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A GLOBAL VIEW OF PRODUCTIVITY GROWTH IN CHINA

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ABSTRACT

How does a country's productivity growth a¤ect worldwide real incomes through international trade? In this paper, we take this classic question to the data by measuring the spillover e¤ects of China's productivity growth. Our framework features traditional terms-of-trade e¤ects and new trade home market e¤ects as suggested by the theoretical literature and works from a reference point which perfectly matches industry-level trade. Focusing on the years 1995 to 2007, we find that the spillover e¤ects of China's productivity growth are small causing the real incomes of China's trading partners to increase by only 0.1 percent on average.

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1 Introduction

One of the classic propositions of international economics is that a country's productivity growth can not only benefit but also harm its trading partners. In traditional models of inter-industry trade based on comparative advantage, productivity shocks transmit only through terms-of-trade effects. They tend to benefit the trading partners if productivity growth is biased towards export-oriented industries and harm the trading partners otherwise (Hicks, 1953). In newer models of intra-industry trade based on product differentiation, productivity shocks also transmit through home market effects. They tend to benefit the trading partners if productivity growth is biased towards industries with a relatively high trade elasticity and harm the trading partners otherwise (Venables, 1987).

For example, if China's productivity growth was biased towards its textile industry, this would cause an improvement in the US terms-of-trade because this is one of China's export-oriented industries. In particular, US consumers would then be able to purchase textiles at lower prices which would make US exports more valuable relative to US imports. Similarly, if China's productivity growth was biased towards its paper industry, this would imply a favorable home market effect in the US because this is one of the high trade elasticity industries. In particular, there would be exit out of the US paper industry allowing entry into other lower trade elasticity industries which would reduce the US price index because entry is more beneficial in lower trade elasticity industries.[1]

In this paper, we take this proposition to the data by measuring the global spillover effects of China's productivity growth. We focus on the years 1995-2007, the 14 largest countries, and a residual Rest of the World. Our main finding is that the spillover effects of China's

[1] As we will see later, "Textiles and leather" is China's most export-oriented industry and "Pulp, paper, printing and publishing" is the highest trade elasticity industry. In a Krugman (1980) model, the trade elasticity would be the elasticity of substitution between varieties. Entry is then more beneficial in lower trade elasticity industries because their varieties are more differentiated implying larger utility gains. In a Melitz (2003) model in which firm productivities are Pareto distributed, the trade elasticity would be the shape parameter of the Pareto distribution. Entry is then more beneficial in lower trade elasticity industries because their firm productivities are more dispersed implying stronger selection effects. We elaborate further on these effects later on.

productivity growth are small causing the real incomes of China's trading partners to increase by only 0.1 percent on average with the effects ranging between -0.1 percent for Germany and 0.9 percent for Korea. One reason is that imports from China still only account for a small share of overall expenditure despite its rising importance to the world economy. Another reason is that the terms-of-trade and home market effects turn out to have an offsetting character given the pattern of China's productivity growth.

Our analysis is based on a multi-country multi-industry general equilibrium model of international trade featuring inter-industry trade as in Ricardo (1817), intra-industry trade as in Krugman (1980), and firm heterogeneity as in Melitz (2003). On the theoretical side, it features terms-of-trade effects as well as home market effects which seems desirable in light of the forecited theoretical results. On the empirical side, it implies an industry-level gravity structure which allows us to measure the spillover effects of China's productivity growth from a reference point which perfectly matches worldwide industry-level trade. The firm-level dimension is not essential to account for terms-of-trade and home market effects, but is important to correct for Melitz (2003) selection effects when estimating China's productivity growth.

Despite the considerable attention our subject received in the theoretical literature, there is relatively little related empirical work. Our paper is preceded mainly by Eaton and Kortum (2002) who illustrate their seminal framework by quantifying the spillover effects of hypothetical US and German productivity shocks on other OECD countries. Eaton and Kortum's framework features only terms-of-trade effects but no home market effects and therefore ignores one of the channels through which productivity shocks transmit. Also, it predicts full specialization according to comparative advantage but allows only for aggregate productivity shocks so that productivity growth is always export-biased in effect.[2]

Having said this, additional work has emerged since the first draft of our paper. Probably most closely related is the work by Di Giovanni et al (2014) who also consider the welfare

[2] Fieler (2011) provides a similar exercise in an Eaton and Kortum (2002) model with non-homothetic preferences.

effects of China's productivity growth. While our analysis has an ex post nature isolating the spillover effects of actual productivity shocks, Di Giovanni et al (2014) take an ex ante approach simulating the spillover effects of hypothetical growth scenarios. Our exercise is also in a similar spirit as the analysis by Levchenko and Zhang (2015) who measure the evolution of sectoral productivities in the world economy over multiple decades. Their main point is that there has been productivity convergence in the sense that productivity grew faster in sectors that were less productive initially.

In terms of its question, our paper is also related to the work of Autor er al (2013) which investigates the local labor market consequences of Chinese import competition in the US. Their main finding is that local labor markets which are more exposed to Chinese import competition also have higher unemployment, lower labor market participation, and reduced wages. The same is true for the work of Bloom et al (2015) which examines the impact of Chinese import competition on technical change in the EU. Their main punchline is that Chinese import competition lead to increased technical change within firms and reallocated employment between firms towards more technologically advanced firms.

The remainder of the paper is organized as follows. Section 2 lays out the theoretical framework: it describes the basic setup, characterizes the equilibrium for given productivities, shows how to calculate the general equilibrium effects of productivity shocks, demonstrates how to isolate the welfare effects of productivity shocks, and introduces a number of extensions to the basic setup. Section 3 turns to the empirical application: it goes over the data, describes the estimation of the model parameters, discusses the estimation of China's productivity growth, explains the procedure used to calculate the spillover effects of China's productivity growth, and reports the empirical results.[3]

[3] In the interest of brevity, derivations are kept to a minimum in the main text. A detailed technical appendix is available upon request.

2 Theoretical framework

2.1 Basic setup

Our framework is based on a multi-industry extension of the Melitz (2003) model used by Arkolakis et al (2012). There are N countries and S industries. Each industry provides consumers with a continuum of differentiated varieties. Preferences over these varieties are summarized by the following utility functions

$$U_j = \prod_{s=1}^{S} \left(\sum_{i=1}^{N} \int_0^{M_{ijs}} x_{ijs} \left(\nu_{is}\right)^{\frac{\sigma_s - 1}{\sigma_s}} d\nu_{is} \right)^{\frac{\sigma_s}{\sigma_s - 1}\mu_{js}} \qquad (1)$$

where x_{ijs} is the quantity of an industry s variety from country i consumed in country j, M_{ijs} is the number of industry s varieties from country i available in country j, $\sigma_s > 1$ is the elasticity of substitution between industry s varieties, and μ_{js} is the fraction of country j income spent on industry s varieties.

Firms are technologically heterogeneous which is captured by the following production process. Entrants into industry s of country i have to hire f_{is}^e units of labor in country i to draw their productivities φ from a Pareto distribution $G_{is}(\varphi) = 1 - \left(\frac{b_{is}}{\varphi}\right)^{\theta_s}$, where f_{is}^e is a fixed cost of entry, b_{is} is the Pareto location parameter, and θ_s is the Pareto shape parameter. Entrants into industry s of country i wishing to sell to country j further need to hire $\frac{x_{ijs}\tau_{ijs}}{\varphi}$ units of labor in country i and f_{ijs} units of labor in country j to deliver x_{ijs} units of output to country j, where $\tau_{ijs} \geq 1$ is an iceberg trade barrier and f_{ijs} is a fixed cost of serving market j. Both the number of entrants into industry s of country i M_{is}^e and the fraction of entrants selling to country j $\frac{M_{ijs}}{M_{is}^e}$ are endogenous.

Given only these basics, we can already anticipate some of the roles the model's traditional and new trade elements will play. In particular, the model will feature inter-industry trade as in Ricardo (1817) since the productivity distributions vary by country and industry. Also, there will be intra-industry trade as in Krugman (1980) since goods are differentiated and consumers value variety. We will model an industry's productivity growth as an increase in the Pareto location parameter b_{is} which shifts the entire distribution of possible productivity draws to the right. Since this will lead to changes in the number of entrants, productivity growth will not only have terms-of-trade effects but also home market effects which would not arise in Eaton and Kortum (2002) type environments.

2.2 Equilibrium for given productivities

Utility maximization implies that firms in industry s of country i face demands

$$x_{ijs} = \frac{p_{ijs}^{-\sigma_s}}{P_{js}^{1-\sigma_s}} \mu_{js} w_j L_j \tag{2}$$

where p_{ijs} is the delivered price of an industry s variety, P_{js} the ideal price index of all industry s varieties, w_j the wage rate, and L_j the number of consumers or workers.

Profit maximization requires that firms in industry s of country i whose productivity draws exceed φ_{ijs}^* charge

$$p_{ijs} = \frac{\sigma_s}{\sigma_s - 1} \frac{\tau_{ijs} w_i}{\varphi} \tag{3}$$

where $\varphi_{ijs}^* = \frac{\sigma_s}{\sigma_s - 1} \frac{\tau_{ijs} w_i}{P_{js}} (\frac{\sigma_s f_{ijs}}{\mu_{js} L_j})^{\frac{1}{\sigma_s - 1}}$ denotes the productivity cutoff above which revenues are sufficiently high to justify incurring the fixed costs of serving market j.

As usual, the ideal price index is given by $P_{js} = (\sum_{i=1}^{N} \int_0^{M_{ijs}} p_{ijs}(\nu_{is})^{1-\sigma_s} d\nu_{is})^{\frac{1}{1-\sigma_s}}$. With the help of equation (3), it can be rewritten as

$$P_{js} = \left(\sum_{i=1}^{N} M_{ijs} p_{ijs} \left(\widetilde{\varphi}_{ijs} \right)^{1-\sigma_s} \right)^{\frac{1}{1-\sigma_s}} \tag{4}$$

where $\widetilde{\varphi}_{ijs} = (\int_{\varphi_{ijs}^*}^{\infty} \varphi^{\sigma_s - 1} g_{is}(\varphi | \varphi > \varphi^*) d\varphi)^{\frac{1}{\sigma_s - 1}}$ denotes the productivity of the representative firm in industry s of country i selling to country j which can be simplified to $\widetilde{\varphi}_{ijs} = (\frac{\theta_s}{\theta_s - \sigma_s + 1})^{\frac{1}{\sigma_s - 1}} \varphi_{ijs}^*$ by imposing the Pareto assumption.

Free entry drives expected profits down to zero so that

$$\sum_{j=1}^{N} prob\left(\varphi > \varphi_{ijs}^{*}\right) E\left(\pi_{ijs}|\varphi > \varphi_{ijs}^{*}\right) = w_i f_{is}^{e} \tag{5}$$

where $prob(\varphi > \varphi_{ijs}^{*}) = (\frac{b_{is}}{\varphi_{ijs}^{*}})^{\theta_s}$ is the probability that an entrant into industry s of country i sells to country j and $E(\pi_{ijs}|\varphi > \varphi_{ijs}^{*}) = \frac{\sigma_s - 1}{\theta_s - \sigma_s + 1} w_j f_{ijs}$ are the expected operating profits of an entrant into industry s of country i from selling to country j conditional on selling to country j.[4]

Finally, labor market clearing ensures

$$\delta_i L_i = \sum_{s=1}^{S} M_{is}^{e} \left(\theta_s + 1\right) f_{js}^{e} \tag{6}$$

where $\delta_i \equiv \sum_{s=1}^{S} \frac{(\theta_s+1)(\sigma_s - 1)}{\theta_s \sigma_s} \mu_{js}$ is the fraction of country i workers hired by country i entrants to cover their fixed costs of entry as well as their variable costs of production and $(\theta_s+1) f_{js}^{e}$ captures the expected number of workers required by entrants into industry s of country i to cover their fixed costs of entry as well as their variable costs of production.

Upon noticing that $M_{ijs} = (\frac{b_{is}}{\varphi_{ijs}^{*}})^{\theta_s} M_{is}^{e}$, equations (3) - (5) can be combined to

$$w_i \frac{\theta_s \sigma_s}{\sigma_s - 1} f_{is}^{e} = \sum_{j=1}^{N} \frac{\left(f_{ijs}\right)^{\frac{\sigma_s - \theta_s - 1}{\sigma_s - 1}} \left(\frac{\tau_{ijs} w_i}{b_{is}}\right)^{-\theta_s}}{\sum_{m=1}^{N} M_{ms}^{e} \left(f_{mjs}\right)^{\frac{\sigma_s - \theta_s - 1}{\sigma_s - 1}} \left(\frac{\tau_{mjs} w_m}{b_{ms}}\right)^{-\theta_s}} \mu_{js} w_j L_j \tag{7}$$

Together with condition (6), this represents a system of N+NS equations in the N+NS unknowns w_i and M_{is}^{e} which can be solved up to a numeraire. An obvious problem, however, is that this system depends on a large set of unknown parameters which are all difficult to estimate empirically.

[4] While imposing free entry is a standard assumption in the literature, it is of course abstracting from many features of real-world firm dynamics, such as that firms start out small, mostly fail, and those that do not fail grow fast.

2.3 General equilibrium effects of productivity shocks

We avoid this problem by computing the general equilibrium effects of productivity shocks using a method inspired by Dekle et al (2007). In particular, conditions (6) and (7) can be written in changes as

$$1 = \sum_{s=1}^{S} \ {}_{is}\widehat{M}_{is}^{e} \tag{8}$$

$$\widehat{w}_v = \sum_{j=1}^{N} \frac{\beta_{vjs} \left(\frac{\widehat{w}_v}{\widehat{b}_{vs}}\right)^{\square\theta_s}}{\sum_{i=1}^{N} \alpha_{ijs} \widehat{M}_{is}^{e} \left(\frac{\widehat{w}_i}{\widehat{b}_{is}}\right)^{\square\theta_s}} \widehat{w}_j \tag{9}$$

where a hat denotes the ratio between the counterfactual and factual value, $\alpha_{ijs} \equiv \frac{T_{ijs}}{\sum_{m=1}^{N} T_{mjs}}$, $\beta_{ijs} \equiv \frac{T_{ijs}}{\sum_{n=1}^{N} T_{ins}}$, $\ {}_{is} \equiv \frac{\sum_{n=1}^{N} \frac{(\sigma_s \square 1)(\theta_s+1)}{\theta_s \sigma_s} T_{ins}}{\sum_{n=1}^{N} \sum_{t=1}^{S} \frac{(\sigma_t \square 1)(\theta_t+1)}{\theta_t \sigma_t} T_{int}}$, and T_{ijs} denotes the factual value of industry s trade from country i to country j.

Equations (8) and (9) represent a system of N+NS equations in the N+NS unknowns $\widehat{w}_i$ and $\widehat{M}_{is}^{e}$. Crucially, their coefficients depend on σ_s, θ_s, and observable trade flows only so that the full general equilibrium response to productivity shocks can be determined without further information on any of the remaining model parameters. Notice that this procedure ensures that the general equilibrium effects are calculated from a reference point which perfectly matches industry-level trade. Essentially, it imposes a restriction on the set of unknown parameters $\{b_{is}, \tau_{ijs}, f_{ijs}, f_{is}^{e}, L_i\}$ such that the predicted T_{ijs} perfectly match the observed T_{ijs} for given values of σ_s and θ_s.

To provide a sense of the nature of these general equilibrium adjustments, Table 1 reports the effects of a hypothetical productivity shock in a simple example economy consisting of two countries (China and the US) and two industries (1 and 2). Productivity is assumed to grow by 10 percent in industry 1 of China and trade flows are taken to be fully symmetric as detailed in the note to Table 1. As can be seen, the productivity growth in industry 1 of China is predicted to cause an increase in the relative wage of China as well as entry into industry 1 of China, exit out of industry 1 of the US, exit out of industry 2 of China, and entry into industry 2 of the US.

Intuitively, expected profits from entering into industry 1 become positive in China and negative in the US. As a result, there is entry into industry 1 of China bidding up wages so that there is also exit out of industry 2. Also, there is exit out of industry 1 of the US depressing wages so that there is also entry into industry 2. The pattern of entry and exit can also be understood in terms of two basic equilibrium constraints. First, labor market clearing requires that entry into one industry leads to exit out of the other industry in the same country. Second, constant expenditure shares imply that entry into one industry leads to exit out of the same industry in the other country.

2.4 Welfare effects of productivity shocks

Given these general equilibrium adjustments of productivity shocks, the implied welfare effects can be computed relatively straightforwardly. Changes in welfare are given by changes in real labor income which are changes in nominal labor income deflated by changes in the ideal aggregate price index: $\widehat{V}_j = \frac{\widehat{w}_j}{\widehat{P}_j}$. Given the Cobb-Douglas structure of aggregate preferences, this can be rewritten in terms of changes in the ideal industry price indices as $\widehat{V}_j = \frac{\widehat{w}_j}{\Pi_{s=1}^{S}(\widehat{P}_{js})^{\mu_{js}}}$. The trick is now to express changes in the ideal industry price indices as functions of changes in wages and entry only. This can be accomplished by rewriting equation (4) in changes after substituting the relationship $M_{ijs} = (\frac{b_{is}}{\varphi^*_{ijs}})^{\theta_s} M^e_{is}$ and the definitions of φ^*_{ijs} and $\widetilde{\varphi}_{ijs}$ which yields $\widehat{P}_{js} = (\sum_{i=1}^{N} \alpha_{ijs} \widehat{M}^e_{is} (\frac{\widehat{w}_i}{\widehat{b}_{is}})^{\square\theta_s})^{\square\frac{1}{\theta_s}}$. As a result, changes in welfare can then be computed from[5]

$$\widehat{V}_j = \prod_{s=1}^{S} \left(\sum_{i=1}^{N} \alpha_{ijs} \left(\widehat{b}_{is} \frac{\widehat{w}_j}{\widehat{w}_i} \right)^{\theta_s} \widehat{M}^e_{is} \right)^{\frac{\mu_{js}}{\theta_s}} \tag{10}$$

To understand precisely how productivity shocks affect welfare, it is useful to begin by contrasting two linear approximations of the growth rates of industry price indices.[6] The first fol-

[5] Notice that no further parameter estimates are required for this computation since $\mu_{js} = \frac{\sum_i T_{ijs}}{\sum_i \sum_s T_{ijs}}$.

[6] All approximations discussed in this section are also first-order derivatives of the equilibrium conditions. As a result, they hold exactly for infinitesimal changes.

lows from equation (4) and reveals that changes in industry price indices are expenditure share weighted averages of changes in average prices and elasticity of substitution adjusted changes in available variety as one intuitively expects: $\frac{\Delta P_{js}}{P_{js}} \approx \sum_{i=1}^{N} \alpha_{ijs}(-\frac{\Delta \widetilde{\varphi}_{ijs}}{\widetilde{\varphi}_{ijs}} + \frac{\Delta w_i}{w_i} - \frac{1}{\sigma_s - 1}\frac{\Delta M_{ijs}}{M_{ijs}})$. The second follows from the expression for $\widehat{P}_{js}$ given above and shows that productivity shocks ultimately affect industry price indices either directly or indirectly through changes in wages or entry: $\frac{\Delta P_{js}}{P_{js}} \approx \sum_{i=1}^{N} \alpha_{ijs}(-\frac{\Delta b_{is}}{b_{is}} + \frac{\Delta w_i}{w_i} - \frac{1}{\theta_s}\frac{\Delta M_{is}^e}{M_{is}^e})$. The links between these two approximations are given by two equations which can be derived using the relationship $M_{ijs} = (\frac{b_{is}}{\varphi_{ijs}^*})^{\theta_s} M_{is}^e$ and the definitions of φ_{ijs}^* and $\widetilde{\varphi}_{ijs}$.

The first link is that $\sum_{i=1}^{N} \alpha_{ijs}\frac{\Delta M_{ijs}}{M_{ijs}} \approx 0$ which implies that changes in available variety have no net effect on industry price indices so that the last term out of the first approximation simply drops out. The basic intuition for this result can be understood by considering the following variety effects of China's productivity growth on the US economy. On the one hand, China's productivity growth implies that more Chinese varieties become available to US consumers as additional Chinese firms start exporting to the US. On the other hand, China's productivity growth means that fewer US varieties remain available to US consumers since some US firms are forced to shut down. The price index implications of these two effects are exactly offsetting so that changes in the overall number of varieties available to US consumers can be ignored.

The second link is that $\sum_{i=1}^{N} \alpha_{ijs}\frac{\Delta \widetilde{\varphi}_{ijs}}{\widetilde{\varphi}_{ijs}} \approx \sum_{i=1}^{N} \alpha_{ijs}\frac{\Delta b_{is}}{b_{is}} + \frac{1}{\theta_s}\sum_{i=1}^{N} \alpha_{ijs}\frac{\Delta M_{is}^e}{M_{is}^e}$ which implies that only changes in average productivity induced either directly by changes in b_{is} or indirectly by changes in M_{is}^e have a net effect on P_{js}. A corollary is that the basic Melitz (2003) selection effects also cancel which is not too surprising since they mirror the abovementioned variety effects. One the one hand, the fact that additional Chinese firms start exporting to the US means that the average productivity of Chinese firms serving the US market grows at a slower rate than China's productivity since these additional firms have below average productivity. On the other hand, the fact that some US firms are forced to shut down means that the average productivity of US firms serving the US market rises since the surviving firms have above average productivity.[7]

The only Melitz (2003) selection effects which continue to matter are the entry effects known from Bernard et al (2007). Their basic intuition can be understood by considering how industry 1 of the US is affected by productivity growth in industry 1 of China. The resulting exit out of industry 1 of the US reduces competition in industry 1 of the US which increases the industry 1 price index of the US by allowing some lower productivity firms to serve the US market. At the same time, the resulting entry into industry 1 of China increases competition in industry 1 of the US which decreases the industry price index of the US by forcing some lower productivity firms out of the US market. Under a realistic parametrization of industry expenditure shares, entry in the US has a stronger effect on US competition than entry in China so that the former effect dominates.[8]

Given this background on how productivity shocks affect industry price indices, it is now easy to see how productivity shocks affect welfare. In particular, changes in welfare can be approximated as $\frac{\Delta V_j}{V_j} \approx \frac{\Delta w_j}{w_j} - \sum_{s=1}^{S} \mu_{js} \frac{\Delta P_{js}}{P_{js}}$ which can be rewritten by substituting the second approximation $\frac{\Delta P_{js}}{P_{js}} \approx \sum_{i=1}^{N} \alpha_{ijs}(-\frac{\Delta b_{is}}{b_{is}} + \frac{\Delta w_i}{w_i} - \frac{1}{\theta_s} \frac{\Delta M_{is}^e}{M_{is}^e})$ from above. The resulting expression is just a linearized version of equation (10):

$$\frac{\Delta V_j}{V_j} \approx \sum_{i=1}^{N} \sum_{s=1}^{S} \mu_{js} \alpha_{ijs} \left(\left(\left(\frac{\Delta w_j}{w_j} - \frac{\Delta b_{js}}{b_{js}} \right) - \left(\frac{\Delta w_i}{w_i} - \frac{\Delta b_{is}}{b_{is}} \right) \right) + \frac{1}{\theta_s} \frac{\Delta M_{is}^e}{M_{is}^e} + \frac{\Delta b_{js}}{b_{js}} \right) \tag{11}$$

The first term $\sum_{i=1}^{N} \sum_{s=1}^{S} \mu_{js} \alpha_{ijs} \left(\left(\frac{\Delta w_j}{w_j} - \frac{\Delta b_{js}}{b_{js}} \right) - \left(\frac{\Delta w_i}{w_i} - \frac{\Delta b_{is}}{b_{is}} \right) \right)$ is the traditional terms-of-trade effect emphasized by Hicks (1953). It captures the direct effect changes in wages and productivities have on the prices of the goods produced by country j relative to the

[7] These findings are similar to the findings in Feenstra (2010) and relate to the discussion of whether allowing for firm heterogeneity increases the measured gains from trade. On the one hand, Arkolakis et al (2013) show that allowing for firm heterogeneity often does not change the measured gains from trade provided that the model parameters are always recalibrated to match the observed trade elasticity. On the other hand, Melitz and Redding (forthcoming) demonstrate that allowing for firm heterogeneity usually increases the measured gains from trade if the model parameters are kept unchanged.

[8] This can also be seen from the third term in approximation $\frac{\Delta P_{js}}{P_{js}} \approx \sum_{i=1}^{N} \alpha_{ijs}(-\frac{\Delta b_{is}}{b_{is}} + \frac{\Delta w_i}{w_i} - \frac{1}{\theta_s} \frac{\Delta M_{is}^e}{M_{is}^e})$. If the number of entrants rises by 10 percent in China and falls by 10 percent in the US, the US price index typically rises because US consumers spend more on US goods than on Chinese goods. Of course, the precise adjustments are determined by complex general equilibrium forces which can be hard to predict.

direct effect changes in wages and productivities have on the prices of the goods consumed by country j. Country j benefits from an increase in the price of its production bundle relative to the price of its consumption bundle since its exports then command more imports in world markets.

The second term $\sum_{i=1}^{N}\sum_{s=1}^{S}\frac{\mu_{js}\alpha_{ijs}}{\theta_s}\frac{\Delta M_{is}^e}{M_{is}^e}$ is the new trade home market effect in Venables (1987). It captures the indirect effect adjustments in entry and exit have on the aggregate price index in country j. Recall that entry into one industry of country j always comes along with exit out of another industry in country j. Recall also that entry into an industry of country j typically reduces the price index of that industry in country j. Hence, the counteracting entry effects give rise to counteracting industry price index effects so that the sign of the aggregate price index effect is not immediately clear.

The last term $\sum_{i=1}^{N}\sum_{s=1}^{S}\mu_{js}\alpha_{ijs}\frac{\Delta b_{js}}{b_{js}}=\sum_{s=1}^{S}\mu_{js}\frac{\Delta b_{js}}{b_{js}}$ is the effect productivity shocks in country j have on welfare in country j under autarky as follows straightforwardly from setting $N = 1$ in equations (9) and (11). It simply says that a country's welfare growth under autarky is an expenditure share weighted average of that country's industry-level productivity growth as one intuitively expects. The previous two terms therefore capture the additional effects arising under trade relative to autarky and thereby identify the channels through which productivity shocks transmit under trade.[9]

To illustrate the key determinants of the signs of these spillover effects, we now return to our simple example economy introduced above. Table 2 reports the effects of a hypothetical 10 percent productivity growth in industry 1 of China on US welfare for three different scenarios: China is a net exporter in industry 1, China is a net importer in industry 1, and there is no inter-industry trade. As one expects from the classic literature, the US experiences a terms-of-trade gain if China's productivity growth is biased towards China's export-oriented industry but a terms-of-trade loss if China's productivity growth is biased towards China's import-

[9]Internationally, the terms-of-trade and home market effects have a zero sum character. This can be seen most clearly in the special case $\sigma_s = \sigma$ and $\theta_s = \theta$ for all s since the worldwide average welfare effect is then completely independent of terms-of-trade and home market effects. In particular, it can be shown that equation (11) then implies $\frac{\Delta \overline{V}}{\overline{V}}=\sum_i\sum_j\sum_s\frac{T_{ijs}}{\sum_v w_v L_v}\frac{\Delta b_{is}}{b_{is}}$, where $\frac{\Delta \overline{V}}{\overline{V}}=\sum_j\frac{w_j L_j}{\sum_v w_v L_v}\frac{\Delta V_j}{V_j}$.

competing industry.

One subtle difference from the textbook analysis is that the terms-of-trade gain the US experiences if China's productivity growth is biased towards China's export-oriented industry exceeds the terms-of-trade loss it experiences if China's productivity growth is biased towards China's import-competing industry. This is also reflected in the fact that the US experiences a positive terms-of-trade effect even if there is no inter-industry trade. This difference is due to the existence of Krugman (1980) type intra-industry trade. In a sense, productivity growth always features an export-bias in a Krugman (1980) model since each country specializes in a unique set of varieties.

Table 3 returns to the case of fully symmetric trade flows and illustrates the role played by cross-industry differences in θ_s. It again reports the effects of a 10 percent productivity growth in industry 1 of China on US welfare. As can be seen, the US experiences a positive home market effect if China's productivity growth is biased towards the high θ_s industry and a negative home market effect if it is biased towards the low θ_s industry. The intuition is that the θ_s parameters govern the strengths of the counteracting industry price index effects. If θ_s is low, there is a lot of variation in firm productivity so that changes in the number of entrants lead to large changes in average productivity.

For example, if China's productivity growth is biased towards the high θ_s industry, there is exit out of the high θ_s industry in the US which tends to increase the aggregate price index in the US. At the same time, there is also entry into the low θ_s industry in the US which tends to decrease the aggregate price index in the US. However, the latter effect tends to dominate the former effect since changes in the number of entrants induce larger changes in average productivity in the low θ_s industry. This is because firm productivity is more dispersed in the low θ_s industry so that adding or dropping marginal firms has a larger effect on average productivity in that industry.

Overall, this discussion suggests two key determinants of the sign of the global spillover effects of China's productivity growth: the correlation between China's productivity growth and China's export-orientation, and the correlation between China's productivity growth and the Pareto shape parameters θ_s which can alternatively be interpreted as trade elasticities in this environment. Of course, the magnitude of the global spillover effects of China's productivity growth also depends critically on the pattern and volume of international trade as captured by the import shares $\mu_{js}\alpha_{ijs}$ in equation (11).

2.5 Extensions

While we emphasize this baseline model throughout the paper, we also report results using an extended model featuring multiple factors and input-output linkages which we explain in detail in the appendix. This extended model is essentially a Ricardo-Heckscher-Ohlin-Krugman-Melitz model with input-output linkages combining all main traditions in international trade theory. The input-output linkages are modeled along the lines of Caliendo and Parro (2015) and mirror national input-output accounts.

We also include nontraded goods when estimating the extended model which we abstract from in the baseline case. However, this does not involve any modeling changes since a nontraded goods sector can simply be interpreted as a traded goods sector with prohibitively high trade costs. Jointly abstracting from intermediate goods and non-traded goods actually turns out to be a reasonable simplification. This is because intermediate goods tend to magnify the spillover effects of productivity shocks while nontraded goods tend to dampen the spillover effects of productivity shocks.

We also account for observed aggregate trade imbalances in the extended model by following the approach of Dekle et al (2007). In particular, we introduce exogenous interstate transfers financing aggregate trade imbalances which we hold constant in all counterfactuals. Notice that unlike most quantitative trade models, our baseline model already features aggregate trade imbalances even if interstate transfers are not introduced. This is because we assume that the fixed cost of exporting are paid in destination country labor which generates international transfers of income.

In practice, we always work with the extended model and simply consider the special case $\eta_{is} = 1$ and $\rho_i^{L,s} = 1$ for all i and s for all results involving the baseline model. As is discussed in the appendix, η_{is} is the share of value added in gross production and $\rho_i^{L,s}$ is the labor share in value added. However, we allow for interstate transfers throughout our analysis so that we can always match all aggregate trade deficits. As a result, even our baseline results are actually calculated using a slight extension of the model presented in the main text.[10]

3 Empirical application

We now apply our framework to isolate and decompose the spillover effects of China's productivity growth between 1995 and 2007. We focus on the world's 14 largest economies and a residual Rest of the World. When using our baseline model, we include 14 traded goods sectors which comprise agriculture, mining, and manufacturing. When using our extended model, we further include a nontraded goods sector which aggregates over all other remaining industries of the economy. The goods made by these residual industries are actually not all entirely nontraded so that our nontraded goods sector is really a traded goods sector with little trade.

To calculate results using our baseline model, we need the complete matrix of industry-level trade flows T_{ijs}, industry-level estimates of the elasticity parameters σ_s and θ_s, and industry-level estimates of China's productivity growths $\widehat{b}_{is}$. To calculate results using our extended model, we further need information on the shares of value added in gross production η_i^s, the coefficients from the input-output tables $\mu_{is}^{I,t}$, and the shares of labor and capital in value added ρ_{is}^L and ρ_{is}^K. Our main data sources are China's Annual Survey of Industrial

[10]When calculating our counterfactuals, we also relax the implicit assumption that the free entry condition always binds in all countries and industries which results in the prediction of negative entry if zero profits are not compatible with positive production. Specifically, we do not immediately compute the counterfactuals with the actual vector of productivity growths but instead take slowly increasing fractions of it, starting at zero and progressing in five percentage point steps. Whenever the number of entrants is predicted to be less than 1 percent of its original value in a particular country and industry, $\hat{M}_{is}^e < 0.01$, we replace the free entry condition for that country and industry with the condition that there is no entry in that country and industry, $\hat{M}_{is}^e = 0$, thereby imposing a corner solution. This happens very rarely in practice.

Production and the World Input-Output Database.[11]

3.1 Aggregation procedure for T_{ijs}

Our data on international and internal trade flows comes from the world input-output tables included in the World Input-Output Database. The data originally has 35 industries which we aggregate to 15 industries by combining "Agriculture, Hunting, Forestry, and Fishing" and "Mining and Quarrying" into "Other Tradables", "Textiles and Textile Products" and "Leather, Leather and Footwear" into "Textiles and Leather", and everything from "Electricity, Gas, and Water Supply" until "Private Households with Employed Persons" into "Nontraded Goods".

3.2 Estimation procedure for σ_s and θ_s

We estimate the demand elasticities σ_s using the theoretical prediction that industry wage payments are proportional to industry revenues with the factor of proportionality being equal to $\frac{\sigma_s - 1}{\sigma_s}$.[12] Instead of using wage payments, we use factor payments, that is the sum of payments to capital and labor. Calculating factor payments involves the rental rate of capital which we obtain by assuming that the sum of factor payments across all industries amounts to $\frac{2}{3}$ of the sum of revenues across all industries. We make this assumption since it implies a plausible aggregate profit share of $\frac{1}{3}$.

We estimate the trade elasticities θ_s using the estimates of σ_s and the theoretical prediction that firm sales follow a Pareto distribution with shape parameter $\frac{\theta_s}{\sigma_s - 1}$ within industries. We follow Eaton et al (2011) in restricting attention to exporters only and back out the shape parameter of the firm sales distribution from a regression of the logarithm of the firm sales rank

[11] The Annual Survey of Industrial Production is a census of all state-owned plants and all large private plants collected by China's National Bureau of Statistics. Additional details on this dataset can be found, for example, in Hsieh and Klenow (2009). The World Input-Output Database is documented in Timmer et al (forthcoming.)

[12] Strictly speaking, the model predicts that *variable* industry wage payments are proportional to industry revenues given the assumption that fixed costs are also incurred in terms of labor. We do not take this assumption literally when taking the model to the data and treat all reported factor payments as variable factor payments.

on the logarithm of firm sales. For our estimation of σ_s and θ_s, we use data on wage payments, capital stocks, and firm sales from the Chinese Annual Survey of Industrial Production.[13]

3.3 Estimation procedure for $\widehat{b}_{is}$

Our estimation of China's productivity growth proceeds in two steps. In the first step, we estimate the productivity growth of the representative Chinese firm in each industry $\widehat{\widetilde{\varphi}}_{iis}$. In the second step, we calculate the fundamental Chinese productivity growth $\widehat{b}_{is}$ in each industry from $\widehat{\widetilde{\varphi}}_{iis}$ by correcting for Melitz (2003) selection effects. Recall that an increase in the Pareto location parameter b_{is} shifts the entire distribution of possible productivity draws to the right. It differs from $\widetilde{\varphi}_{iis}$ because not all Chinese entrants find it optimal to serve the Chinese market given the fixed costs f_{iis}.

Our baseline model suggests to estimate $\widehat{\widetilde{\varphi}}_{iis}$ as the growth rate of real industry output per worker. To see this, recall that employment in a given firm is given by $\sum_j \frac{\tau_{ijs} x_{ijs}(\varphi)}{\varphi}$ which can be manipulated after substituting the pricing formula to yield $\widehat{\widetilde{\varphi}}_{iis} = \frac{1}{\widehat{p_{iis}(\widetilde{\varphi}_{iis})}} \frac{\widehat{S}_{is}}{\widehat{L}_{is}}$, where S_{is} are the total sales in industry s of country i and L_{is} is the total employment in industry s of country i.[14] The representative price $p_{iis}(\widetilde{\varphi}_{iis})$ is an output share weighted average of the prices charged by domestic producers in the industry which follows from rewriting it as $p_{iis}(\widetilde{\varphi}_{iis}) = \int_{\varphi^*_{iis}}^{\infty} p_{iis}(\varphi) \frac{x_{iis}(\varphi)}{x_{iis}(\widetilde{\varphi}_{iis})} g_{si}(\varphi | \varphi > \varphi^*_{iis}) \, d\varphi$.

We estimate $\widehat{\widetilde{\varphi}}_{iis}$ using our data from the Annual Survey of Industrial Production. Instead of computing the growth rate of industry output per worker, we compute the growth rate of industry output per composite factor of production which we take to be a Cobb-Douglas aggregate of capital and labor. We calculate the labor shares from the shares of wage payments

[13] While our estimation procedure for σ_s is fully consistent with the baseline model, it would really have to be somewhat adjusted to also be fully in line with the extended model. In particular, intermediate good expenditures would have to be included when calculating the share $\frac{\sigma_s - 1}{\sigma_s}$ which would tend to increase the estimated σ_s. However, capital expenditures would also have to be evaluated at a lower interest rate to maintain an aggregate profit share of $\frac{1}{3}$ which would tend to decrease the estimated σ_s. To keep our results comparable across specifications, we use the baseline estimates of σ_s and θ_s throughout.

[14] Strictly speaking, L_{is} is the total employment in industry s of country i *net of fixed costs* because we have assumed fixed costs to be incurred in terms of labor. As explained in footnote 12, we do not take this assumption literally when taking the model to the data.

in industry revenues net of profits and the capital shares as the residuals of these labor shares. We proxy for the representative price $p_{iis}\left(\widetilde{\varphi}_{iis}\right)$ using producer price deflators which we obtain from the China Statistical Yearbook.

When we work with the extended model, we adjust these baseline estimates by taking them to the power of the share of value added in gross production: $\widehat{\widetilde{\varphi}}_{iis}^{extended} = \left(\widehat{\widetilde{\varphi}}_{iis}^{baseline}\right)^{\eta_i^s}$. This adjustment is necessary because now $\widehat{\widetilde{\varphi}}_{iis}=\frac{1}{\widehat{p_{iis}(\widetilde{\varphi}_{iis})}} \frac{\widehat{S}_{is}}{\widehat{I}_{is}}$, where I_{is} is the aggregate input defined in equation (14) in the appendix. Intuitively, the productivity growth of the representative Chinese firm in each industry is now lower than the growth rate of real industry output per composite factor of production, because real industry output also grows because of the improved provision with intermediate goods. As should be easy to verify, our simple adjustment is exactly correct under the plausible assumption that real intermediate consumption grows at the same rate as real industry output: $\hat{C}_i^{I,s} = \frac{\hat{S}_{is}}{\widehat{p_{iis}(\widetilde{\varphi}_{iis})}}$.

Both models further imply $b_{is} = \left(\frac{\theta_s}{\theta_s \square \sigma_s+1}\right)^{\frac{1}{1 \square \sigma_s}} \left(\frac{\theta_s \square \sigma_s+1}{\sigma_s \square 1} \frac{f_{is}^e}{f_{iis}} \lambda_{iis}\right)^{\frac{1}{\theta_s}} \widetilde{\varphi}_{iis}$, where $\lambda_{iis} \equiv \frac{T_{iis}}{\sum_m T_{ims}}$ is an inverse measure of trade openness. Assuming that $\widehat{f^e}_{is} = \widehat{f}_{iis}$, $\widehat{b}_{is}$ can therefore be inferred from $\widehat{\widetilde{\varphi}}_{iis}$ using the relationship $\widehat{b}_{is} = \left(\widehat{\lambda}_{iis}\right)^{\frac{1}{\theta_s}} \widehat{\widetilde{\varphi}}_{iis}$. Intuitively, the term $\left(\widehat{\lambda}_{iis}\right)^{\frac{1}{\theta_s}}$ corrects for the effects changes in trade openness have on representative productivity (the Melitz (2003) selection effects). It is well-known that such selection effects are often important and ignoring them would have indeed biased our productivity growth estimates for some industries to a sizeable degree.

3.4 Estimation procedure for η_i^s, $\mu_{is}^{I,t}$, $\rho_i^{L,s}$, and $\rho_i^{K,s}$

We also obtain our estimates of the shares of value added in gross production, η_i^s, and the coefficients of the input-output tables, $\mu_{is}^{I,t}$, from the world input-output tables included in the World Input-Output Database. In particular, we calculate $\eta_i^s = 1 \square \frac{\sum_{m=1}^N \sum_{n=1}^N \sum_{t=1}^S T_{mnt}^{I,s}}{\sum_{m=1}^N \sum_{n=1}^N T_{mns}}$ and $\mu_{is}^{I,t} = \frac{\sum_{m=1}^N \sum_{n=1}^N \sum_{p=1}^S T_{mns}^{I,p}}{\sum_{m=1}^N \sum_{n=1}^N \sum_{q=1}^S \sum_{p=1}^S T_{mnq}^{I,p}}$, where $T_{mit}^{I,s}$ is the value of intermediate goods from industry t in country m purchased by industry s in country i and T_{ins} is again just the total value of industry s trade flowing from country i to country n.

Notice that these estimates average over countries and downstream industries, $\eta_i^s = \eta^s$ and $\mu_{is}^{I,t} = \mu_s^I$ for all i and t. As is explained in detail in Costinot and Rodriguez-Clare (2014), we cannot use the more disaggregated estimates $\eta_i^s = 1 \square \frac{\sum_{m=1}^N \sum_{t=1}^S T_{mit}^{I,s}}{\sum_{n=1}^N T_{ins}}$ and $\mu_{is}^{I,t} = \frac{\sum_{m=1}^N T_{mis}^{I,t}}{\sum_{m=1}^N \sum_{s=1}^S T_{mis}^{I,t}}$ in our calculations because entry would then lead to a process of cumulative causation in some countries and industries. Intuitively, if the share of value added in gross production is too low and the expenditure share on intermediates is too high in some industries, entry induces further entry because the increased variety reduces input costs too much.[15]

We calculate the shares of labor and capital in value added from the Socio Economic Accounts available from the World Input Output Database. These accounts include information on labor compensation, capital compensation, and value added so that we can construct the shares $\rho_i^{L,s}$ and $\rho_i^{K,s}$ straightforwardly.

3.5 Isolating the effects of China's productivity growth

Our goal is to isolate the spillover effects of China's productivity growth. To this end, we plug the measured productivity growth rates $\hat{b}_{is}$ into our model and simulate what would have happened to the world economy if only China's productivity had changed. We do this on a year-to-year basis considering all time periods from 1995-1996 until 2006-2007 and aggregate over the entire time span 1995-2007 in the end. For each time period, we use the trade data from the base year, that is 1995 trade data for the time period 1995-1996 and so on.[16] Of course, world trade flows change for many reasons other than China's productivity growth so that the factual end-of-period trade flows are generally different from the counterfactual

[15] When faced with the same problem, Balisteri et al (2011) only average over downstream industries. Unfortunately, this is not sufficient in our case so that we average over countries as well. Strictly speaking, our extended model even suggests to calculate $\eta_i^s = 1 \square \frac{\sum_{m=1}^N \sum_{t=1}^S T_{mit}^{I,s}}{\sum_{n=1}^N T_{ins} \square \frac{\theta_s \square \sigma_s + 1}{\theta_s \sigma_s} NX_{is}}$, where NX_{is} is the value of net exports in industry s of country i. The adjustment $\frac{\theta_s \square \sigma_s + 1}{\theta_s \sigma_s} NX_{is}$ is necessary because of our assumption that the fixed costs of exporting are incurred in destination country labor, capital, and intermediates. We do not take this assumption literally when taking the model to the data.

[16] More precisely, we allow T_{ijs}, η_i^s, and $\mu_{is}^{I,t}$ to vary over time but use the same values for σ_s, θ_s, $\hat{b}_{is}$, $\rho_i^{L,s}$, and $\rho_i^{K,s}$ throughout.

end-of-period trade flows our productivity growth counterfactuals predict.

3.6 Results

Table 4 reports the share of imports from all countries in total expenditure, both excluding as well as including nontraded goods. Table 5 summarizes the share of imports from China in total expenditure, again excluding as well as including nontraded goods. As can be seen, the share of Chinese imports in total expenditure is small in absolute terms even though the share of Chinese imports in total imports is rising over time. This suggests that the spillover effects of China's productivity growth will be small since they transmit through import shares as decomposition (11) makes clear.

Our estimates of σ_s and θ_s are listed in Table 6. Our estimates of σ_s range from 3.1 to 16.1 and average 6.1 and our estimates of θ_s range from 3.0 to 39.9 and average 8.5. These averages are broadly within the range of existing estimates found in the literature.[17] Notice that our estimates of σ_s and θ_s are such that θ_s is larger than $\sigma_s - 1$ throughout. This is consistent with our earlier theoretical assumption that $\theta_s > \sigma_s - 1$ and implies that the sales distribution deviates somewhat from Zipf's law. It ensures that the expected profits of entrants are always finite in all industries.

Our estimates of China's productivity growth rates are also listed in Table 6 and their distribution is plotted in Figure 1. To attenuate possible measurement error, we take China's productivity growth rates in each year to be the geometric average of the estimated productivity growth rates over all years. Notice that China's productivity growth rates are large and vary substantially across industries. They range from 5.0 percent to 13.8 percent and average 11.2 percent. To be clear, these are the unadjusted annualized values we use to calculate our baseline results.

Figure 2 plots these productivity growth rates against China's export orientation in each industry. As can be seen, China's import-competing industries tend to grow faster which

[17] Eaton and Kortum (2002), for example, estimate the trade elasticity to be 3.6 in one specification and 8.3 in another specification.

suggests that the associated terms-of-trade effects will tend to be negative. Similarly, Figure 3 plots them against the estimated trade elasticity in each industry. Notice that China's productivity growth rates tend to be higher in high trade elasticity industries which implies that the associated home market effects will tend to be positive. As a result, these two effects will tend to have an offsetting character.

Figures 4 and 5 summarize what would have happened to relative wages and entry if only China's productivity had changed. These effects are computed by simulating the general equilibrium effects of China's productivity growth using the baseline model for every year. In particular, Figure 4 shows that the wages of all countries relative to China's wages are predicted to fall, as one would expect.[18] Moreover, Figure 5 highlights that there is predicted to be entry into China's fast-growing industries and exit out of China's slow-growing industries, as one would also expect.

Table 7 builds on these calculations and shows what would have happened to welfare if only China's productivity had changed. The first column gives the predicted welfare effects on China, the second and third columns the predicted welfare effects on the "World" and the "Rest of the World" defined as the output share weighted averages of the predicted welfare effects on all countries and all countries other than China, and the last column the ratios of the entries in columns three and two. The last row computes the cumulative effects by taking geometric averages of the annual effects in the previous rows.

As can be seen, China's welfare is predicted to increase by a cumulative 259.8 percent, "World" welfare is predicted to increase by a cumulative 14.2 percent, and "Rest of the World" welfare is predicted to increase by a cumulative 0.213 percent. This implies that only 1.5 percent of the worldwide benefits of China's productivity growth are predicted to spill over to other countries. The above discussion suggests that this is because Chinese imports only account for a small share of total expenditure and the terms-of-trade and home market

[18] Recall that we take "labor" to be a Cobb-Douglas aggregate of capital and labor in our empirical application. As a consequence, changes in "wages" should then also be thought of as changes in Cobb-Douglas aggregates of interest rates and wages. For expositional simplicity, we continue to use the term "wages" in the text.

effects work in offsetting ways.

Table 8 explores these welfare effects further reporting the cumulative spillover effects on all countries and the components due to terms-of-trade and home market effects following approximation (11). Notice that all the welfare effects are small, ranging from -0.10 percent to 0.88 percent and averaging 0.07 percent. As we expect, the decomposition reveals that the terms-of-trade effects tend to be negative and the home market effects tend to be positive making them offset each other on average. They do not exactly add up to the welfare effects because they are computed using an approximation.

Table 9 investigates whether our simplifying assumptions of abstracting from multiple factors, intermediate goods, and nontraded goods make sense. In particular, it again reports the welfare effects computed using the baseline model and contrasts them to the welfare effects computed using the extended model, as explained in section 2.5 above. As can be seen, the results are indeed similar with the average welfare effect falling from 0.07 percent to -0.02 percent. This is because the spillover effects of China's productivity growth tend to be magnified by intermediate goods but dampened by nontraded goods.

This is further illustrated in Figure 6 which plots the welfare effects obtained from the baseline model against the welfare effects obtained from the extended model. Notice that the results are highly correlated especially when the outliers Canada, Korea, and Rest of the World are removed. The main reason why the welfare estimates tend to be a bit lower in the extended model is that we use scaled productivity growth estimates. Recall that we have to scale the productivity growth rates of the representative Chinese firm in each industry using the share of value added in gross production, $\widehat{\widetilde{\varphi}}_{iis}^{extended} = \left(\widehat{\widetilde{\varphi}}_{iis}^{baseline}\right)^{\eta_i^s}$, to keep the empirics consistent with the theory.

4 Conclusion

How does a country's productivity growth affect worldwide real incomes through international trade? In this paper, we took this classic question to the data by measuring the spillover effects of China's productivity growth. Our framework featured traditional terms-of-trade effects and new trade home market effects as suggested by the theoretical literature and worked from a reference point which perfectly matched industry-level trade. Focusing on the years 1995 to 2007, we found that the cumulative welfare effect on individual regions ranged between -0.1 percent and 0.9 percent and only 1.5 percent of the worldwide gains of China's productivity growth accrued to the rest of the world.

Our analysis is only a first pass at this question. Of the many possible extensions, a particularly interesting one would be to let aggregate manufacturing employment respond endogenously to productivity growth. On the one hand, this would dampen relative wage growth in China thereby generating additional terms-of-trade gains for the rest of the world. On the other hand, this would relocate aggregate manufacturing employment to China thereby inflicting additional home market losses on the rest of the world. These counteracting effects may well been quantitatively important in the case of China given the extent of rural-urban migration observed during the sample period.

5 Appendix: Extended model

This extension adds multiple factors, input-output linkages, and aggregate trade imbalances to our baseline model, as explained in section 2.5 of the main text. In the interest of clarity, we present it here in a self-contained fashion which involves briefly repeating some material from section 2. As in the main text, we keep derivations to a minimum and provide a detailed technical appendix upon request.

5.1 Basic setup

There are N countries and S industries. Each industry provides a continuum of differentiated varieties. These varieties are combined into final and intermediate consumption using the aggregators

$$C_j^F = \prod_{s=1}^{S} \left. \sum_{i=1}^{N} \int_0^{M_{ijs}} x_{ijs}^F (\nu_{is})^{\frac{\sigma_s - 1}{\sigma_s}} d\nu_{is} \right)^{\frac{\sigma_s}{\sigma_s - 1} \mu_{js}^F} \tag{12}$$

$$C_j^{I,t} = \prod_{s=1}^{S} \left. \sum_{i=1}^{N} \int_0^{M_{ijs}} x_{ijs}^{I,t} (\nu_{is})^{\frac{\sigma_s - 1}{\sigma_s}} d\nu_{is} \right)^{\frac{\sigma_s}{\sigma_s - 1} \mu_{js}^{I,t}} \tag{13}$$

where x_{ijs}^F is the quantity of an industry s variety from country i used for final consumption in country j, $x_{ijs}^{I,t}$ is the quantity of an industry s variety from country i used for intermediate consumption by industry t in country j, M_{ijs} is the number of industry s varieties from country i available in country j, $\sigma_s > 1$ is the elasticity of substitution between industry s varieties, μ_{js}^F is the fraction of country j's final consumption expenditure spent on industry s varieties, and $\mu_{js}^{I,t}$ is the fraction of country j's intermediate consumption expenditure from industry t spent on industry s varieties. Final consumption is turned one-for-one into utility so that $U_j = C_j^F$.

Firms are technologically heterogeneous which is captured by the following production process. Entrants into industry s of country i have to hire f_{is}^e units of an aggregate input specific to industry s of country i to draw their productivities φ from a Pareto distribution

$G_{is}(\varphi) = 1 - \left(\frac{b_{is}}{\varphi}\right)^{\theta_s}$, where f_{is}^e is a fixed cost of entry, b_{is} is the Pareto location parameter, and θ_s is the Pareto shape parameter. Entrants into industry s of country i wishing to sell to country j further need to hire $\frac{x_{ijs}\tau_{ijs}}{\varphi}$ units of an aggregate input specific to industry s in country i and f_{ijs} units of an aggregate input specific to industry s in country j to deliver x_{ijs} units of output to country j, where $\tau_{ijs} \geq 1$ is an iceberg trade barrier and f_{ijs} is a fixed cost of serving market j. Both the number of entrants into industry s of country i, M_{is}^e, and the fraction of entrants selling to country j, $\frac{M_{ijs}}{M_{is}^e}$, are endogenous.

The aggregate input specific to industry s of country i combines labor, L_{is}, capital, K_{is}, and intermediate goods in a Cobb-Douglas fashion and is given by

$$I_{is} = \left(\frac{1}{\eta_i^s} \left(\frac{L_{is}}{\rho_i^{L,s}}\right)^{\rho_i^{L,s}} \left(\frac{K_{is}}{\rho_i^{K,s}}\right)^{\rho_i^{K,s}} \right)^{\eta_i^s} \left(\frac{C_i^{I,s}}{1 - \eta_i^s}\right)^{1-\eta_i^s} \tag{14}$$

where η_i^s are the shares of value added in gross production and $\rho_i^{L,s}$ and $\rho_i^{K,s}$, $\rho_i^{L,s} + \rho_i^{K,s} = 1$, are the shares of labor and capital in value added. To be clear, we refer to these inputs as "aggregate" because they combine labor, capital, and intermediate goods and "country-industry-specific" because this is done with country-industry-specific weights. Labor and capital are freely mobile across sectors within countries as usual.

5.2 Equilibrium for given productivities

Given the Cobb-Douglas structure of the aggregate input (14), firms spend a fraction $1 - \eta_i^s$ of their input costs on intermediates, a fraction $\eta_i^s \rho_i^{L,s}$ of their input costs on workers, and a fraction $\eta_i^s \rho_i^{K,s}$ of their input costs on capital. This implies that intermediate costs and capital costs can be expressed in terms of labor costs as follows

$$E_i^{I,s} = \frac{1 - \eta_i^s}{\rho_i^{L,s} \eta_i^s} w_i L_{is} \tag{15}$$

$$r_i K_{is} = \frac{\rho_i^{K,s}}{\rho_i^{L,s}} w_i L_{is} \tag{16}$$

The total expenditure of country i on varieties from industry s, E_{is}, consists of final expenditures, $E_{is}^F = \mu_{is}^F (w_i L_i + r_i K_i - {}_i)$, and intermediate expenditures, $E_{is}^I = \sum_{t=1}^S \mu_{is}^{I,t} E_i^{I,t}$, where $w_i L_i$ is labor income, $r_i K_i$ is capital income, ${}_i$ is an inter-state transfer satisfying $\sum_{i=1}^N {}_i = 0$, and $E_i^{I,t}$ is the intermediate expenditure of industry t from country i overall. Together with equations (15) and (16), this implies

$$E_{is} = \sum_{t=1}^S \left(\mu_{is}^F \left(1 - \frac{{}_i}{\sum_{v=1}^S \frac{w_i L_{iv}}{\rho_i^{L,v}}} \right) \eta_i^t + \mu_{is}^{I,t} \left(1 - \eta_i^t \right) \right) \frac{w_i L_{it}}{\eta_i^t \rho_i^{L,t}} \tag{17}$$

Profit maximization requires that firms in industry s of country i whose productivity draws exceed φ_{ijs}^* charge $p_{ijs} = \frac{\sigma_s}{\sigma_s - 1} \frac{\tau_{ijs} c_{is}}{\varphi}$, where $\varphi_{ijs}^* = \frac{\sigma_s}{\sigma_s - 1} \frac{\tau_{ijs} c_{is}}{P_{js}} \left(\frac{\sigma_s c_{js} f_{ijs}}{E_{js}} \right)^{\frac{1}{\sigma_s - 1}}$ denotes the productivity cutoff above which revenues are sufficiently high to justify incurring the fixed costs of serving market j and c_{is} is the unit cost of the aggregate input. Letting w_i be the wage rate, r_i be the interest rate, and P_{is} be the ideal price index for industry s varieties in country i, this unit cost is given by

$$c_{is} = \left((w_i)^{\rho_i^{L,s}} (r_i)^{\rho_i^{K,s}} \right)^{\eta_i^s} \prod_{t=1}^S (P_{it})^{(1-\eta_i^s)\mu_{it}^{I,s}} \tag{18}$$

As before, the ideal price index is given by $P_{js} = \left(\sum_{i=1}^N M_{ijs} p_{ijs} \left(\widetilde{\varphi}_{ijs} \right)^{1-\sigma_s} \right)^{\frac{1}{1-\sigma_s}}$, where $\widetilde{\varphi}_{ijs} = \left(\int_{\varphi_{ijs}^*}^{\infty} \varphi^{\sigma_s - 1} g_{is}(\varphi | \varphi > \varphi^*) d\varphi \right)^{\frac{1}{\sigma_s - 1}}$ denotes the productivity of the representative firm in industry s of country i selling to country j which can be simplified to $\widetilde{\varphi}_{ijs} = \left(\frac{\theta_s}{\theta_s - \sigma_s + 1} \right)^{\frac{1}{\sigma_s - 1}} \varphi_{ijs}^*$ by imposing the Pareto assumption. Upon noticing that $M_{ijs} = \left(\frac{b_{is}}{\varphi_{ijs}^*} \right)^{\theta_s} M_{is}^e$, this can be rewritten using the pricing formula and the definition of φ_{ijs}^* as

$$P_{js} = \left(\sum_{i=1}^N \frac{\theta_s}{\theta_s - \sigma_s + 1} M_{is}^e \left(\frac{\sigma_s}{\sigma_s - 1} \frac{\tau_{ijs} c_{is}}{b_{is}} \right)^{-\theta_s} \left(\frac{\sigma_s c_{js} f_{ijs}}{E_{js}} \right)^{\frac{\sigma_s - \theta_s - 1}{\sigma_s - 1}} \right)^{-\frac{1}{\theta_s}} \tag{19}$$

Free entry drives expected profits to zero so that $\sum_{j=1}^{N} prob\left(\varphi > \varphi_{ijs}^{*}\right) E\left(\pi_{ijs}|\varphi > \varphi_{ijs}^{*}\right) = c_{is}f_{is}^{e}$, where $prob(\varphi > \varphi_{ijs}^{*}) = (\frac{b_{is}}{\varphi_{ijs}^{*}})^{\theta_s}$ is the probability that an entrant into industry s of country i sells to country j and $E(\pi_{ijs}|\varphi > \varphi_{ijs}^{*}) = \frac{\sigma_s \square 1}{\theta_s \square \sigma_s + 1} c_{js} f_{ijs}$ are the expected operating profits of an entrant into industry s of country i from selling to country j conditional on selling to country j. Invoking again that $M_{ijs}= (\frac{b_{is}}{\varphi_{ijs}^{*}})^{\theta_s} M_{is}^{e}$, this can be rewritten using the pricing formula and the definition of φ_{ijs}^{*} as

$$c_{is}\frac{\theta_s\sigma_s}{\sigma_s \square 1} f_{is}^{e} = \sum_{j=1}^{N} \frac{\left(f_{ijs}\right)^{\frac{\sigma_s \square \theta_s \square 1}{\sigma_s \square 1}} \left(\frac{\tau_{ijs}c_{is}}{b_{is}}\right)^{\square \theta_s}}{\sum_{m=1}^{N} M_{ms}^{e} \left(f_{mjs}\right)^{\frac{\sigma_s \square \theta_s \square 1}{\sigma_s \square 1}} \left(\frac{\tau_{mjs}c_{ms}}{b_{ms}}\right)^{\square \theta_s}} E_{js} \tag{20}$$

Input market clearing ensures $I_{is} = M_{is}^{e}\left(\theta_s + 1\right) f_{is}^{e} + \frac{\theta_s \square \sigma_s + 1}{c_{is}\theta_s\sigma_s} E_{is}$, where $M_{is}^{e}\left(\theta_s + 1\right) f_{is}^{e}$ captures the amount of inputs required by all entrants into industry s of country i to cover their fixed cost of entry as well as their variable costs of production and $\frac{\theta_s \square \sigma_s + 1}{c_{is}\theta_s\sigma_s} E_{is}$ captures the amount of inputs required by all industry s firms serving country i to cover their fixed cost of exporting. Solving this for M_{is}^{e} and adding basic labor market and capital market clearing, one obtains

$$M_{is}^{e} = \frac{1}{\left(\theta_s + 1\right) c_{is} f_{is}^{e}} \left. \frac{w_i L_{is}}{\rho_i^{L,s}\eta_i^{s}} \square \frac{\theta_s \square \sigma_s + 1}{\theta_s\sigma_s} E_{is} \right) \tag{21}$$

$$L_i = \sum_{s=1}^{S} L_{is} \tag{22}$$

$$K_i = \sum_{s=1}^{S} K_{is} \tag{23}$$

Equations (16) - (23) represent a system of $6NS+2N$ equations in the $6NS+2N$ unknowns $\{E_{is}, c_{is}, P_{is}, L_{is}, K_{is}, M_{is}^{e}, w_i, r_i\}$ which can be solved up to a numeraire. However, it is again useful to express them in changes to deal with the large number of unknown parameters.

5.3 General equilibrium effects of productivity shocks

Following the method popularized by Dekle et al (2007), equations (16) - (23) can be written in changes as

$$\hat{w}_i \hat{L}_{it} = \hat{r}_i \hat{K}_{it} \tag{24}$$

$$\hat{E}_{is} = \sum_{t=1}^{S} \frac{E_{is}^t}{E_{is}} \frac{\mu_{is}^F \left(1 - \frac{\Omega_i}{\sum_{v=1}^S \frac{w_i L_{iv} \hat{w}_i \hat{L}_{iv}}{\rho_i^{L,v}}}\right) \eta_i^t + \mu_{is}^{I,t} \left(1 - \eta_i^t\right)}{\mu_{is}^F \left(1 - \frac{\Omega_i}{\sum_{v=1}^S \frac{w_i L_{iv}}{\rho_i^{L,v}}}\right) \eta_i^t + \mu_{is}^{I,t} \left(1 - \eta_i^t\right)} \hat{w}_i \hat{L}_{it} \tag{25}$$

$$\hat{c}_{is} = \left((\hat{w}_i)^{\rho_i^{L,s}} (\hat{r}_i)^{\rho_i^{K,s}} \right)^{\eta_i^s} \prod_{t=1}^{S} \left(\hat{P}_{it}\right)^{(1-\eta_i^s)\mu_{it}^{I,s}} \tag{26}$$

$$P_{js} = \left(\sum_{i=1}^{N} \alpha_{ijs} \hat{M}_{is}^e \left(\frac{\hat{c}_{is}}{\hat{b}_{is}}\right)^{-\theta_s} \left(\frac{\hat{c}_{js}}{\hat{E}_{js}}\right)^{\frac{\sigma_s - \theta_s - 1}{\sigma_s - 1}} \right)^{-\frac{1}{\theta_s}} \tag{27}$$

$$\hat{c}_{is} = \sum_{j=1}^{N} \beta_{ijs} \frac{\left(\frac{\hat{c}_{is}}{\hat{b}_{is}}\right)^{-\theta_s}}{\sum_{m=1}^N \alpha_{mjs} \hat{M}_{ms}^e \left(\frac{\hat{c}_{ms}}{\hat{b}_{ms}}\right)^{-\theta_s}} \hat{E}_{js} \tag{28}$$

$$\hat{M}_{is}^e = \frac{1}{\hat{c}_{is}} \left(\frac{\frac{w_i L_{is}}{\rho_i^{L,s} \eta_i^s}}{\frac{w_i L_{is}}{\rho_i^{L,s} \eta_i^s} - \frac{\theta_s - \sigma_s + 1}{\theta_s \sigma_s} E_{is}} \hat{w}_i \hat{L}_{is} - \frac{\frac{\theta_s - \sigma_s + 1}{\theta_s \sigma_s} E_{is}}{\frac{w_i L_{is}}{\rho_i^{L,s} \eta_i^s} - \frac{\theta_s - \sigma_s + 1}{\theta_s \sigma_s} E_{is}} \hat{E}_{is} \right) \tag{29}$$

$$w_i L_i = \sum_{s=1}^{S} w_i L_{is} \hat{L}_{is} \tag{30}$$

$$r_i K_i = \sum_{s=1}^{S} r_i K_{is} \hat{K}_{is} \tag{31}$$

where a hat denotes the ratio between the counterfactual and factual value, $\alpha_{ijs} = \frac{T_{ijs}}{\sum_{m=1}^N T_{mjs}}$, $\beta_{ijs} = \frac{T_{ijs}}{\sum_{n=1}^N T_{ins}}$, $NX_{is} = \sum_{n=1}^N T_{ins} - \sum_{m=1}^N T_{mis}$, $w_i L_{is} = \eta_i^s \rho_i^{L,s} \left(\sum_{n=1}^N T_{ins} - \frac{\theta_s - \sigma_s + 1}{\theta_s \sigma_s} NX_{is}\right)$, $r_i K_{is} = \eta_i^s \rho_i^{K,s} \left(\sum_{n=1}^N T_{ins} - \frac{\theta_s - \sigma_s + 1}{\theta_s \sigma_s} NX_{is}\right)$, $E_i^{I,s} = (1 - \eta_i^s) \left(\sum_{n=1}^N T_{ins} - \frac{\theta_s - \sigma_s + 1}{\theta_s \sigma_s} NX_{is}\right)$, $E_{is}^{I,t} = \mu_{is}^{I,t} E_i^{I,t}$, $\square_i = \sum_{s=1}^S \frac{(\theta_s + 1)(\sigma_s - 1)}{\theta_s \sigma_s} NX_{is}$, $E_i^F = \sum_{s=1}^S (w_i L_{is} + r_i K_{is}) - \square_i$, $E_{is} =$

$\sum_{m=1}^{N} T_{mis}$, $E_{is}^{F} = E_{is} \square \sum_{t=1}^{S} E_{is}^{I,t}$, $\mu_{is}^{F} = \frac{E_{is}^{F}}{E_{i}^{F}}$, $E_{is}^{t} = \mu_{is}^{F} \quad 1 \square \frac{\Omega_i}{\sum_t \frac{w_i L_{it}}{\rho_i^{L,t}}} \Bigg) \frac{w_i L_{it}}{\rho_i^{L,t}} + E_{is}^{I,t}$, and T_{ijs} denotes the factual value of industry s trade flowing from country i to country j.

Equations (24) - (31) represent a system of $6NS+2N$ equations in the $6NS+2N$ unknowns $\left\{\hat{E}_{is}, \hat{c}_{is}, \hat{P}_{is}, \hat{L}_{is}, \hat{K}_{is}, \hat{M}_{is}^{e}, \hat{w}_i, \hat{r}_i\right\}$. As shown above, their coefficients can be expressed in terms of σ_s, θ_s, η_i^s, $\rho_i^{L,t}$, $\rho_i^{K,t}$ and observable trade flows only. It is easy to verify that the model reduces to the baseline model from section 2 for $\eta_i^s = \rho_i^{L,s} = 1 \; \forall \; i$ and s and $\quad_i = 0 \; \forall \; i$.

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6 Tables

TABLE 1: Hypothetical Effect of Chinese Productivity Growth on Relative Wages and Entry

$\widehat{w}_{CH}/\widehat{w}_{US}$	$\widehat{M}^e_{CH,1}$	$\widehat{M}^e_{CH,2}$	$\widehat{M}^e_{US,1}$	$\widehat{M}^e_{US,2}$
4.3%	21.5%	-21.5%	-22.4%	22.4%

Notes: Entries are predicted growth rates in Chinese wage relative to US wage (column 1), Chinese number of entrants in industry 1 and 2 (columns 2 and 3), and US number of entrants in industry 1 and 2 (columns 4 and 5) from 10% productivity growth in China in industry 1. Simulation assumes that nominal incomes are the same in both countries, industry expenditure shares are 50% in both countries and industries, import expenditure shares are 20% in both countries and industries, theta1=theta2=5, and sigma1=sigma2=3.

TABLE 2: Hypothetical Effect of Chinese Productivity Growth on US Welfare

	Terms-of-trade	+	Home market	≈	Total
$NX_{CH,1} > 0$	0.6%		0.0%		0.8%
$NX_{CH,1} = 0$	0.1%		0.0%		0.4%
$NX_{CH,1} < 0$	-0.4%		0.0%		-0.2%

Notes: Entries are predicted growth rates in US real income due to the terms-of-trade effect (column 1) and the home market effect (column 2) from 10% productivity growth in China in industry 1 following equation (11). Column 3 calculates net welfare gain following equation (10). Simulation assumes that nominal incomes are the same in both countries, industry expenditure shares are 50% in both countries and industries, theta1=theta2=5, and sigma1=sigma2=3. In the first row, China is assumed to have an import expenditure share of 10% in industry 1 and an import expenditure share of 30% in industry 2 with the US being the mirror image so that China is a net exporter in industry 1. In the second row, import expenditure shares are assumed to be 20% in both countries and industries so that there is only intra-industry trade. In the third row, China is assumed to have an import expenditure share of 30% in industry 1 and an import expenditure share of 10% in industry 2 with the US being the mirror image so that China is a net importer in industry 1.

TABLE 3: Hypothetical Effect of Chinese Productivity Growth on US Welfare

	Terms-of-trade	+	Home market	≈	Total
$\theta_1 > \theta_2$	-0.2%		1.0%		1.0%
$\theta_1 = \theta_2$	0.1%		0.0%		0.4%
$\theta_1 < \theta_2$	0.4%		-0.9%		-0.2%

Notes: Entries are predicted growth rates in US real income due to the terms-of-trade effect (column 1) and the home market effect (column 2) from 10% productivity growth in China in industry 1 following equation (11). Column 3 calculates net welfare gain following equation (10). Simulation assumes that nominal incomes are the same in both countries, industry expenditure shares are 50% in both countries, import expenditure shares are 20% in both countries and industries, and sigma1=sigma2=3. In the first row, theta1=7 and theta2=3. In the second row, theta1=5 and theta2=5. In the third row, theta1=3 and theta2=7.

TABLE 4: Share of Imports in Total Expenditure

	w/o non-traded			w/ non-traded		
	1995	2001	2007	1995	2001	2007
Brazil	10.3%	15.5%	13.0%	4.9%	7.4%	6.4%
Canada	44.3%	49.1%	45.9%	18.2%	19.9%	17.2%
Germany	28.6%	38.7%	46.1%	11.2%	15.8%	19.4%
Spain	24.5%	33.3%	38.8%	10.5%	14.5%	15.0%
France	29.6%	35.2%	40.5%	10.1%	12.7%	13.2%
United Kingdom	34.2%	41.7%	47.2%	13.1%	13.2%	13.6%
India	8.1%	12.5%	19.0%	5.7%	7.0%	11.1%
Italy	23.3%	27.7%	31.9%	10.5%	11.8%	13.3%
Japan	9.1%	12.6%	18.5%	3.7%	4.8%	7.6%
South Korea	21.8%	25.0%	26.6%	12.7%	14.5%	16.0%
Mexico	25.4%	31.2%	34.7%	12.9%	14.6%	16.0%
Russia	20.9%	22.8%	23.7%	10.7%	11.5%	11.0%
United States	17.6%	21.5%	26.1%	6.1%	6.5%	8.1%
Rest of the World	21.4%	23.4%	26.8%	12.3%	13.4%	14.8%
Median	22.6%	26.3%	29.4%	10.6%	12.9%	13.5%

Notes: Entries are imports/total expenditure, either excluding or including non-traded goods.

TABLE 5: Share of Chinese Imports in Total Expenditure

	w/o non-traded			w/ non-traded		
	1995	2001	2007	1995	2001	2007
Brazil	0.2%	0.4%	1.4%	0.1%	0.2%	0.6%
Canada	1.2%	1.6%	4.2%	0.5%	0.7%	1.5%
Germany	0.7%	1.1%	3.2%	0.2%	0.4%	1.2%
Spain	0.3%	0.6%	2.0%	0.1%	0.3%	0.9%
France	0.5%	0.8%	2.2%	0.1%	0.3%	0.7%
United Kingdom	0.8%	1.5%	3.2%	0.3%	0.5%	0.8%
India	0.3%	0.7%	2.8%	0.2%	0.4%	1.5%
Italy	0.4%	0.6%	1.6%	0.2%	0.3%	0.6%
Japan	0.8%	1.6%	3.4%	0.3%	0.6%	1.3%
South Korea	1.1%	2.4%	4.6%	0.7%	1.5%	2.8%
Mexico	0.2%	0.7%	3.4%	0.1%	0.3%	1.5%
Russia	0.5%	1.0%	2.8%	0.3%	0.5%	1.3%
United States	1.0%	1.4%	3.9%	0.3%	0.4%	1.1%
Rest of the World	0.8%	1.4%	4.0%	0.4%	0.8%	1.9%
Median	0.6%	1.1%	3.2%	0.3%	0.4%	1.3%

Notes: Entries are imports from China/total expenditure, either excluding or including non-traded goods.

TABLE 6: Estimated elasticities and productivity growth

	σ	θ	$\triangle b/b$
Other tradables	6.1	8.5	11.2%
Food, beverages, and tobacco	3.3	6.1	12.3%
Textiles and leather	6.1	9.5	6.8%
Wood and products of wood and cork	4.6	7.1	10.8%
Pulp, paper, printing and publishing	16.1	39.9	9.3%
Coke, refined petroleum, and nuclear fuel	6.5	8.5	7.5%
Chemicals and chemical products	11.4	37.4	13.8%
Rubber and plastics	6.3	11.5	9.6%
Other non-metallic minerals	3.5	6.7	12.0%
Basic metals and fabricated metals	3.1	4.9	12.3%
Other machinery	8.0	22.3	12.5%
Electrical and optical equipment	3.5	5.6	12.8%
Transport equipment	7.4	18.9	11.2%
Other manufacturing and recycling	3.1	3.0	5.0%
Non-tradables	6.1	8.5	11.2%
Median	6.1	8.5	11.2%

Notes: Entries are industry descriptions, estimated σ_s, estimated θ_s, and the geometric averages of the estimated $\frac{\triangle b_{is}}{b_{is}}=\widehat{b}_{is}$□1. Since we only have data on Chinese manufacturing firms, we cannot estimate σ_s, θ_s, and $\frac{\triangle b_{is}}{b_{is}}$ for "Other tradables" and "Non-tradables" and simply use the average values for those.

TABLE 7: Welfare Gains from China's Productivity Growth

	China	World	Rest of World	Share Rest of World
95-96	11.3%	0.70%	0.005%	0.7%
96-97	11.2%	0.81%	0.007%	0.8%
97-98	11.3%	0.90%	0.011%	1.2%
98-99	11.3%	0.97%	0.010%	1.1%
99-00	11.2%	0.97%	0.012%	1.2%
00-01	11.2%	1.01%	0.014%	1.4%
01-02	11.1%	1.14%	0.015%	1.3%
02-03	11.1%	1.01%	0.019%	1.8%
03-04	11.2%	1.15%	0.023%	2.0%
04-05	11.2%	1.38%	0.030%	2.2%
05-06	11.4%	1.54%	0.032%	2.1%
06-07	11.6%	1.79%	0.035%	2.0%
95-07	259.8%	14.2%	0.213%	1.5%

Notes: Entries are predicted welfare changes from productivity growth in China. World welfare gain is average welfare gain in the world weighted by each country's output share. Rest of World refers to countries other than China. 95-07 welfare gain (last row) is cumulative welfare gain from 1995 to 2007.

TABLE 8: Decomposition of Welfare Gains from China's Productivity Growth

	Welfare	≈	Terms-of-trade	+	Home market	=	Sum
Brazil	0.02%		0.05%		-0.07%		-0.02%
Canada	0.22%		-0.20%		0.27%		0.07%
Germany	-0.10%		-0.03%		-0.16%		-0.19%
Spain	-0.08%		-0.03%		-0.12%		-0.15%
France	-0.01%		0.00%		-0.10%		-0.10%
United Kingdom	-0.08%		-0.07%		-0.14%		-0.21%
India	0.40%		0.28%		0.08%		0.36%
Italy	0.05%		-0.03%		0.00%		-0.03%
Japan	0.28%		-0.08%		0.24%		0.16%
South Korea	0.88%		0.32%		0.47%		0.79%
Mexico	0.08%		0.04%		0.00%		0.04%
Russia	-0.03%		-0.19%		0.02%		-0.17%
United States	0.11%		-0.16%		0.09%		-0.07%
Rest of the World	0.50%		-0.03%		0.43%		0.40%
Median	0.07%		-0.03%		0.01%		-0.02%

Notes: Entries are cumulative effects from 1995 to 2007 from China's productivity growth. Column 1 gives net welfare gain following equation (10), columns 2-3 the terms-of-trade effects and home market effects following equation (11), and column 4 the sum of columns 2-3.

TABLE 9: Welfare effects in extended model

	Baseline model	Extended model
Brazil	0.02%	-0.05%
Canada	0.22%	-0.23%
Germany	-0.10%	-0.02%
Spain	-0.08%	-0.11%
France	-0.01%	-0.01%
United Kingdom	-0.08%	-0.07%
India	0.40%	0.14%
Italy	0.05%	0.00%
Japan	0.28%	0.08%
South Korea	0.88%	0.23%
Mexico	0.08%	0.07%
Russia	-0.03%	-0.12%
United States	0.11%	0.00%
Rest of the World	0.50%	-0.14%
Median	0.07%	-0.02%

Notes: Entries are cumulative effects from 1995 to 2007 from China's productivity growth. Column 1 gives the welfare effects from the baseline model. Column 2 shows the welfare effects from the extended model, featuring non-traded goods, intermediate goods, and multiple factors.

7 Figures

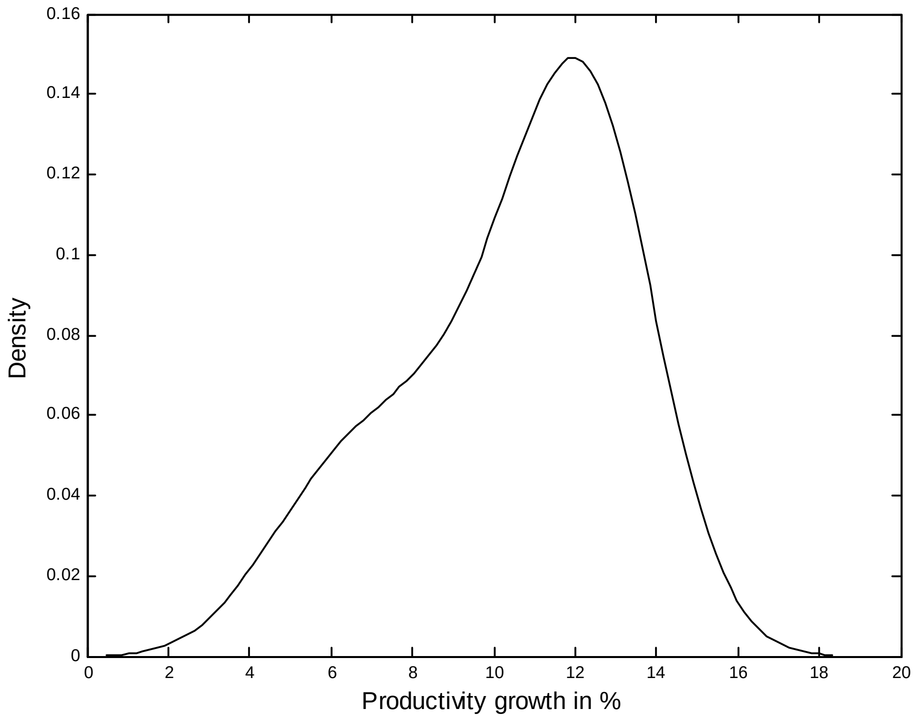

Figure 1: Distribution of productivity growth across manufacturing industries in China

Notes: This is a kernel density plot of the geometric average of the estimated productivity growth rates from 1995 to 2007 across manufacturing industries in China.

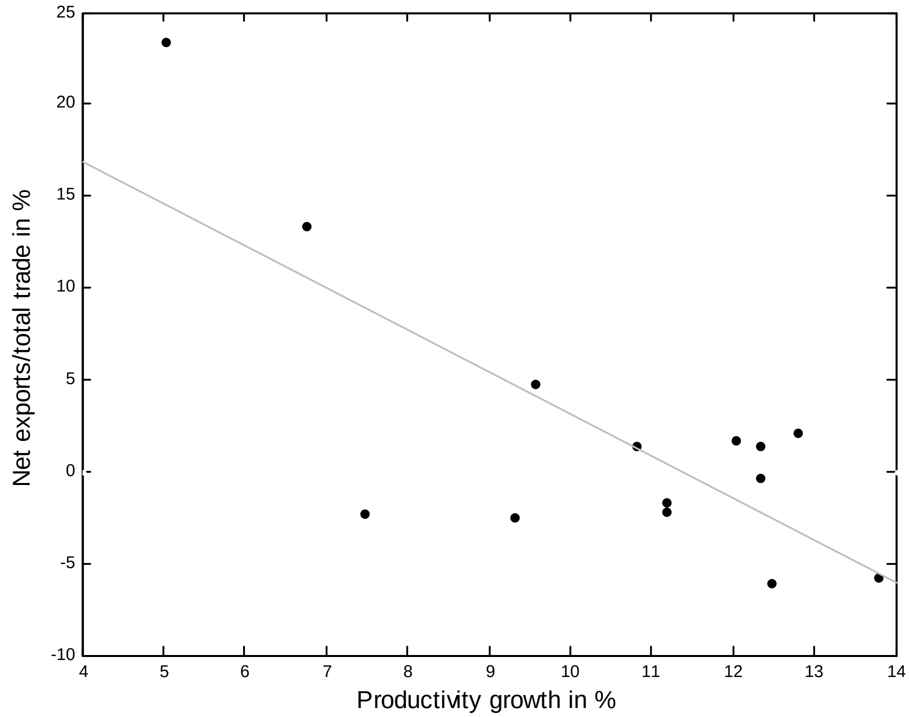

Figure 2: Industry productivity growth and industry net exports in China

Notes: This figure plots the relationship between industry productivity growth and normalized industry net exports in China. Productivity growth is computed as in Figure 1. Industry net exports are computed as the simple average of industry net exports from 1995-2007. Total trade is computed as the simple average of the sum of exports and imports from 1995-2007. The line is a linear regression line.

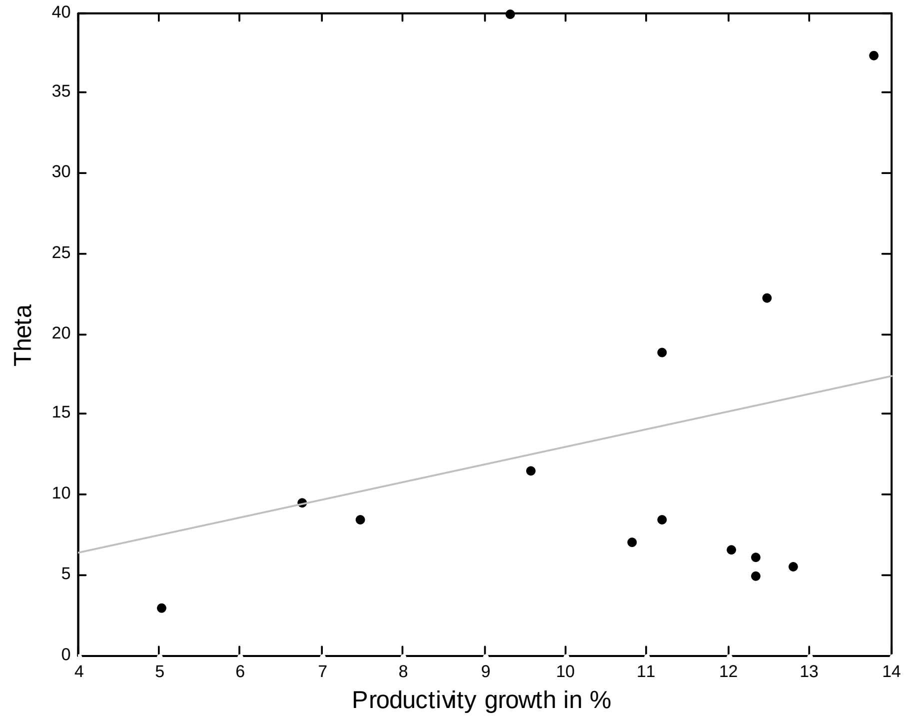

Figure 3: Industry productivity growth and industry trade elasticities in China

Notes: This figure plots the relationship between industry productivity growth and industry trade elasticities in China. Productivity growth is computed as in Figure 1. The line is a linear regression line.

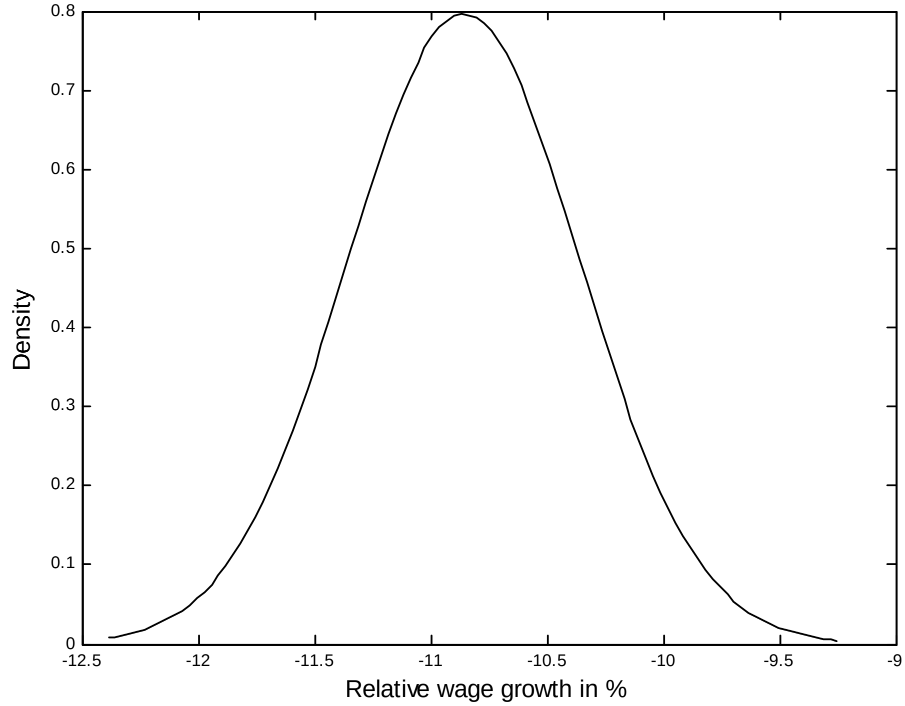

Figure 4: Distribution of predicted changes in wages relative to China's wage

Notes: This is a kernel density plot of the simple average of the predicted annual changes in wages relative to China's wage from 1995 to 2007 across China's trading partners.

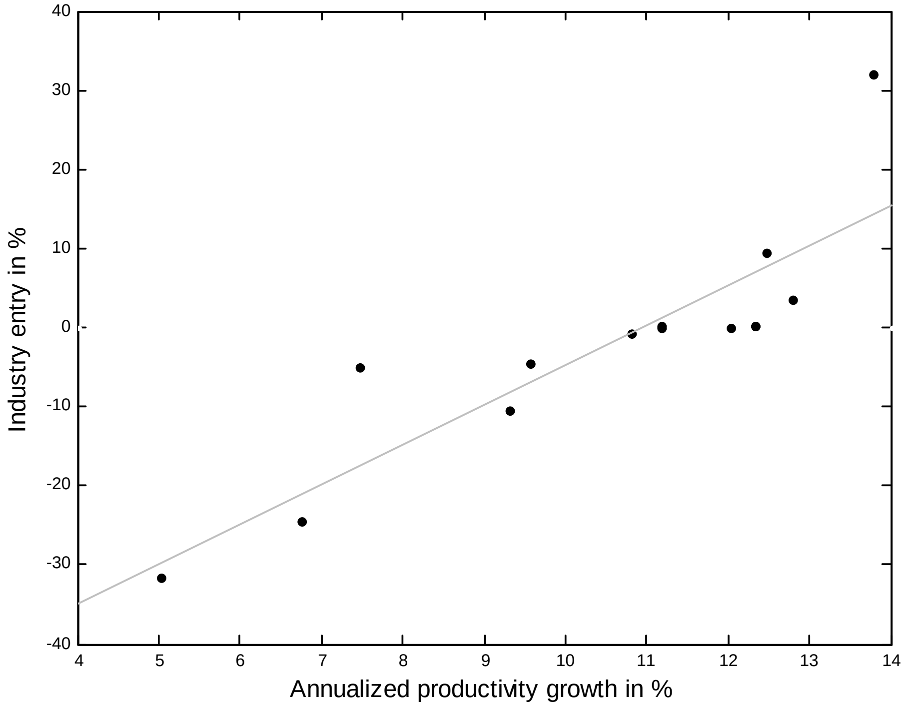

Figure 5: Industry entry and industry productivity growth in China

Notes: This figure plots the relationship between industry productivity growth and industry entry in China. Productivity growth is computed as in Figure 1. Industry entry is computed as the simple average of the predicted annual changes in the number of industry entrants from 1995-2007. The line is a linear regression line.

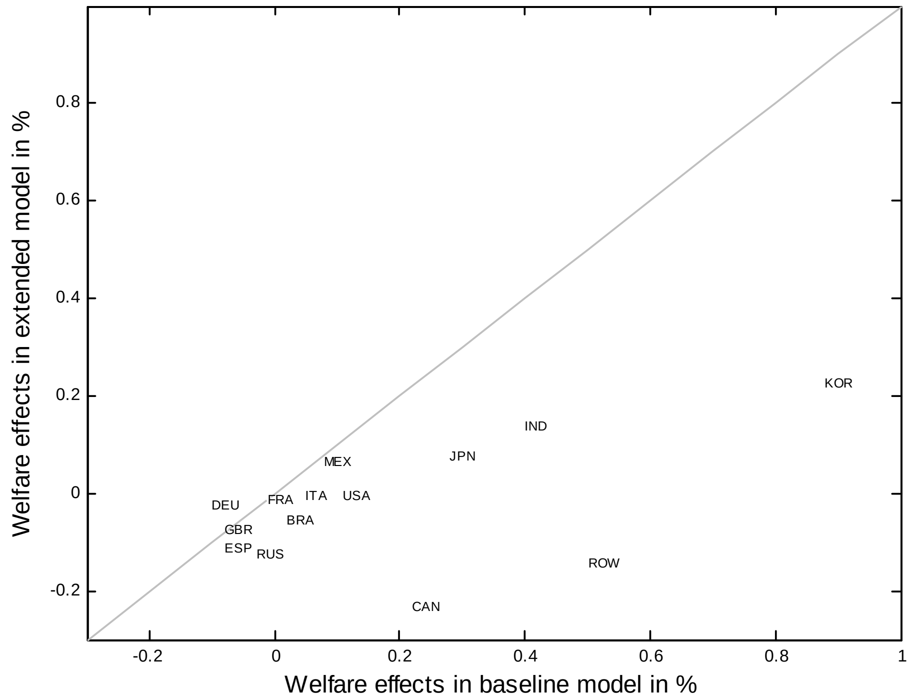

Figure 6: Welfare effects in baseline model versus extended model

Notes: This figure plots the entries from Table 9. The line is the 45 degree line.