in 1990 to 296 in 1992, and the process continued subsequently. The most significant reform area was tariff reduction. The average tariff rate on industrial goods went from 125 percent in 1990-91 down to 71 percent in 1993-94, and further to 18 percent by 2005-06.

Figure 1 plots a measure of openness (exports plus imports share in GDP) together with per capita income relative to U.S. level. The vertical line indicates the reform date (1991). Consistent with the dramatic reduction in tariffs and non-tariff barriers, aggregate trade share in GDP increased substantially from 17 percent in 1990 to over 45 percent in 2006. Sectoral trade shares, although not shown here, display similar upward trends over the same period, with the shares of manufacturing and services trade going from 7.8 to 17.3 percent and 3.3 to 15.1 percent of GDP, respectively. However, Figure 1 shows that trade openness has not been accompanied by a commensurable improvement in relative income for India.

Figure 2 shows the pattern of sectoral specialization after trade liberalization. Clearly, India is not following the path led by development miracles such as China, South Korea and Taiwan, whose post-reform growth was largely driven by exports of low-skilled manufactured products. Instead, India has been specializing in modern services (e.g. software and telecommunications services, banking, finance and insurance), which are relatively more skill-intensive compared to traditional manufacturing. The gap between its manufacturing trade deficit and services surplus has widened after liberalization and especially after 2000, mainly due to a massive jump in software exports, which in 2005 account for roughly 36.5 percent of total services exports.

Inequality: In contrast to predictions of conventional factor proportion trade theory, the empirical trade literature has found overwhelming evidence that increasing exposure to international trade in unskilled labor-abundant developing countries coincides with the worsening of various measures of inequality (see, e.g., Goldberg and Pavcnik (2007) for a survey). On this front India is no exception. For example, Kijima (2006) uses household survey data and finds that wage income inequality, as measured by the gap between the 10th and 90th percentile of the wage distribution, increased by 15.4 percent between 1993 and 1999, mainly due to increased returns to skill. A consumption-based measure of inequality is found to move in the same direction as wage inequality (Goldberg and Pavcnik (2007)).

Structural Change: Like its sectoral specialization pattern, India’s pattern of structural change exhibits features that are remarkably different compared to a typical economy at similar level of

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6 Data on services trade come from the (net) non-factor services component of the balance of payments, reported by the Reserve Bank of India. Non-factor services consist of travel, transportation, insurance, government not included elsewhere, and miscellaneous services. The last category includes softwares, technology and business related services, technicians’ and professional fees, management and agency services, etc.
development. Figure 3 shows the evolution of value added shares in GDP of agriculture, manufacturing, and services between 1960 and 2008. The share of manufacturing has remained at a relatively low level of around 15-16 percent since 1960, while the declining share of agricultural activities has been almost entirely mirrored by a boom in services. Buera and Kaboski (2008), using a sample of 30 major countries at various levels of development, estimate that the share of manufacturing tends to exhibit a humped shape over development, and the average share at peak is around 40 percent. By this measure, India’s industrialization has not progressed to the full extent witnessed in other countries, and instead the services sector has played a more prominent role in the sectoral reallocation process. 

Further, several scholars have documented that the rise of services in India is a relatively recent phenomenon, occurring around 1980 onwards. This period coincides with the opening up of India’s economy for foreign investment and trade. In fact, during this period traded services industries have experienced significantly higher growth rates compared to services with low tradability such as retail, health and education. This motivates us to examine the role of international trade in driving structural transformation. Explanation of structural change based on open economy, in addition to the traditional theories of non-homothetic preferences and biased productivity growth, has been motivated by, for example, Matsuyama (2009) and Buera and Kaboski (2009).

2.2 Policies and Micro Distortions

This subsection gives a brief overview of the policy environment circa 1991 - the context against which trade reform was introduced. Three major and long-standing industrial policies characterize the regulatory framework in India, namely small-scale industries reservation, industrial licensing, and labor regulations as specified by the Industrial Disputes Act. We review each of these policy measures and the extent to which they were reformed at the time of trade liberalization.

By the small-scale industries (SSI) reservation policy introduced in 1967, the government created a list of manufacturing products that would henceforth be reserved for production exclusively by

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7 In terms of employment, although annual data are not complete, examination of sectoral labor shares from various India Economic Censuses confirms the pattern for value added shares. Specifically, manufacturing share of employment declined from 30.1 to 25.3 percent between 1990 and 2005, while employment share of the services sector went from 57 to 63.4 percent during the same period.

8 For example, Kochhar et al. (2006), based on analysis of a large sample of countries, find that between 1981 and 2000 India records an increase in the size of the services sector that is 10 percentage points in GDP greater than that in the average country, but not before 1980. Consistent with this finding, Panagariya (2008) calculates that the average annual growth rate of India’s services sector has overtaken that of manufacturing for the period 1988-2006 (7.8 vs 6.8 percent).

9 For example, data from the Central Statistics Office (CSO) show that during the 1990s, services industries with leading average annual growth rates were business services (19.8%) communications (13.6%), and banking (12.7%). Nontradable services grow at a much lower rate (e.g. storage 2%, personal services 5%, public administration and defense 6%, etc.).

10 Panagariya (2008) provides an excellent comprehensive discussion of the four major growth phases of Indian economy and the economic policies associated with each phase.
small-scale units. Small-scale units were originally defined as undertakings with investment of 0.75 million rupees (approx. US$17,000) or less in plant and machinery. The asset threshold was revised over time, and in 1990 stood at Rs. 6 million (approx. US$136,000). Once an item was placed on the reserved list, no new medium or large enterprises were permitted to enter, and the production capacity of the existing medium or large firms were frozen. According to Mohan (2006), the bulk of reserved items were labor-intensive products such as clothing, knitted textiles, toys, and leather products. The reserved list quickly expanded from 47 items at the beginning to 504 in 1978, and peaked at 836 items in 1994. It was not until 1997 that "de-reservation," i.e. freeing items off the list, started and gradually proceeded. By 2005, around 500 products remained reserved for small-scale production.

By the licensing regulations, established under the 1951 Industries Development and Regulation Act (IDRA), firms in the registered manufacturing sector\(^\text{11}\) were required to obtain an industrial license to "establish a new factory, significantly expand capacity, start a new product line, or change location." Originally, investments in fixed assets of less than Rs. 10 million (approx. US$226,000) were exempted from licensing, but the asset threshold for exemption changed over time. This threshold clearly creates the differential impact of the licensing policy on firms of different sizes. For example, Sharma (2006) document that the average size of firms exempted from licensing is 220 employees, while non-exempt firms average over 1,800 employees. Some piecemeal attempts at "de-licensing" were carried out in the late 1970s, with the major waves occurring in 1985 and 1991. However, eighteen 3-digit sectors (or 16 percent of manufacturing output) remained subject to licensing regulations in the post-1991 period.

The 1947 Industrial Disputes Act regulates issues related to labor disputes such as worker layoff and retrenchment, strikes and lock-outs, etc. By the 1976 Amendment, establishments employing 300 workers or more were required to seek permission from the state government for worker dismissal or plant closure. In 1982, the employment threshold is further reduced to 100 workers, making it more restrictive. Government permission is rarely granted, making it almost impossible for large firms to fire workers. Unlike with other regulations, little attempt was made to reform the labor laws to date.

Thus, India liberalized trade amidst an environment in which numerous policies imposed restrictions on a wide range of industrial activities. The above discussion makes clear that these restrictions apply more severely to larger firms, either through precluding them entirely from the production of certain products or defining investment or employment thresholds over which regulations kick in. Importantly, these regulations have asymmetric impacts across sectors of the economy. For example, SSI reservation and licensing only apply to the manufacturing sector. Labor laws do not apply to workers in administrative and managerial capacity or those earning above certain wages, and therefore also put less burden on tradable services industries, which are likely

\(^\text{11}\)Firms in India are required to register if they either (i) use power and employ more than ten workers, or (ii) don’t use power and employ more than twenty workers.
more skill-intensive.\textsuperscript{12} Moreover, many of the tradable services industries are newly-developed industries, and as a result are not subject to the old regulations.\textsuperscript{13}

Our quantitative exercise attempts to quantify the effects of these restrictive policies by relating them directly to the extent of idiosyncratic distortions measured from manufacturing firm-level data. Our finding that substantial distortions are present in the manufacturing sector after trade liberalization is consistent with evidence from Hsieh and Klenow (2009) that resource misallocation in India’s manufacturing did not improve between 1987 and 1994. In the same spirit, Bollard, Klenow, and Sharma (2010) find that resource reallocation played a minor role in explaining the post-reform increase in manufacturing TFP. We return to this subject in section 5.

3 Model

In this section, we develop a simple framework to study trade liberalization in an environment where firms are subject to sector-specific idiosyncratic distortions. We consider a standard trade model with heterogeneous firms and endogenous entry and production decisions a la Melitz (2003), extended to the case of multiple sectors and multiple factors. In this respect, the model resembles that used in Burstein and Vogel (2010b) and Bernard, Redding, and Schott (2007). We then incorporate idiosyncratic distortions, modeled as firm-specific taxes or subsidies on revenue. We describe the model economy in details below.

The model economy features two countries, denoted by Home and Foreign. Country $i$ ($i = H, F$) is endowed with $L_i$ and $S_i$ aggregate units of unskilled and skilled labor, respectively, which are the only two factors of production. The factors are perfectly mobile across sectors within a country, but not across countries.

3.1 The final good

Country $i$ produces a non-traded final good $Q_i$ by combining three types of intermediate goods via a Cobb-Douglas aggregator that is identical across countries:

$$Q_i = \prod_{j=1,2,3} Q_i(j)^{\alpha_j}$$  \hspace{1cm} (1)

where $\sum_j \alpha_j = 1$. Sectors 1 and 2 produce tradable and differentiated goods, while sector 3’s good is homogeneous and non-traded. We include a nontradable sector to account for the relatively high share of non-traded services industries in many countries. The tradable intermediate good $Q_i(j)$

\textsuperscript{12}Moreover, an important component of the labor laws is a firing cost in the form of a fixed per-employee payment, which likely has disproportionately large effects on manufacturing firms since they tend to operate on larger scale.

\textsuperscript{13}For example, the share in GDP of the banking industry - an important component of services trade - was a mere 1.9 percent in 1980. Due to double-digit average annual growth rate during the 1990s, its share has more than tripled to 6.3 percent of GDP by 2000.
\((j = 1, 2)\) is a CES aggregate of different varieties, indexed by \(\omega \in \Omega_i(j)\):

\[
Q_i(j) = \left( \int_{\omega \in \Omega_i(j)} q_i(\omega, j) \frac{\sigma - 1}{\sigma} d\omega \right)^{\frac{\sigma}{\sigma - 1}}
\]

Here, \(\sigma > 1\) is the elasticity of substitution between varieties within a sector. If variety \(q_i(\omega, j)\) charges a price \(p_i(\omega, j)\), then the sectoral price index is \(P_i(j) = \left( \int_{\omega \in \Omega_i(j)} p_i(\omega, j)^{1-\sigma} d\omega \right)^{\frac{1}{1-\sigma}}\). Aggregate price index in country \(i\) is \(P_i = \prod_{j=1,2,3} P_i(j)^{\alpha_j}\).

### 3.2 Intermediate goods

We start by describing production, entry and exit decisions of firms in the tradable sectors. Thus, \(j \in \{1, 2\}\) until otherwise noted. In each tradable sector there is a continuum of firms, each producing a unique variety. Firms are heterogeneous in productivity \(z \geq 1\). A sector \(j\) firm from country \(i\) with productivity \(z\) uses a constant returns to scale Cobb-Douglas technology:

\[
y_i(z, j) = z A_i(j) l^{\beta_j} s^{1-\beta_j}
\]

where \(l\) and \(s\) are the employed units of unskilled and skilled labor, respectively, \(\beta_j \in (0, 1)\) denotes the unskilled labor intensity of production in sector \(j\), and \(A_i(j)\) denotes sector \(j\)'s exogenous total factor productivity (TFP), which is also country-specific.

Firms from country \(i\) also face a fixed cost \(f_{in} \geq 0\) of selling in country/market \(n\) \((n = i, -i)\). Production of fixed costs use the two types of labor in the same intensity as the variable production. In addition, there is an iceberg transportation cost \(\phi_{in}(j) \geq 1\), such that firms from country \(i\) and sector \(j\) must ship \(\phi_{in}(j)q\) units of goods for \(q\) units to arrive in country \(n\). We assume \(\phi_{in}(j) = 1\) \(\forall j\), meaning there is no iceberg cost to ship goods domestically. In order to supply \(q > 0\) units of goods to market \(n\), a sector \(j\) firm with productivity \(z\) from country \(i\) incurs a cost:

\[
C_{in}(q) = v_i(j) \left( q\phi_{in}(j) + f_{in} \right)
\]

Here, \(v_i(j)\) denotes the cost of the sectoral composite input bundle:

\[
v_i(j) = \frac{w_{L,i}^{\beta_j} w_{S,i}^{1-\beta_j}}{A_i(j) \beta_j^{\beta_j} (1 - \beta_j)^{1-\beta_j}}
\]

where \(w_L\) and \(w_S\) denote the wages of unskilled and skilled labor, respectively. Here we see two potential sources of exogenous comparative advantage. In particular, relative input cost in sector \(j\) in a country is determined by both the interaction between factor endowments, which determine wages, and factor intensity \(\beta_j\) (Heckscher-Ohlin comparative advantage), and relative sectoral TFP \(A_i(j)\) (Ricardian comparative advantage).

Intermediate goods firms are potentially subject to idiosyncratic distortions \(\tau_i(z, j)\), which assume the form of an abstract tax or subsidy on firm revenue \((\tau_i(z, j) < 1\) if a tax, and \(\tau_i(z, j) > 1\) if a subsidy).
if a subsidy). In other words, with distortions firms can keep only a fraction $\tau_i(z, j)$ of their revenue. These distortions are potentially country-, sector-, as well as firm-specific. The profit function for a sector $j$ firm in country $i$ with productivity $z$ who sells in market $n$ is:

$$\pi_{in}(z, j) = \tau_i(z, j)p_{in}(z, j)q_{in}(z, j) - C_{in}(q_{in}(z, j))$$  \hspace{1cm} (6)

Note that we do not consider the case where distortions are market-specific (e.g. an export tax/subsidy).

Profit maximization implies that the firm charges a constant markup over its marginal cost, which with distortions is a function of the firm’s after-tax productivity:

$$p_{in}(z, j) = \frac{\sigma}{\sigma - 1} \frac{v_i(j)\phi_{in}(j)}{z\tau_i(z, j)}$$  \hspace{1cm} (7)

Final good producers in market $n$ demand $q_{in}(z, j) = D_n(j)p_{in}(z, j)^{-\sigma}$, where $D_n(j) \equiv \alpha_j Q_n P_n P_n(j)^{\sigma - 1}$. Given price and quantity, a firm’s market-specific revenue is:

$$r_{in}(z, j) = \tau_i(z, j)D_n(j) \left[ \frac{\sigma}{\sigma - 1} \frac{v_i(j)\phi_{in}(j)}{z\tau_i(z, j)} \right]^{1-\sigma}$$  \hspace{1cm} (8)

and its profit net of fixed cost is:

$$\pi_{in}(z, j) = \frac{r_{in}(z, j)}{\sigma} - v_i(j)f_{in}$$  \hspace{1cm} (9)

With Cobb-Douglas technology, firms hire unskilled and skilled labor as variable inputs according to:

$$l_{in}(z, j) = \frac{\sigma - 1}{\sigma} \beta_j \frac{r_{in}(z, j)}{w_{L,i}}$$  \hspace{1cm} (10)

$$s_{in}(z, j) = \frac{\sigma - 1}{\sigma} (1 - \beta_j) \frac{r_{in}(z, j)}{w_{S,i}}$$  \hspace{1cm} (11)

where $r_{in}(z, j)$ is given by (8). Thus, idiosyncratic distortions distort both pricing and employment decisions of firms.

**Entry and Selection:** In each tradable sector in each country, there is an unbounded mass of ex-ante identical potential entrants. To enter a sector, a firm must pay a fixed entry cost $f_e > 0$ in unit of the sectoral composite input bundle. That is, startup cost in sector $j$ in country $i$ equals $v_i(j)f_e$. After entry, firms draw their productivity $z \geq 1$ from a Pareto distribution that can potentially vary across sectors and/or countries: $G_{ij}(z) = \Pr(Z \leq z) = 1 - z^{-c_{ij}}$. Here, $c_{ij}$ is the parameter determining the shape of the productivity distribution, or the degree of technological heterogeneity across firms in sector $j$ in country $i$. As in the literature, we assume that $c_{ij} > \sigma - 1 \forall i, j$ so that the productivity distribution has a finite variance.
A firm drawing productivity $z$ chooses to supply market $n$ if its variable profit at least covers the fixed cost of accessing the market, that is, $\pi_{in}(z, j) \geq 0$ or equivalently, $r_{in}(z, j) \geq \sigma v_i(j) f_{in}$. There is a productivity threshold $z_{in}^*(j)$, defined by the zero-profit condition, below which firms in sector $j$ in country $i$ do not sell in market $n$:

$$r_{in}(z_{in}^*(j), j) = \sigma v_i(j) f_{in}$$  \hfill (12)

Firms face an exogenous probability of death $\delta > 0$ each period. The number of active firms each period, $M_{in}(j)$, is determined by the number of firms surviving from last period, plus the fraction of new entrants who are productive enough to enter production. In a steady state equilibrium, we have:

$$\delta M_{in}(j) = \left[1 - G_{ij}(z_{in}^*(j))\right] K_i(j)$$  \hfill (13)

where $K_i(j)$ denote the mass of firms that enter sector $j$ in country $i$. This means that the number of new successful entrants in steady state is exactly enough to offset those who die exogenously.

If $K_i(j)$ is positive, then the free entry condition, for all $j \in \{1, 2\}$, is given by:

$$\frac{1}{\delta} \int_{z_{in}^*(j)}^{\infty} \pi_{in}(z, j) dG_{ij}(z) = v_i(j) f_e$$  \hfill (14)

This condition states that firms enter until the entry cost equals the expected value of entry, which is the expected lifetime profitability conditional on successful entry summed over all markets.

**Sector Price Index:** We can now rewrite the sector price index in market $n$ as:

$$P_n(j) = \left[\sum_i \frac{1}{\delta} K_i(j) \int_{z_{in}^*(j)}^{\infty} p_{in}(z, j) dG_{ij}(z)\right]^{\frac{1}{1-\sigma}}$$  \hfill (15)

**Nontradable Good:** The nontradable intermediate good is supplied by competitive firms, who hire unskilled and skilled labor, produce using a constant returns to scale technology with zero fixed cost, and face no distortions. Thus, for $j = 3$:

$$Q_i(j) = A_i(j) l^{\beta_j} s^{1-\beta_j}$$  \hfill (16)

**Labor Market Clearing:** Labor demand in this economy comes from production and entry activities of tradable firms, as well as from the nontradable sector. With Cobb-Douglas production function and the fact that variable production, fixed cost and entry use the same labor intensity, a constant share $\beta_j$ of sector $j$’s total cost is paid to unskilled labor, and a share $1 - \beta_j$ to skilled labor. Market clearing conditions for unskilled and skilled labor in country $i$, respectively, are given by:

$$w_{L,i} L_i = \sum_{j=1,2,3} \beta_j R_i(j)$$  \hfill (17)

$$w_{S,i} S_i = \sum_{j=1,2,3} (1 - \beta_j) R_i(j)$$  \hfill (18)
where $R_i(j) \equiv \sum_{n=i,-i} \frac{1}{\delta} K_i(j) \int_{z_n^*(j)}^{\infty} r_{in}(z,j) dG_{ij}(z)$ for $j \in \{1, 2\}$ is the total after-tax revenue of the tradable sectors, which equals total cost since profits are zero with free entry. For the competitive nontradable sector ($j = 3$), $R_i(3) = Q_i(3)P_i(3) = \alpha_3 Q_i P_i$ by the maximization decision of final good producers.

**Trade Balance:** We require that trade balance holds in each country, that is, total expenditure equals total income:

$$Q_i P_i = w_{L,i} L_i + w_{S,i} S_i + T_i$$

(19)

where $T_i$ denotes the lump-sum transfer to households as a result of the taxes/subsidies and is given by:

$$T_i = \sum_{j=1,2} \sum_{n=i,-i} \frac{1}{\delta} K_i(j) \int_{z_n^*(j)}^{\infty} (1 - \tau_i(z,j)) \frac{r_{in}(z,j)}{\tau_i(z,j)} dG_{ij}(z)$$

(20)

### 3.3 Equilibrium

An equilibrium of this model is referenced by the following vector of variables:

$$\{w_{L,i}, w_{S,i}, z_n^*(j), K_i(j), P_i(j), Q_i P_i\}$$

for country $i \in \{H, F\}$, sector $j \in \{1, 2\}$, and market $n \in \{i, -i\}$. All other endogenous variables may be written as functions of these quantities. Wages are determined by the labor market clearing conditions (17) and (18) (note that by Walras’ law one of these equations is redundant). The productivity thresholds are determined by zero-profit condition in (12). The free entry condition (14) is used to solve for the mass of entering firms. Sector price indices are given by expression (15) for each country and each sector, and aggregate income comes from the trade balance condition (19).

### 4 Idiosyncratic Distortions, Heterogeneity, and Responses to A Trade Liberalization

In this section, we first specify a parametric form for the idiosyncratic distortions. We then use a simple version of the quantitative model to investigate the primary channels through which idiosyncratic distortions affect the responses of an economy to a trade liberalization. We focus on the behavior of sectoral specialization and skill premium.

**Idiosyncratic Distortions:** We assume the following parametric form for the idiosyncratic distortions:

$$\tau(z) = b z^{-\theta}$$

(21)
where $\theta \in [0, \frac{\sigma - 1}{\sigma}]$ and $b > 0$. The upper bound $\frac{\sigma - 1}{\sigma}$ for $\theta$ is to ensure that firm revenue and labor demand under distortions are increasing in firm productivity $z$.\textsuperscript{14} Here it is implicitly understood that $b$ and $\theta$ can vary across sectors and/or countries although we suppress sector and country subscripts. This asymmetry allows our model to be flexible in the type of question examined since empirically, distortions tend to result from government policies which are likely country- and sector-specific.

In this specification, the parameter $b$ is a constant shifting all firms’ profitability up or down by the same amount, while $\theta$ governs the extent to which $\tau$ and $z$ are correlated. Specifically, $\theta = 0$ corresponds to the case where distortions are uncorrelated with firm productivity. We focus on the interesting case where $\theta$ takes on positive values, indicating that more productive firms are more heavily taxed while less productive firms tend to be subsidized. Higher $\theta$ increases the "idiosyncraticness" of distortions, spreading out the distribution of $\tau$. Restuccia and Rogerson (2008) consider a case where firm size and idiosyncratic distortions are positively correlated, which is in the same spirit.

An apparent advantage of this functional form of distortions is that, combined with the assumption of Pareto distribution, it facilitates simple closed-form solutions of key equilibrium quantities. A second advantage is that the parameters $b$ and $\theta$ can be easily estimated from firm-level data. Last but not least, this representation of idiosyncratic distortions, albeit over-simplified and abstract, captures various types of real-world frictions. The most obvious example is size-dependent policies, e.g. policies that impose restrictions on large firms at the expense of small firms, as have been studied by Guner, Ventura, and Xu (2008). This is particularly relevant in the case of India, given the policy environment described in section 2.\textsuperscript{15} We discuss in more details the identification of distortions from firm-level data and parameter estimation strategy in the next section.

The analysis below closely follows the approach in Burstein and Vogel (2010b). The main difference with their paper is that we allow for potential differences in the degree of productivity heterogeneity across sectors and/or countries, which is governed by parameter $c_{ij}$. We first study a simple case of the benchmark (frictionless) model and show that heterogeneity is a determinant of comparative advantage. We then derive an intuitive connection between heterogeneity and idiosyncratic distortions and discuss the primary channels through which idiosyncratic distortions affect the economy’s response to a trade reform in terms of specialization and skill premium.

\textsuperscript{14}With this specification of distortions, firm revenue is given by:

$$r_{in}(z, j) = z^{\sigma - \theta \sigma - 1} D_n(j)b^{\sigma} \left[ \frac{\sigma}{\sigma - 1} v_i(j) \phi_{in}(j) \right]^{1-\sigma}$$

so that we need $\theta < \frac{\sigma - 1}{\sigma}$ for $r_{in}(z, j)$ to be increasing in $z$.

\textsuperscript{15}More generally, financial frictions also likely affect productive firms more severely because they are the ones in need of capital to finance expansion (see, for example, Buera, Kaboski, and Shin (2010) and Midrigan and Xu (2010)). Thus, financial frictions can also generate firm-level output distortions that are increasing in firm productivity.
Gravity: Consider a frictionless economy, in which $\theta_{ij} = 0$ and $b_{ij} = 1 \forall i, j$. Assume for convenience that $\alpha_3 = 0$, so that there are only two tradable sectors in the economy. As in Burstein and Vogel (2010b), our analysis builds on a key equilibrium object, namely expenditure share, defined below.

**Definition 1** Sector $j$ expenditure share in market $n$ on goods from country $i$ is denoted by $\Lambda_{in}(j)$ and defined as:

$$
\Lambda_{in}(j) \equiv \frac{K_i(j) \int_{z_{in}^*}^{\infty} r_{in}(z, j) dG_{ij}(z)}{\sum_{k=i,-i} K_k(j) \int_{z_{kn}^*}^{\infty} r_{kn}(z, j) dG_{kj}(z)}
$$

where $r_{in}(z, j)$ is firm revenue given by (8).

The sectoral gravity equation specifies the flow of sector $j$ goods between the two markets:

$$
X_{in}(j) = \Lambda_{in}(j) Q_i(j) P_i(j)
$$

Integrating over the productivity distribution, using the parametric form for distortions specified above, yields:

$$
\Lambda_{in}(j) = \frac{K_i(j) \phi_{in}(j)^{1-\sigma} v_i(j)^{1-\sigma} \phi_{ij}^{\frac{1}{\sigma-1}} z_{in}^*(j)^{\frac{1}{\sigma-1}}}{\sum_{k=i,-i} K_k(j) \phi_{kn}(j)^{1-\sigma} v_k(j)^{1-\sigma} \phi_{kj}^{\frac{1}{\sigma-1}} z_{kn}^*(j)^{\frac{1}{\sigma-1}}}
$$

The productivity thresholds are determined by zero-profit condition (12) and given by:

$$
z_{in}^*(j) = \max \left\{ 1; \left[ \frac{\phi_{in}(j)^{\sigma-1} \phi_{ni}^{\frac{\sigma}{\sigma-1}}}{D_{n}(j)} \right] \right\}^{\frac{1}{\sigma-1}}
$$

where $\lambda_{\sigma} \equiv \sigma (\sigma - 1)^{1-\sigma}$.

**Case of Exogenous Entry and No Selection:** In what follows, we focus on analyzing a simple specification in which entry is exogenous and there is no selection into markets. Specifically, we assume that the mass of entry $K_i(j)$ is exogenous, and without loss of generality identical across sectors, i.e. $K_i(j) = K_i$.\(^{16}\) We also assume that endogenous selection of firms into markets is not active, that is, all fixed costs are zero ($f_{in} = 0 \forall i, n$) so that all firms who pay the entry cost decide to produce and export ($z_{in}^*(j) = 1 \forall i, n, j$). Further, for convenience let variable trade cost be symmetric across sectors and countries, so that $\phi_{in}(j) = \phi_{in} = \phi_{ni}$. Expenditure share in this case is simplified to:

$$
\Lambda_{in}(j) = \frac{K_i \phi_{in}^{1-\sigma} v_i(j)^{1-\sigma} \phi_{ij}^{\frac{1}{\sigma-1}}}{\sum_{k=i,-i} K_k \phi_{kn}^{1-\sigma} v_k(j)^{1-\sigma} \phi_{kj}^{\frac{1}{\sigma-1}}}
$$

\(^{16}\)Although the case of exogenous entry is not strictly a nested special case of the full model, it is useful for intuition, particularly for understanding the entry channel.
It is straightforward to show that the equilibrium in this simple model is characterized by equation (25) plus two labor market clearing conditions determining wages:

\[ w_{L,i}L_i = \frac{1}{2} \sum_j \sum_n \beta_j \Lambda_{in}(j) (w_{L,n}L_n + w_{S,n}S_n) \]  

(26)

\[ w_{S,i}S_i = \frac{1}{2} \sum_j \sum_n (1 - \beta_j) \Lambda_{in}(j) (w_{L,n}L_n + w_{S,n}S_n) \]  

(27)

We define several key objects for the analysis below.

**Definition 2** The trade share in country \( i \) is defined as \( \Delta^i_+ \equiv \Lambda_{-ii}(1) + \Lambda_{-ii}(2) \), for \( i = H, F \).

**Definition 3** The extent of specialization in Home is defined as the difference in import shares between the two sectors \( \Delta_- \equiv \Lambda_{FH}(2) - \Lambda_{FH}(1) \).

**Definition 4** The skill premium in country \( i \) is defined as \( \pi_i \equiv w_{S,i}/w_{L,i} \).

The variable \( \Delta_- \) measures the extent of sectoral specialization in the home country. For a given trade share, higher values of \( \Delta_- \) correspond to the home country specializing more in sector 1. Expenditure shares \( \Lambda_{in}(j) \) shape both the extent of specialization and the skill premium, the latter since conditions (26) and (27) imply that wages are completely pinned down by expenditure shares and exogenous factor endowments.

We now define comparative advantage in this economy.

**Definition 5** The home country has comparative advantage in sector 1 if, in autarky:

\[ \tilde{v}_H(1)/\tilde{v}_H(2) < \tilde{v}_F(1)/\tilde{v}_F(2) \]

(28)

where \( \tilde{v}_i(j) \equiv \frac{v_i(j)}{\mu_i(j)^{1-\sigma}} = \frac{\beta_j w_{L,i} w_{S,i}^{1-\beta_j}}{\Lambda_i(j) \mu_i(j)^{1-\sigma}} \), and \( \mu_i(j) \equiv \frac{c_{ij}}{c_{ij}(\sigma-1)} \).

We term \( \tilde{v}_i(j) \) the "heterogeneity-adjusted" input cost of sector \( j \) in country \( i \), since it is a function of both sectoral input cost \( v_i(j) \) and within-sector heterogeneity \( c_{ij} \). For the discussion below, we assume parameters of the model are such that this condition holds. The following result states that (28) is the necessary and sufficient condition for the home country to specialize in sector 1, i.e. \( \Delta_- > 0 \).

**Proposition 1** Suppose that trade shares are positive \( (\Delta^H_+, \Delta^F_+ > 0) \). The home country is a net exporter in sector 1 \( (\Delta_- > 0) \) if and only if \( \tilde{v}_H(1)/\tilde{v}_H(2) < \tilde{v}_F(1)/\tilde{v}_F(2) \).

**Proof.** See Appendix A  ■

It is immediately clear that heterogeneity plays a role in determining comparative advantage. High values of \( c_{ij} \) (less heterogeneity) reduce \( \mu_i(j) \), the mean of the revenue distribution in sector
and thus is equivalent to a decrease in sectoral productivity $A_i(j)$ in terms of shaping relative input costs. Intuitively, a sector’s comparative advantage depends on not only the average firm productivity but also the presence of extremely productive firms in the sectoral distribution.

We now investigate the effect of heterogeneity on the extent of specialization ($\Delta_-$) and the skill premium in Home ($\pi_H$).

**Definition 6** Home’s relative productivity advantage (or disadvantage) in sector 1 is defined as:

$$a \equiv \frac{\tilde{A}_H(1)}{\tilde{A}_H(2)} \frac{\tilde{A}_F(1)}{\tilde{A}_F(2)}$$

where $\tilde{A}_i(j) \equiv A_i(j) \left[ \frac{c_{ij}}{c_{ij}-(\sigma-1)} \right]^{\frac{1}{\sigma-1}}$.

Thus, $\tilde{A}_i(j)$ is an augmented sectoral productivity that takes into account heterogeneity in addition to sectoral TFP. Without loss of generality, suppose that sector 1 is unskilled labor intensive ($\beta_1 > \beta_2$). Our key result, presented in Proposition 2, relates changes in $a$ to changes in the extent of specialization and skill premium as a response to a trade liberalization.

**Proposition 2** In the specification of the frictionless model with exogenous entry and no selection, the extent of sectoral specialization ($\Delta_-$) and the decrease in the skill premium in Home ($\pi_H$) caused by moving from autarky to fixed values of trade shares $\Delta^H_+, \Delta^F_+ > 0$ is increasing in $a$.

**Proof.** See Appendix A □

Under our assumption that Home has comparative advantage in sector 1, opening up for trade always causes Home to specialize in sector 1 ($\Delta_- > 0$) by Proposition 1. Since sector 1 is unskilled labor intensive, the skill premium decreases as a result of resource reallocation raising the demand for unskilled labor. Proposition 2 is a statement about how the magnitude of $\Delta_-$ and of the decrease in the skill premium depend on the strength of sector 1’s relative productivity advantage, which is determined in part by its degree of heterogeneity.

As an illustration, consider a reduction in the heterogeneity of sector 1 in the home country ($c_{H1}$ increases). This decreases $a$ since $\tilde{A}_H(1)$ is now lower. A reduction in $a$ increases the home country’s cost in sector 1 relative to its cost in sector 2, relative to that in Foreign. This change in relative costs offsets Home’s comparative advantage, inducing Home to specialize less in sector 1 ($\Delta_-$ falls). In order for labor markets to clear, the skill premium must fall by less in the home country.

The analysis above makes it straightforward to study the effects of idiosyncratic distortions, since as we will argue, this particular type of distortions lowers the perceived heterogeneity in the distorted sector. This is intuitive since the distortions hurt more productive firms and favor less productive ones, effectively making firms more alike ex-post.
Idiosyncratic Distortions and Comparative Advantage: In the economy with idiosyncratic distortions ($\theta_{ij} > 0$ for some $i, j$), the expression for expenditure shares in equation (25) becomes:

$$A_{in}(j) = \frac{K_{i} \phi_{in} 1-\sigma \left[ \frac{\beta_{j} w_{L,i}^{\beta_{j}} w_{S,i}^{1-\beta_{j}}}{A_{i}(j) b_{ij}} \right]^{1-\sigma} c_{ij}}{\sum_{k=i,-i} K_{k} \phi_{kn} 1-\sigma \left[ \frac{\beta_{j} w_{L,k}^{\beta_{j}} w_{S,k}^{1-\beta_{j}}}{A_{k}(j) b_{kj}} \right]^{1-\sigma} c_{kj}}$$

(30)

where we have replaced $v_{i}(j) = \frac{w_{L,i}^{\beta_{j}} w_{S,i}^{1-\beta_{j}}}{A_{i}(j)}$. We use equation (30) to discuss the partial equilibrium insight into the working of idiosyncratic distortions, holding fixed factor prices $w_{L,i}, w_{S,i}$.

First, we note that a change in $b_{ij}$ is equivalent to a change in $A_{i}(j)$, intuitively since both parameters shift all firms’ profitability up or down in the same manner. For example, a tax on all firms in the sector ($b_{ij} < 1$) is equivalent to a decrease in sectoral productivity.

We are more interested in the effect of changing $\theta_{ij}$, which governs the extent to which more productive firms are subject to higher taxes, that is, the extent to which distortions are "idiosyncratic." Equation (30) shows that idiosyncratic distortions directly reduce expenditure share by reducing the mean of the revenue distribution: $\mu_{i}(j) = \frac{c_{ij}}{c_{ij} - (1-\theta_{ij})(\sigma-1)}$ is decreasing in $\theta_{ij}$. Alternatively, we note that if $\theta_{ij} > 0$, then before-tax firm revenues follow a Pareto distribution with shape parameter $\frac{c_{ij}}{(1-\theta_{ij})(\sigma-1)}$. Therefore, an increase in $\theta_{ij}$ is equivalent to an increase in $c_{ij}$, or a reduction in heterogeneity, in this partial equilibrium framework.

Given that the implications of heterogeneity for the responses of specialization and skill premium are well understood from the above analysis (Proposition 2), implications of idiosyncratic distortions follow. In particular, idiosyncratic distortions are isomorphic to lowering sectoral productivity, weakening the sector’s perceived comparative advantage. Conceivably, if $\theta_{ij}$ is large enough, perceived comparative advantage can be reversed, leading to reversals in trade patterns and skill premium.

An implication of this analysis is that in the specification with no entry and no selection, changes in $b_{ij}$ and changes in $\theta_{ij}$ are isomorphic, in the sense that both are equivalent to changing sectoral TFP. In the quantitative analysis, we explore the effects of idiosyncratic distortions in the full model allowing for both endogenous entry and selection. We find that these margins magnify the effects of idiosyncratic distortions, while driving a clear distinction between distortions that uniformly apply to all firms ($b_{ij}$) and those that are idiosyncratic ($\theta_{ij}$). We discuss numerical results in more details in the next section.

17 The country- and sector-specificity of distortions make it difficult to characterize the equilibrium with distortions. We numerically solve the general equilibrium model in the next section.
5 Quantitative Analysis

This section presents a quantitative analysis of India’s trade liberalization episode. As documented in section 2, the 1991 reform dramatically reduced tariff rates and eliminated many import and export licensing requirements. In the model, we capture the various forms of tariff and non-tariff trade barriers with a simple variable trade cost (\(\phi\)) for each tradable sector and study a trade liberalization represented by reduction in \(\phi\).

5.1 Calibration

We use the model presented in section 3. The two countries are calibrated to India and the rest of the world. The two tradable sectors (sector 1 and sector 2) correspond to manufacturing and tradable services, respectively, and the nontradable sector (sector 3) corresponds to nontradable services.\(^{18}\) As a general strategy, we calibrate the reduction in the variable trade cost in each tradable sector to match the observed increase in the sectoral trade share (in gross sector output) from pre-reform to post-reform period. We pick other parameters to reproduce several salient features of the Indian economy in the initial steady state. We then compare the responses of the benchmark (frictionless) economy to those of a distorted economy to the trade liberalization.

Comparative advantage in our model is determined by factor endowment \((S_i/L_i)\), sectoral productivities \((A_i(j))\), within-sector productivity heterogeneity \((c_{ij})\), as well as sector-specific idiosyncratic distortions \((b_{ij}, \theta_{ij})\). Our strategy for calibrating these important parameters is as follows. We calibrate countries’ endowment of unskilled and skilled labor using cross-country data on human capital. We cannot separately identify \(A_i(j)\) from \(b_{ij}\), since both parameters shift all firms’ profitability up or down in the same manner. Therefore, we set \(b_{ij} = 1 \forall i, j\) and choose sectoral TFP \(A_i(j)\) to match the pattern of sectoral relative prices across countries. Our results are insensitive to this normalization. As discussed in more details in the next subsection, we assume Home’s tradable services sector as well as both tradable sectors in Foreign are always undistorted, and use firm-level data to infer the extent of distortions in Home’s manufacturing, or the magnitude of \(\theta_{H1}\). Thus, our "benchmark" economy refers to an economy where \(\theta_{ij} = 0 \forall i \in \{H, F\} \text{ and } j \in \{1, 2\}\), whereas the "distorted" economy refers to one where \(\theta_{H1} > 0\) and \(\theta_{H2} = \theta_{F1} = \theta_{F2} = 0\). Given these values of \(\theta_{ij}\), we calibrate \(c_{ij}\) to match the upper tail of the sectoral size distributions across countries.

\(^{18}\)We follow Jensen and Kletzer (2005)’s approach to identify "tradable services" industries. In particular, they use a measure of geographic concentration (locational Gini) of service activities within the United States to identify which service activities are traded domestically, and classify these as potentially tradable internationally. For each 2-digit NAICS sector, they obtain an estimate of employment shares in tradable and nontradable industries. We include a services industry in our calibration if at least half of its labor is employed in the tradable part. Thus the following industries constitute our tradable services sector: wholesale trade, transportation/warehouse, information, finance and insurance, real estate and rental, professional, scientific and technical services, and management. Nontradable services include administrative support, education, health care/social services, arts, entertainment and recreation, accommodation, and public administration.
For simplicity, we assume that variable trade costs and fixed costs are symmetric across the two countries: \( \phi_{in}(j) = \phi_{ni}(j) = \phi_j, \) \( f_{ii} = f_{-i-i} = f, \) \( f_{in} = f_{ni} = f_x \) \( \forall i \in \{H,F\}, n \in \{i,-i\}, \) and \( j \in \{1,2\} \). Shipping goods domestically is costless, so that \( \phi_{ii}(j) = \phi_{-i-i}(j) = 1.19 \)

Tables 1 and 2 present values of the calibrated parameters and the match between data and model objects where applicable. We start with choosing values for \( \phi_j \) and \( \phi'_j \), the pre-reform and post-reform sectoral trade costs, respectively. In World Development Indicators data, India’s manufacturing trade share in sector gross output increased from an average of 8.6 percent for the 1975-80 period to 35.5 percent in 2008, while services trade share increased from 4 to 18.5 percent.20 Matching these trade shares gives us four values of trade costs.21

We normalize total labor supply in the home country \((L_H + S_H)\) to one, and choose the ratio \( S_H / L_H \) to match the relative endowment of skilled labor for India in 1985. Data on skill endowment are taken from the Barro-Lee human capital data sets, with "skilled labor" corresponding to "completion of primary school." We pick the level of unskilled labor supply in the foreign country \((L_F)\) such that GDP of Home relative to Foreign equals 11 percent. This figure corresponds to the income of India relative to a trade-weighted average of its trade partners’ incomes, calculated from the NBER trade database. We follow Burstein and Vogel (2010a) and choose the relative skill endowment of Foreign \((S_F / L_F)\) to match a population-weighted average endowment of skilled labor, defined similarly as above, for India’s trade partners. Our procedure results in \( S_H / L_H = 0.43 \) and \( S_F / L_F = 0.88 \), giving India a large endowment-based comparative advantage in unskilled labor-intensive production (manufacturing).

We normalize the world’s sectoral TFP, \( A_F(j) = 1 \), and calibrate India’s relative sectoral productivities to match the pattern of relative prices reported in the 2005 ICP.22 For example, in the data, the price of India’s manufacturing relative to the world is 24 percent higher than that in tradable services. In our model, this higher relative price translates to lower relative productivity, that is, manufacturing TFP is lower than tradable services TFP by roughly 16 percent. This gives India a Ricardian disadvantage in the manufacturing sector.

We follow Giovanni and Levchenko (2010) in calibrating \( c_{ij} \), the shape parameter of the productivity distribution, which governs the degree of heterogeneity across firms. In particular, the model

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19 Variable trade costs in services may have less to do with shipping physical goods, rather they can be thought of in terms of price/quantity regulations, or the quality of the electrical and communication network.

20 Since data on sectoral gross output are not available for India, we use value added data and make assumptions about the share of intermediate inputs in gross output for each sector. Specifically, we assume input usage is 40% of gross output in services (Gordon and Gupta (2003)’s calculation from I/O matrix), and 77% in manufacturing (Annual Survey of Industries, average 1973-2003).

21 We carry out this procedure separately for the benchmark and distorted economy, so that the increases in sectoral trade shares are identical in the two economies, even though this results in two slightly different sets of trade costs. Table 1 reports the trade costs in the distorted economy.

22 ICP stands for International Comparison Programme of the United Nations, which provides internationally comparable price levels for a number of disaggregated sectors. Note that these are the prices of final consumption, and thus potentially also reflect distribution and retail costs.
implies that the sectoral firm size distribution, where size is measured by either revenue or employment, follows $H_{ij}(x) = \Pr(X \leq x) = 1 - \left(\frac{\zeta_{ij}}{x}\right)^{\eta_{ij}}$, where $\zeta_{ij}$ is some constant and $\eta_{ij} \equiv \frac{c_{ij}}{(1-\theta_{ij})(\sigma-1)}$ is a shape parameter that can be estimated from the data. We obtain an estimate of $\eta_{Hj}$ for $j = 1, 2$ from the empirical size distribution in India’s manufacturing and services sector, respectively, which allows us to back out $c_{Hj}$ given values of $\theta_{Hj}$ and the assumed elasticity $\sigma$. For the foreign country, we calibrate $c_{Fj}$ to Zipf’s law, i.e. a fat-tailed distribution known to characterize the firm size distribution for the United States. Thus, we use the widely-reported value $\eta_{Fj} = 1.06$ for both $j = 1, 2$ (see, e.g., Axtell (2001)).

The next group of parameters govern sectoral technology, and entry and exit decisions of intermediate goods firms: $\beta_j, f, f_x, f_e, \delta$. We calibrate the shares of unskilled labor in production, $\beta_j$ for $j \in \{1, 2, 3\}$, to U.S. industry data, since due to the sector-specific distortions factor shares in India may be distorted. We follow Mankiw, Romer, and Weil (1992) and infer a sector’s unskilled labor share from the average wage and a measure of the unskilled wage, where "unskilled" is defined as "less than 9th grade" in order to be consistent with the definition used in the calibration of factor endowments. Our calibration shows that the tradable services sector is the most skill-intensive ($\beta_2 = 0.44$), and the nontradable services sector is the most unskilled labor intensive ($\beta_3 = 0.9$). Importantly, manufacturing is more unskilled labor-intensive than tradable services ($\beta_1 = 0.59$).

In the model, firm exit rate is governed by two parameters: the exogenous death rate $\delta$ and the fixed production cost $f$, which determines what fraction of firms decides to enter production after paying the entry cost and getting a productivity draw. Since we cannot separately identify these two parameters, we follow Bernard, Redding and Schott (2007) to normalize $\delta = 0.025$ and choose $f$ to match an empirical exit rate for India. We pick the fixed exporting cost $f_x$ such that exporters account for 7 percent of total firms in the pre-reform period. The entry cost $f_e$ is normalized since it would only rescale the mass of active firms in the model.

Finally, we choose sectoral expenditure shares, $\alpha_j$ for $j \in \{1, 2\}$, to match the shares of manufacturing, tradable and nontradable services sector in U.S. gross output in 1990, reported by BEA. We set the elasticity of substitution across varieties $\sigma = 5$, midpoint of the three-to-eight range estimated in the literature (see, e.g., Broda and Weinstein (2006)).

---

23 We calculate the size distributions from India’s 2005 Economic Census.

24 Average wages by sector and the unskilled wage come from the 2002 Census.

25 This is consistent with the pattern documented by Buera and Kaboski (2008), who look at the fraction of college educated workers in services industries and use their income shares as a measure of sectoral skill intensity.

26 It is difficult to have an accurate estimate of exit rate among Indian firms, since the early firm-level surveys, such as the Annual Survey of Industry, do not track individual firms through time. OECD (2007) estimates a low exit rate of three percent using Prowess data; however, this figure is likely an underestimate of the true exit rate since firms in the Prowess database are mostly public or large private companies. We choose $f$ to match an exit rate of five percent, and later do sensitivity check with respect to this parameter.

27 We calculate the fraction of exporters from India’s Annual Survey of Industry, and adjust the figure to take into account the fact that registered manufacturing firms, which are covered in ASI, produce only 63 percent of total manufacturing output, and the rest is produced by unregistered firms who are small and unlikely to export.
5.2 Measuring idiosyncratic distortions

To capture the sector-specificity of India’s policy regime discussed in section 2, we assume that idiosyncratic distortions are present in the manufacturing sector and not in (tradable or nontradable) services. This assumption is partly driven by data availability, since firm-level data are not available for India’s services industries. Our results must therefore be interpreted as the upper bound of the effects of idiosyncratic distortions in manufacturing. However, we later argue that our treatment of distortions in manufacturing is conservative, to the extent that we only model a particular source of variation in firm-level distortions that is positively correlated with firm productivity, and ignore the large amount of measured idiosyncratic distortions that is uncorrelated with productivity.

We follow the approach in Hsieh and Klenow (2009) to identify firm-level output distortions in manufacturing using India’s 2005 Annual Survey of Industry. For each manufacturing plant surveyed, the ASI provides information on its industry (four-digit ISIC), value added, labor compensation, and book value of the fixed capital stock. Assuming a standard model of monopolistic competition with heterogeneous firms and two factors of production (capital and labor), we can calculate the marginal revenue products of capital and labor for each plant. The key insight is that, in the absence of distortions, marginal revenue products should be equalized across plants within a narrowly-defined industry. To the extent that marginal products differ across plants in the data, we can use them to recover a measure of plant-level distortions. In particular, marginal products would be higher in firms facing disincentives (such as government restrictions on size or high transportation costs), and lower in firms that benefit from subsidies.

We use the data on revenue and input uses to calculate a measure of plant productivity. Note that this is physical TFP (as opposed to revenue-based TFP), so although we do not observe each plant’s real output we infer it from revenue and the assumed elasticity of demand. Appendix B describes in more details the computation of plant-level distortions and productivity.

Denote the computed plant-level distortions by $\tau_{si}$ and plant-level productivity by $z_{si}$, where subscript $i$ identifies the plant and subscript $s$ refers to the four-digit sector where the plant belongs. Denote deviations of plant variables from industry-weighted means as:

$$\Delta \tau_{si} = \log \frac{\tau_{si}}{\bar{\tau}_s}$$
$$\Delta z_{si} = \log \frac{z_{si}}{\bar{z}_s}$$

Recall from section 4 that we assume the parametric form $\tau = b z^{-\theta}$ for the distortions. Estimate of the parameter $\theta$ can be obtained from a linear regression of $\Delta \tau_{si}$ on $\Delta z_{si}$ (standard errors are in parentheses):

$$\Delta \tau_{si} = -0.39 - 0.26 \Delta z_{si}, \quad R^2 = 0.24, \quad \text{nobs} = 67,335 \text{ plants}$$

(31)  
(.0018)  (.0023)
This gives $\theta = 0.26$. Figure 4 provides a visual representation of the result. It plots the average log output distortions by percentile of log plant TFP. If distortions were uncorrelated with plant productivity, the graph should be a horizontal line. The fact that the line is negatively sloped indicates that large/more productive firms are more severely constrained.\(^{28}\)

In the quantitative experiment with distortions, we set $\theta = 0.26$ for the manufacturing sector in the home country, and zero for Home’s tradable services and both tradable sectors in the foreign country. Although we are not able to measure any distortions that may be present in the tradable services sector, our approach to quantifying manufacturing distortions is conservative. The above regression indicates that we only capture a relatively small fraction (24 percent) of the total variation in manufacturing firm-level distortions, i.e. the part that is positively correlated with firm productivity. In particular, without trade, our $\theta$ estimate implies a gain in manufacturing TFP of 40 percent as a result of moving to the frictionless benchmark, compared to approximately a 100 percent gain estimated by Hsieh and Klenow (2009) for India.

5.3 Results

For each model economy (benchmark and distorted), we consider a trade liberalization in which variable trade cost in sector $j$ is reduced from $\phi_j$ to $\phi'_j$. The magnitude of the trade liberalization is identical across the two economies in the sense that the resulting increases in sectoral trade shares are the same. Table 3 reports the responses of net exports, skill premium, sectoral reallocation, aggregate productivity, and welfare.

Specialization: It is clear that the distorted economy provides a better description of India’s trade liberalization experience compared to the benchmark. For example, the model with distortions predicts a manufacturing trade deficit of 2.9 percent of GDP in the post-reform period, or roughly 27% of the deficit observed in the data (2008). In contrast, the benchmark model predicts a manufacturing trade surplus of 5.4 percent. The prediction of standard trade theory, that trade openness induces an economy to specialize in the sector of comparative advantage, does not hold in the presence of sector-specific distortions such as what we consider here.

Skill Premium: The Stolper-Samuelson Theorem would suggest that trade liberalization will raise the returns of the factor used more intensively in the comparative advantage sector, which is unskilled labor in the case of India. Consequently, inequality such as measured by the skill premium is expected to go down as a result of trade reform. In contrast to this prediction, wage inequality in India increased by 15.4 percent between 1993 and 1999. We note that this measure of

\(^{28}\)How do we know that our measure of firm-level distortions captures the extent of idiosyncratic policy distortions rather than being a by-product of, for example, measurement errors? Hsieh and Klenow (2009) address some of these concerns by relating their measures of distortions to various policies such as size restriction and licensing in India. Further, we note that if plant TFP is measured with errors, and measurement errors are uncorrelated with true TFP, then our estimate of $\theta$ may be biased downward.
wage inequality (90th/10th percentile ratio) is likely to over-estimate the increase in inequality. For instance, over the period 1963-2005, the increase in U.S. wage inequality as measured by the 90/10 ratio amounts to over 50 percent, while the increase in inequality as measured by the college/high school premium amounts to only 26 percent (see, e.g., Autor, Katz, and Kearney (2008)).

The model with distortions predicts a small increase in the skill premium of 1.5 percent, or one-tenth of the reported increase, as opposed to a decrease of 2.6 percent predicted by the frictionless benchmark. Our model abstracts from features such as skill-biased technological change, which may have contributed to raising the demand for skill. Thus, the predicted 1.5 percent can be thought of as the contribution of sector-specific idiosyncratic distortions to the observed rise in inequality.

The reversed trade patterns and the rise in skill premium predicted by the model with distortions are consistent with our theory and intuition in section 4, that idiosyncratic distortions offset ex ante comparative advantage by reducing the perceived heterogeneity in the distorted sector. In particular, our estimate of idiosyncratic distortions is quantitatively significant in that it is able to induce a perceived comparative advantage that is reversed from the exogenous comparative advantage. We note that, however, exogenous comparative advantage in our model is shaped by the interaction of different sources, reinforcing and counteracting each other. For example, our calibration exercise shows that although India’s manufacturing sector has an overwhelming endowment-based advantage coming from the large relative supply of unskilled labor, there is a Ricardian disadvantage: manufacturing TFP is roughly 16 percent lower than that in tradable services. This Ricardian disadvantage plays a role in the reversal of specialization patterns and the increase in skill premium in the distorted economy. As we will show shortly, endogenous entry and selection also play important roles in reinforcing these effects.

**Sectoral Reallocation:** According to the model with idiosyncratic distortions, output is reallocated from manufacturing into services during the trade reform, whereas the benchmark model predicts that sectoral output shares shift in the opposite direction. For example, in the distorted economy, services (both tradable and nontradable) share in GDP gains 2.3 percentage points between pre-reform and post-reform period, or roughly 24 percent of the gain in the data between 1990 and 2008. This is the contribution of trade openness and its interaction with sector-specific distortions to the observed sectoral reallocation. Buera and Kaboski (2009) show how the two traditional theories of non-homothetic preferences and biased productivity growth have trouble in matching U.S. structural change data. Along this line, our findings highlight the importance of incorporating features such as openness and sector-specific distortions in the study of long-run structural change.

**TFP:** Consistent with Melitz (2003)’s insight that openness shifts resources to high productivity firms and induce low productivity firms to exit, trade liberalization increases aggregate TFP by 4 percent in our benchmark economy. The TFP gain from trade in the distorted economy is smaller at 1.5 percent, since idiosyncratic distortions hinder to an extent the efficient reallocation process.
In the data, the overall TFP gain in India relative to the U.S. between 1990 and 2005 amounts to 6 percent. Thus, the contribution of trade-induced TFP gain in overall TFP gain would have been 2.6-fold higher if there were no distortions.

The welfare gain from trade in this experiment is also smaller in the presence of distortions (1 percent compared to 1.7 percent in the benchmark).

**Endogenous Entry and Selection:** We explore the question whether allowing for endogenous entry and selection mitigates or strengthens our results on the pattern of specialization and the skill premium. Burstein and Vogel (2010b) show that in this framework changes in the mass of active firms in a sector, which come from selection and entry, is an endogenous source of comparative advantage. We find that this endogenous margin interacts with idiosyncratic distortions to magnify the effects on specialization and skill premium.

We summarize the pattern of specialization with the variable $\Delta$. Recall from section 4 that $\Delta$ is the difference between the import share of services and manufacturing. In the model, a positive $\Delta$ means that the country specializes in manufacturing, and vice versa, a negative $\Delta$ means the country specializes in tradable services. Table 4 shows the responses of $\Delta$ and skill premium for three specifications of the model with distortions: (i) the full specification, (ii) specification with no entry, and (iii) specification with no entry and no selection. In (ii), the number of new entrants is fixed across the initial and final trade equilibria. In (iii), the mass of operating firms is fixed, meaning that neither the number of entrants nor the productivity cutoffs, which determine the fraction of surviving firms, were allowed to adjust.

In terms of specialization, the full model with distortions predicts that import share in manufacturing is 4.3 percentage points higher than import share in services, compared to 5.4 percentage points in 2008 data. If there were no adjustment in entry, the figure drops to 3.7 percentage points. If there were neither entry nor selection, the figure drops further to 2.9 percentage points. In terms of the skill premium, the full specification predicts a 1.5 percent increase in the skill premium. The increase is smaller at 1 percent without entry, and 0.7 percent without both entry and selection.

Clearly, allowing for adjustments in the number of firms, either through entry or selection, is important for the model to more closely reproduce the empirical pattern of specialization and skill premium. First, distortions reduce the number of firms entering the manufacturing sector due to lower expected profitability. In the full specification, entry to this sector is 8 percent lower than in the frictionless benchmark. Second, distortions in manufacturing make the services sector become relatively less selective, enabling more services producers to survive and export. Both channels result in a larger ratio of the number of firms in services to that in manufacturing, compared to the benchmark. This mitigates the endowment-based comparative advantage of manufacturing, contributing to reverse the trade patterns and increase the skill premium.
In Figures 5 and 6, we vary aggregate trade share and decompose the changes in specialization ($\Delta_{\text{..}}$) and skill premium into contribution by entry, given by the gap between the solid line and the diamond-marked line, and the cumulative contribution by entry and selection, given by the gap between the solid line and the dotted line. This exercise shows that the magnification effects of entry and selection are monotonic with respect to trade share, and that entry matters more than selection.

**Trade Share:** Idiosyncratic distortions also contribute to shaping the trade elasticity. Figure 7 demonstrates that the elasticity of trade, which is the sum of import and export shares in GDP, is higher in the distorted economy compared to the frictionless benchmark. In other words, a given reduction in variable trade cost increases trade by more in the presence of distortions (dashed line). The diamond-marked line represents the response of trade share in the model with distortions, shutting down the selection channel. It shows that without selection, the trade elasticity becomes lower in the distorted economy compared to the benchmark. Thus, it is the extensive margin - entry of new exporters - that is responsible for the increased trade elasticity.

All of the increase in trade comes from actions in the distorted sector (manufacturing). In particular, there is a larger response from foreign exporters entering the domestic market, since distortions reduce the ability of domestic producers to compete. More surprisingly, there is also a larger influx of domestic producers exporting to the world market. This is due to the lower perceived heterogeneity in manufacturing. With lower heterogeneity, there is a denser mass of firms concentrating around any productivity cutoff. As a result, a given reduction in the export cutoff caused by lowering trade cost will induce a larger mass of new firms coming in.

The increase in trade elasticity arises as a particular consequence of the fact that distortions are idiosyncratic, as opposed to being uniform across all firms in the sector. In other words, this is one of the aspects in which the effect of distorting $\theta_{ij}$ diverges from that of distorting $b_{ij}$.

**Welfare:** We consider two welfare experiments using our calibrated model. In the first experiment (Figure 8), we explore whether the welfare cost of idiosyncratic distortions depends on the degree of openness of the economy. Specifically, we fix distortions at the empirical value for India’s manufacturing ($\theta = 0.26$) and compare the welfare loss from adding distortions to a frictionless economy at varying degrees of initial openness, as measured by aggregate trade share. Figure 8 shows that welfare loss is monotonically higher in a more open economy. For example, at a trade share of 60 percent, the welfare loss from idiosyncratic distortions is 3.5 percentage points higher than in autarky. This is because as the economy is increasingly exposed to trade, more weight is shifted to the largest and most productive firms, who are most affected by idiosyncratic distortions. This quantitative result emphasizes the importance of understanding theoretically the welfare impact of idiosyncratic distortions in an open economy setting. Buera, Burstein, and Cravino (2010) is an example of work in this direction.
In the second experiment (Figure 9), we examine the interaction between idiosyncratic distortions and the welfare gain from trade. We consider the welfare gains from a trade liberalization of the magnitude witnessed in India’s reform episode for economies with different levels of distortions captured by variation in $\theta$. We find that there is a non-monotonic relationship between welfare gain and distortions. In particular, for very small $\theta$, the welfare gain from trade is up to 12 percent higher than in the frictionless benchmark. The welfare gain then decreases as $\theta$ increases, until a range of high enough $\theta$ (larger than roughly 0.45 in this experiment), welfare gain becomes increasing with distortions. This experiment shows that idiosyncratic distortions play an important role in shaping the benefits of opening up an economy for international trade. In the case of India ($\theta = 0.26$), the welfare gain from trade is 40 percent lower than what it would have been if there were no distortions.

6 Concluding Remarks

We developed a framework to study trade liberalization in the presence of sector-specific idiosyncratic distortions. The model incorporates features from two important strands of literature, namely the literature on trade with firm heterogeneity and the recent literature emphasizing the role of firm-level distortions for aggregate outcomes. The first contribution of the paper is to establish an intuitive connection between idiosyncratic distortions and heterogeneity, which facilitates our understanding of trade reform in a distorted environment. Specifically, we show that distortions that are positively correlated with firm productivity reduce the perceived degree of heterogeneity across firms. This has important implications for the response of trade patterns and skill premium to a trade liberalization, since lower heterogeneity mitigates exogenous comparative advantage.

The second contribution of the paper is an empirical analysis of the trade liberalization episode in India, in which we precisely isolate and quantify the effects of distortions on trade and other aggregate outcomes. In particular, we use firm-level data to measure the extent of idiosyncratic distortions in the manufacturing sector, which we argue largely result from a restrictive policy environment that discriminates large firms. We calibrate other parameters of the model to match several key statistics of India’s economy in the pre- and post-reform period. The model with idiosyncratic distortions outperforms the frictionless benchmark in that it is able to predict the reversed comparative advantage pattern of trade and the increase in skill premium, as observed in the data. Consistent with our theory, idiosyncratic distortions alter the perceived comparative advantage. Our analysis indicates that the concept of comparative advantage should be thought of as a complex interaction of various exogenous and endogenous forces, among which is government policies across sectors and across countries.

Our quantitative model also has implications for structural change, aggregate productivity, and welfare. In particular, we find that the welfare loss resulting from idiosyncratic distortions is higher the more open the economy becomes. In addition, for a large range of distortions we also find that the welfare gain from trade is substantially lower (by up to 67 percent) than the welfare gain in
a frictionless economy. Our results highlight the intricate interaction between trade openness and distortions, which remains an interesting open theoretical question. From a policymaker’s point of view, understanding this interaction is the key to structuring domestic and external policies and reforms that would yield the maximum possible welfare improvement.
References


Burstein, A. and J. Vogel (2010b, June). International trade patterns, the skill premium, and heterogeneous firms. UCLA working paper.


Appendix A

**Proof.** (Proposition 1)

Using the expression for expenditure share $\Lambda_{in}(j)$ in equation (25), $\Delta_- = \Lambda_{FH}(2) - \Lambda_{FH}(1) > 0$ if and only if:

$$\frac{\phi_{FH}^{1-\sigma} K_F}{K_H} \left( \frac{\tilde{v}_F(2)}{\tilde{v}_H(2)} \right)^{1-\sigma} > \frac{\phi_{FH}^{1-\sigma} K_F}{K_H} \left( \frac{\tilde{v}_F(1)}{\tilde{v}_H(1)} \right)^{1-\sigma}$$

$$\iff \tilde{v}_H(1)/\tilde{v}_H(2) < \tilde{v}_F(1)/\tilde{v}_F(2)$$

The proof of Proposition 2 requires an intermediate result, which we state in Lemma 1.

**Lemma 1** Consider two equilibria with parameters $\{a, \phi \equiv \phi_{in}/\phi_{ii}\}$ and $\{a', \phi' \equiv \phi_{in}'/\phi_{ii}'\}$ and equal endowments $\{L_i, S_i\}$ and factor intensities $(\beta_j)$ across equilibria. If parameter values are such that $\Delta_- = \Delta'_+ > 0$ for $i \in \{H, F\}$ and $\Delta_- > \Delta'_-$, then $\pi_H < \pi_H'$ and $\pi_F > \pi_F'$.

**Proof.** See the proof of Proposition 1 in Burstein and Vogel (2010b) ■

Lemma 1 is essentially a statement about the relationship between the extent of sectoral specialization and the skill premium. The intuition is that, as a country’s net exports increase in its comparative advantage sector, labor will be reallocated toward the sector of comparative advantage, raising the relative demand and hence the relative price of the factor used intensively there (unskilled labor).

**Proof.** (Proposition 2)

By Lemma 1, we have that if $\Delta_- \geq \Delta'_- > 0$, then:

$$\pi_H \leq \pi_H' \quad \text{(32)}$$

$$\pi_F \geq \pi_F' \quad \text{(33)}$$

We also have that, $\Delta_- \geq \Delta'_-$ if and only if:

$$\left[ \frac{1}{a} \left( \frac{\pi_F}{\pi_H} \right)^{\beta_1-\beta_2} \right]^{\sigma-1} \leq \left[ \frac{1}{a'} \left( \frac{\pi_F'}{\pi_H'} \right)^{\beta_1-\beta_2} \right]^{\sigma-1} \quad \text{(34)}$$

To obtain a contradiction, suppose that $a < a'$ and $\Delta_- \geq \Delta'_- > 0$. Condition (34) implies that:

$$\frac{1}{a} \left( \frac{\pi_F}{\pi_H} \right)^{\beta_1-\beta_2} \leq \frac{1}{a'} \left( \frac{\pi_F'}{\pi_H'} \right)^{\beta_1-\beta_2}$$

which contradicts (32) and (33). Thus, if $a < a'$, then $\Delta_- < \Delta'_-$. Results for the skill premium follow by Lemma 1. ■

32
Appendix B

In this Appendix, we describe the calculation of firm-level distortions $\tau_{si}$ and TFP $z_{si}$. The methodology closely follows that in Hsieh and Klenow (2009). Consider a simple model of monopolistic competition with heterogeneous firms, similar to the model presented in section 3 without trade and without entry and exit. There are $S$ sub-sectors or industries in the manufacturing sector, denoted by $s$. Industry output $Y_s$ is a CES aggregate of $M_s$ differentiated varieties:

$$Y_s = \left( \sum_{i=1}^{M_s} Y_{si}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}$$

where, since there is no entry or exit, the number of firms in each industry $M_s$ is fixed and exogenous. Each firm produces a unique variety using capital and labor:

$$Y_{si} = z_{si} K_{si}^{\alpha_s} L_{si}^{1-\alpha_s}$$

With output distortions, profits are given by:

$$\pi_{si} = \tau_{si} P_{si} Y_{si} - w L_{si} - r K_{si}$$

Profit maximization yields the standard condition that price is a constant markup over marginal cost:

$$P_{si} = \frac{\sigma}{\sigma-1} \left( \frac{r}{\alpha_s} \right)^{\alpha_s} \left( \frac{w}{1-\alpha_s} \right)^{1-\alpha_s} \frac{1}{z_{si} \tau_{si}}$$

The marginal revenue product of labor is proportional to revenue per worker:

$$MRP L_{si} \equiv (1 - \alpha_s) \frac{\sigma - 1}{\sigma} \frac{P_{si} Y_{si}}{L_{si}} = \frac{w}{\tau_{si}} \quad (35)$$

The marginal revenue product of capital is proportional to the revenue-capital ratio:

$$MRP K_{si} \equiv \alpha_s \frac{\sigma - 1}{\sigma} \frac{P_{si} Y_{si}}{K_{si}} = \frac{r}{\tau_{si}} \quad (36)$$

Since output distortions change the marginal products of labor and capital by the same proportion, we can infer $\tau_{si}$ from either (35) or (36). For example, using (35) we can calculate $\tau_{si}$ from firm-level data on revenue $(P_{si} Y_{si})$, wage payment $(w L_{si})$ and an assumed factor share $\alpha_s$ and elasticity of substitution $\sigma$:

$$\tau_{si} = \frac{\sigma}{\sigma-1} \left( 1 - \alpha_s \right) \frac{w L_{si}}{P_{si} Y_{si}}$$

Finally, we calculate a measure of firm productivity as:

$$z_{si} = \frac{(P_{si} Y_{si})^{\frac{\sigma}{\sigma-1}}}{K_{si}^{\alpha_s} L_{si}^{1-\alpha_s}}$$

where we have inferred unobserved physical quantity $Y_{si}$ from observed revenue and an assumed elasticity of demand.
Tables and Figures

Table 1: Calibration Results

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Target</th>
<th>Data</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trade cost in manuf, initial</td>
<td>$\phi_1 = 2.5$</td>
<td>Manuf trade share, pre-reform</td>
<td>8.6%</td>
<td>8.6%</td>
</tr>
<tr>
<td>Trade cost in manuf, final</td>
<td>$\phi'_1 = 1.9$</td>
<td>Manuf trade share, post-reform</td>
<td>35.5%</td>
<td>35.5%</td>
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<tr>
<td>Trade cost in services, initial</td>
<td>$\phi_2 = 3$</td>
<td>Services trade share, pre-reform</td>
<td>4.0%</td>
<td>4.0%</td>
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<tr>
<td>Trade cost in services, final</td>
<td>$\phi'_2 = 2.2$</td>
<td>Services trade share, post-reform</td>
<td>18.5%</td>
<td>18.5%</td>
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<tr>
<td>Fixed production cost</td>
<td>$f = 0.15$</td>
<td>Firm exit rate</td>
<td>5.0%</td>
<td>4.5%</td>
</tr>
<tr>
<td>Fixed exporting cost</td>
<td>$f_x = 0.057$</td>
<td>Fraction of firms exporting</td>
<td>7.0%</td>
<td>7.6%</td>
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<tr>
<td>Foreign labor endowment</td>
<td>$L_F = 2$</td>
<td>GDP relative to trade partners</td>
<td>11.0%</td>
<td>10.5%</td>
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<td>Relative TFP of manuf</td>
<td>$A_1/A_2 = 0.84$</td>
<td>Relative price of manuf</td>
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<td>1.25</td>
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<td>Relative TFP of NT services</td>
<td>$A_3/A_2 = 0.66$</td>
<td>Relative price of NT services</td>
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Table 2: Other Parameter Values

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<th>Parameter</th>
<th>Value</th>
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<tr>
<td>Sectoral technology</td>
<td>$\beta_1 = 0.59; \beta_2 = 0.44; \beta_3 = 0.9$</td>
<td>U.S. 2002 Census</td>
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<tr>
<td>Sectoral expenditure shares</td>
<td>$\alpha_1 = 0.34; \alpha_2 = 0.42$</td>
<td>BEA</td>
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<td>Home skill endowment</td>
<td>$S_H/L_H = 0.43$</td>
<td>Barro-Lee data</td>
</tr>
<tr>
<td>Foreign skill endowment</td>
<td>$S_F/L_F = 0.88$</td>
<td>Barro-Lee data</td>
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<tr>
<td>Productivity distribution</td>
<td>$c_{H1} = 4.8; c_{H2} = 6.5; c_{F1} = c_{F2} = 4.2$</td>
<td>Firm size distributions US, India</td>
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<td>Elasticity of substitution</td>
<td>$\sigma = 5$</td>
<td>Literature</td>
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<td>Entry cost</td>
<td>$f_e = 5$</td>
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<td>Exogenous death probability</td>
<td>$\delta = 0.025$</td>
<td>Normalization</td>
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Table 3: Responses to Trade Liberalization

<table>
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<tr>
<th>Variable</th>
<th>Benchmark</th>
<th>Distorted</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing net exports ((NX_1/GDP))</td>
<td>5.4%</td>
<td>-2.9%</td>
<td>-11.0%</td>
</tr>
<tr>
<td>Services net exports ((NX_2/GDP))</td>
<td>-5.4%</td>
<td>2.9%</td>
<td>4.6%</td>
</tr>
<tr>
<td>Skill premium (% chg from pre-reform)</td>
<td>-2.6%</td>
<td>1.5%</td>
<td>15.4%</td>
</tr>
<tr>
<td>Change in value added share of manuf</td>
<td>4.2%</td>
<td>-2.3%</td>
<td>-0.7%</td>
</tr>
<tr>
<td>Change in value added share of services</td>
<td>-4.2%</td>
<td>2.3%</td>
<td>9.6%</td>
</tr>
<tr>
<td>Aggregate TFP (% chg from pre-reform)</td>
<td>4.0%</td>
<td>1.5%</td>
<td>6.0%</td>
</tr>
<tr>
<td>Welfare (% chg from pre-reform)</td>
<td>1.7%</td>
<td>1.0%</td>
<td>–</td>
</tr>
</tbody>
</table>

Notes: The benchmark economy is a frictionless economy where \(\theta_{ij} = 0\ \forall i, j\). The distorted economy is an economy where India’s manufacturing sector is subject to idiosyncratic distortions \((\theta_{H1} = 0.26)\).

Table 4: Magnification Effects of Entry and Selection

<table>
<thead>
<tr>
<th>Variable ((\Delta_{-}))</th>
<th>Data</th>
<th>Distorted</th>
<th>Distorted, no entry</th>
<th>Distorted, no entry or selection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specialization ((\Delta_{-}))</td>
<td>-5.4%</td>
<td>-4.3%</td>
<td>-3.7%</td>
<td>-2.9%</td>
</tr>
<tr>
<td>Skill premium</td>
<td>15.4%</td>
<td>1.5%</td>
<td>1.0%</td>
<td>0.7%</td>
</tr>
</tbody>
</table>

Notes: \(\Delta_{-}\) is defined as the difference between services import share and manufacturing import share. \(\Delta_{-} < 0\) implies specialization in services. Column 3 reports predictions from the full model with distortions. Column 4 reports predictions from the model with distortions in which the number of entrants is fixed across the initial and final steady state. Column 5 reports predictions from the model with distortions in which the total number of active firms is fixed across steady states.
Figure 1: Trade Openness and Income

Notes: Openness (solid line) is measured as the sum of export and import shares in GDP. Income (dashed line) is per capita real income relative to U.S. level. The vertical line indicates the date of trade liberalization (1991).

Figure 2: Sectoral Specialization

Notes: The figure shows trade balance for India’s manufacturing and services sectors, measured as net export share in GDP. The vertical line indicates the date of trade liberalization (1991).
Figure 3: Structural Change 1960-2008

Figure 4: Output Distortions and Plant Productivity

Notes: Distortions and productivity are calculated using firm-level data from the 2005 Annual Survey of Industries.
Figure 5: Effects of Entry and Selection on Specialization

Notes: Specialization is measured by the difference between import shares in services and manufacturing. Negative values imply specialization in services. In the specification with no entry, the number of entrants is fixed across trade equilibria. In the specification with no entry and no selection, the total number of active firms is fixed across equilibria.

Figure 6: Effects of Entry and Selection on Skill Premium

Notes: The skill premium is normalized to one at the initial trade share value.
Figure 7: Elasticity of Trade Share with respect to Trade Cost

Notes: Trade share is normalized to one at the initial value of trade cost. Trade share is measured as the sum of import and export shares in GDP. In the specification with no selection, the productivity cutoffs, which determine the fraction of surviving firms, are fixed across trade equilibria.

Figure 8: Welfare Costs of Idiosyncratic Distortions

Notes: In this experiment, distortions in manufacturing are fixed at the estimated value (\( \theta = 0.26 \)). The figure shows the welfare loss from adding distortions to a frictionless benchmark at varying levels of trade openness, measured by trade share.
Figure 9: Welfare Gains from Trade

Notes: In this experiment, we consider a trade liberalization of the magnitude similar to India’s episode. The figure shows the welfare gain from trade at varying levels of distortions ($\theta$). Welfare gain in the frictionless benchmark is normalized to 100.