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A GLOBAL VIEW OF PRODUCTIVITY GROWTH IN CHINA

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ABSTRACT

We revisit a classic question in international economics: how does a country's productivity growth affect worldwide real incomes through international trade? We first identify the channels through which productivity shocks transmit in a model featuring inter-industry trade as in Ricardo (1817), intra-industry trade as in Krugman (1980), and firm heterogeneity as in Melitz (2003). We then estimate China's productivity growth at the industry level and use our model to quantify what would have happened to real incomes throughout the world if nothing but China's productivity had changed. We find that average real income in the rest of the world increased by a cumulative 0.48% from 1992-2007 due to China's productivity growth. This represents 2.2% of the total income gains to the world.

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1 Introduction

In an economy closed to international trade, real income given factor inputs depends only on total factor productivity (TFP). Holding factor inputs fixed, a 10 percent increase in TFP simply results in a 10 percent increase in real income. In an economy open to international trade, real income given factor inputs is instead also affected by the gains from trade. Holding factor inputs fixed, a 10 percent increase in TFP then no longer necessarily leads to a 10 percent increase in real income since the TFP shock then also spills over to other countries through changes in the gains from trade.

A classic literature including Hicks (1952), Johnson (1955), Bhagwati (1958), and Dornbusch, Fischer, and Samuelson (1977) analyzes such spillover effects in the context of simple trade models in which the gains from trade derive solely from comparative advantage. The central message of this work is that the international spillover effects of a country's TFP growth can be positive or negative. In particular, TFP growth tends to benefit the trading partner if it is biased towards the export-oriented industry as this improves the trading partner's terms-of-trade. In contrast, TFP growth tends to harm the trading partner if it is biased towards the import-competing industry as this deteriorates the trading partner's terms-of-trade.

Despite the potential importance of such spillover effects, surprisingly little is known about their empirical importance. Some ground is covered by Eaton and Kortum (2002) who illustrate their seminal framework by quantifying the effects of hypothetical TFP shocks on other countries.[1] However, their analysis focuses on hypothetical TFP shocks only and is also subject to two methodological limitations. In particular, their framework only allows for aggregate TFP shocks and therefore cannot account for biased TFP shocks of the sort emphasized by the classic literature. Also, their framework only features gains from comparative advantage and therefore cannot capture potential spillover effects through changes in

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

the gains from increased variety or the gains from increased industry productivity that are the focus of much of the 'new' trade literature.

In this paper, we quantify the spillover effects of actual TFP shocks using a methodology which does not suffer from these limitations. At the core of our analysis lies 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). This model allows us to account for biased TFP shocks as well as spillover effects through changes in the 'new' gains from trade.

Our application focuses on the TFP growth associated with China's emergence as a global manufacturing powerhouse during the past two decades. Specifically, we measure China's TFP growth at the 2-digit industry level for the years 1992 through 2007 from plant level data, and use our model to quantify what would have happened to real incomes around the world if nothing but China's TFP had changed. We find that the TFP of the median Chinese manufacturing industry grew at an average rate of 15% per year with a standard deviation of 3.6. Our estimates suggest that the cumulative spillover effect of China's productivity growth was a 0.48% increase in the average real income of the rest of the world. This implies that 2.2% of the cumulative worldwide gains from China's productivity growth accrued to the rest of the world.

In terms of the question we ask, our work is most closely related to the classic literature on the spillover effects of productivity growth as well as Eaton and Kortum's (2002) important paper. Such spillover effects are also central to Acemoglu and Ventura (2002) who incorporate an endogenous growth model into an Armington (1969) model of international trade. Since growth is export-biased in such a model, higher growth leads to a deterioration of the terms-of-trade which generates de facto diminishing returns to growth. In terms of the model we use, our framework is a multi-industry extension of the Melitz (2003) model used by Arkolakis et al (2008, 2010). Arkolakis et al (2008, 2010) demonstrate how changes in the gains from trade can be measured from observed changes in openness. Here, we essentially predict counterfactual changes in openness from observed changes in China's TFP. Notice that changes in China's TFP are but only one of the multiple forces that affect openness so that observed changes in openness are not informative of the spillover effects of China's productivity growth.

The remainder of the paper is structured as follows. Section 2 introduces the framework, identifies the channels through which productivity shocks affect welfare, and demonstrates how we quantify the global welfare effects of productivity growth. Section 3 shows how we estimate China's productivity growth, describes the data, and reports the empirical results. In the interest of brevity, derivations are omitted in the main text. A detailed technical appendix is available upon request.

2 Theoretical framework

2.1 Setup

There are N countries indexed by i or j and S industries indexed by s. Consumers have access to a continuum of differentiated varieties. Preferences over these varieties are summarized by the following utility functions

$$U_j = \prod_s \left(\sum_i \int_0^{M_{ijs}} x_{ijs} \left(\nu_{is}\right)^{\frac{\sigma_s - 1}{\sigma_s}} d\nu_{is} \right)^{\frac{\sigma_s}{\sigma_s - 1}\mu_{js}} \tag{1}$$

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 fe_{is} units of labor in country i to draw their productivities φ from a distribution $G_{is}(\varphi)$, where fe_{is} is a fixed cost of entry. We assume that $G_{is}(\varphi)$ varies by country and industry giving rise to Ricardian comparative advantage. 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} a fixed cost of serving market j. Both the number of entrants into industry s of country i Me_{is} and the fraction of entrants selling to country j $\frac{M_{ijs}}{Me_{is}}$ are endogenous.

2.2 Equilibrium

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

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

where p_{ijs} is the delivered price of an industry s variety, $P_{js} \equiv \left(\sum_i \int_0^{M_{ijs}} p_{ijs} \left(\nu_{is}\right)^{1-\sigma_s} d\nu_{is} \right)^{\frac{1}{1-\sigma_s}}$ the ideal price index of all industry s varieties, ω_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

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

where $\varphi_{ijs}^* \equiv \frac{\sigma_s}{\sigma_s-1} \frac{\tau_{ijs}\omega_i}{P_{js}} \left(\frac{\sigma_s f_{ijs}}{\mu_{js} L_j}\right)^{\frac{1}{\sigma_s-1}}$ denotes the productivity cutoff above which revenues are sufficiently high to justify incurring the fixed costs of exporting. Free entry yields

$$\sum_j prob\left(\varphi > \varphi_{ijs}^*\right) E\left(\pi_{ijs} | \varphi > \varphi_{ijs}^*\right) = \omega_i fe_{is} \tag{4}$$

where $prob(\varphi > \varphi_{ijs}^*)$ is the probability that an entrant into industry s of country i sells to country j and $E(\pi_{ijs}|\varphi > \varphi_{ijs}^*)$ 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. Labor market clearing ensures

$$\delta_i L_i = \sum_s Me_{is} E\left(l_{is}^{e+v}\right) \tag{5}$$

where δ_i denotes 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 $E\left(l_{is}^{e+v}\right)$ denotes 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. Finally, the industry price indices can be written as

$$P_{js} = \left(\sum_i M_{ijs} p_{ijs}\left(\widetilde{\varphi}_{ijs}\right)^{1-\sigma_s}\right)^{\frac{1}{1-\sigma_s}} \tag{6}$$

where $\widetilde{\varphi}_{ijs} \equiv (\int_{\varphi^*_{ijs}}^{\infty} \varphi^{\sigma_s-1} g_{is}(\varphi|\varphi > \varphi^*)d\varphi)^{\frac{1}{\sigma_s-1}}$ is the productivity of the representative firm in industry s of country i selling to country j and $M_{ijs} = prob(\varphi > \varphi^*_{ijs})Me_{is}$. These industry price indices then determine the aggregate price indices through the relationships $P_j \equiv \prod_s (\frac{P_{js}}{\mu_{js}})^{\mu_{js}}$.

It is useful to assume that the productivity distribution is Pareto with shape parameter $\theta_s > \sigma_s - 1$ and location parameter b_{is}: $G_{is}(\varphi) = 1 - (\frac{b_{is}}{\varphi})^{\theta_s}$. The above equilibrium conditions can then be simplified using the relationships $prob(\varphi > \varphi^*_{ijs}) = (\frac{b_{is}}{\varphi^*_{ijs}})^{\theta_s}$, $E(\pi_{ijs}|\varphi > \varphi^*_{ijs}) = \frac{\sigma_s-1}{\theta_s-\sigma_s+1}\omega_j f_{ijs}$, $E(l_{is}^{e+v}) = (\theta_s+1)fe_{js}$, $\delta_i = \sum_s \frac{(\theta_s+1)(\sigma_s-1)}{\theta_s\sigma_s}\mu_{js}$, and $\widetilde{\varphi}_{ijs} = (\frac{\theta_s}{\theta_s-\sigma_s+1})^{\frac{1}{\sigma_s-1}}\varphi^*_{ijs}$. We use the equilibrium conditions implied by the Pareto distribution henceforth.

2.3 Transmission channels

We now examine the channels through which productivity shocks transmit. Productivity growth in industry s of country i is captured by an increase in the productivity parameter b_{is} which shifts the entire distribution of possible productivity draws to the right. We restrict attention to small productivity shocks for now.

Since welfare is given by real labor income, changes in welfare V_j induced by small changes in the productivity parameters b_{is} can be expressed as

$$\widehat{V}_j = \widehat{\omega}_j - \sum_s \mu_{js} \widehat{P}_{js} \tag{7}$$

where a 'hat' denotes a growth rate. Using equations (3) and (6), changes in the industry price indices P_{js} caused by small changes in the productivity parameters b_{is} can be decomposed as

$$\widehat{P}_{js} = \sum_i \alpha_{ijs} \left(-\widehat{\widetilde{\varphi}}_{ijs} + \widehat{\omega}_i - \frac{1}{\sigma_s - 1} \widehat{M}_{ijs} \right) \tag{8}$$

where $\alpha_{ijs} \equiv \frac{T_{ijs}}{\sum_m T_{mjs}}$ and T_{ijs} denotes the total value of industry s trade from country i to country j. Changes in the industry price indices P_{js} are thus expenditure share weighted averages of changes in average prices $\widehat{\widetilde{p}}_{ijs} = -\widehat{\widetilde{\varphi}}_{ijs} + \widehat{\omega}_i$ and elasticity of substitution adjusted changes in available variety.

Using equation (8) and the definitions of φ^*_{ijs} and $\widetilde{\varphi}_{ijs}$, it can be shown that $\sum_i \alpha_{ijs} \widehat{M}_{ijs} = 0$ and $\sum_i \alpha_{ijs} \widehat{\widetilde{\varphi}}_{ijs} = \sum_i \alpha_{ijs} \widehat{b}_{is} + \frac{1}{\theta_s} \sum_i \alpha_{ijs} \widehat{Me}_{is}$. Equation (8) therefore simplifies to

$$\widehat{P}_{js} = \sum_i \alpha_{ijs} \left(-\widehat{b}_{is} + \widehat{\omega}_i - \frac{1}{\theta_s} \widehat{Me}_{is} \right) \tag{9}$$

Ultimately, changes in b_{is} affect P_{js} either directly, or indirectly through changes in ω_i or Me_{is}. To understand the intuition underlying this result, it is useful to consider these direct and indirect effects in turn.

Consider first an increase in one b_{is}, say b_{vs}, leaving all other b_{is} as well as all ω_i and Me_{is} unchanged. This directly decreases P_{js} by increasing $\widetilde{\varphi}_{vjs}$, as firms in country v get more productive. This effect is captured by the first term in equation (9). In addition, the increase in b_{vs} also increases the proportion of country v's entrants selling to country j and decreases the proportion of all other countries' entrants selling to country j. As a consequence, M_{vjs} increases and $\widetilde{\varphi}_{vjs}$ decreases as the new exporters in country v are less productive that the incumbent exporters. Similarly, M_{ijs} decreases and $\widetilde{\varphi}_{ijs}$ increases as the *former* exporters in the other countries are less productive that the continuing exporters. The effect of the increase in M_{vjs} on P_{js} is exactly offset by the effect of the decrease in the other M_{ijs}. Similarly, the effect of the decrease in $\widetilde{\varphi}_{vjs}$ on P_{js} is exactly offset by the increase in the other $\widetilde{\varphi}_{ijs}$.

Consider now an increase in one ω_i, say ω_v, leaving all other ω_i as well as all b_{is} and Me_{is} unchanged. This directly increases P_{js} by making all industry s varieties from country v more expensive in country j. This effect is captured by the second term in equation (9). Just as above, all additional variety and productivity effects exactly cancel.

Consider finally an increase in one Me_{is}, say Me_{vs}, leaving all other Me_{is} as well as all b_{is} and ω_i unchanged. This directly decreases P_{js} by increasing M_{vjs}. In addition, it also decreases the proportion of all countries' entrants selling to country j by increasing φ^*_{ijs} in all countries. As a consequence, there is a reduction in all M_{ijs} and an increase in all $\widetilde{\varphi}_{ijs}$ as the *former* exporters in all countries are less productive than the continuing exporters. On balance, M_{vjs} increases but all other M_{ijs} decrease. These offsetting variety effects again exactly cancel. What is different now is that all $\widetilde{\varphi}_{ijs}$ increase so that there is no offsetting in the productivity effects. These productivity effects are captured by the last term in equation (9).

In summary, changes in variety induced either directly or indirectly by changes in b_{is} have no net effect on P_{js}. Moreover, only changes in average productivity induced either directly by changes in b_{is} or indirectly by changes in Me_{is} have a net effect on P_{js}. These findings are related to the recent results by Arkolakis et al (2008, 2010), Feenstra (2009), and Atkeson and Burstein (2009) that changes in trade barriers often have similar aggregate effects in models with and without firm heterogeneity. They make us depart in critical ways from two important literatures.

The first is the literature on the measurement of changes in the variety gains from trade (e.g. Feenstra, 1994, Broda and Weinstein, 2008). In that literature, changes in the variety gains from trade are typically computed from changes in the number of imported varieties only. But consider the variety effects of China's productivity growth. On the one hand, China's productivity growth implies that more Chinese varieties become available to US consumers as Chinese firms become relatively more competitive. On the other hand, it means that fewer US varieties remain available to US consumers as US firms become relatively less competitive. Our analysis suggests that these two effects are exactly offsetting so that changes in the number of domestic varieties cannot be ignored.[2]

The second is the literature on the measurement of changes in the productivity gains from trade (e.g. Pavcnik, 2002, Trefler, 2004). In that literature, improvements in domestic industry productivity are typically interpreted as increases in the productivity gains from trade. But while China's productivity growth forces the weakest US firms to stop serving the US market, it also allows some weaker Chinese firms to start serving the US market. The first effect increases the average productivity of firms serving the US market but the latter effect decreases the average productivity of firms serving the US market and both have to be taken into account when measuring changes in the productivity gains from trade.

Overall, equations (7) and (9) imply that changes in welfare induced by small changes in the productivity parameters b_{is} can be written as

$$\widehat{V}_j = \sum_i \sum_s \mu_{js} \alpha_{ijs} \left(\widehat{b}_{is} + (\widehat{\omega}_j - \widehat{\omega}_i) + \frac{1}{\theta_s} \widehat{Me}_{is} \right) \tag{10}$$

The first term $\sum_i \sum_s \mu_{js} \alpha_{ijs} \widehat{b}_{is}$ captures the direct effect changes in b_{is} have on prices in country j so that we will refer to it as *direct price effect*. The second term $\sum_i \sum_s \mu_{js} \alpha_{ijs} (\widehat{\omega}_j - \widehat{\omega}_i)$ captures the change in purchasing power induced by the general equilibrium adjustment in relative wages so that we will refer to it as *relative wage effect*. In combination, the direct price and indirect relative wage effect can be thought of as a *terms-of-trade effect*. The third term $\sum_i \sum_s \frac{\mu_{js} \alpha_{ijs}}{\theta_s} \widehat{Me}_{is}$ captures the change in average productivity induced by the indirect effect changes in b_{is} have on entry and exit. Since entry in one industry of one country always comes along with exit out of the same industry in another country we will refer to it as *pro-*

[2] While the exact offsetting is clearly the result of special functional form assumptions, it captures two basic counteracting forces which also feature in more general models.

duction relocation effect. We explore the determinants of the signs of these spillover effects in the next section.

Internationally, the relative wage and production relocation 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 relative wage and production relocation effects. In particular, it can be shown that equation (10) then implies

$$\overline{\widehat{V}} = \sum_i \sum_j \sum_s \frac{T_{ijs}}{\sum_v \omega_v L_v} \widehat{b}_{is} \tag{11}$$

where $\overline{\widehat{V}} \equiv \sum_j \frac{\omega_j L_j}{\sum_v \omega_v L_v} \widehat{V}_j$ is the GDP-weighted average of all countries' welfare effects. This implies that the worldwide average welfare effect is simply a sales-share weighted average of the productivity growth rates in every sector and country.

2.4 Quantification

We now extend the above analysis by allowing for productivity shocks of any size and by characterizing the general equilibrium adjustments in relative wages and entry. We do so by adapting the method of Dekle, Eaton, and Kortum (2006) to our framework.

Specifically, using equations (3) and (6) as well as the definitions of φ^*_{ijs} and $\widetilde{\varphi}_{ijs}$, changes in welfare induced by discrete changes in the productivity parameters b_{is} can be written as

$$1 + \widehat{V}_j = \prod_s \left(\sum_i \alpha_{ijs} \left(\left(1 + \widehat{b}_{is}\right) \left(\frac{1 + \widehat{\omega}_j}{1 + \widehat{\omega}_i} \right) \right)^{\theta_s} \left(1 + \widehat{Me}_{is}\right) \right)^{\frac{\mu_{js}}{\theta_s}} \tag{12}$$

where a 'hat' denotes a growth rate just as before.[3] This equation can be thought of as an integral over equation (10). Notice that it also features direct price, indirect relative wage, and indirect production relocation effects. However, they now affect welfare multiplicatively since their impacts on trade shares are taken into account.

[3] In the previous section, we focused on small changes so that $\widehat{x} = \frac{dx}{x}$. Now we consider changes of any size so that $\widehat{x} = \frac{\triangle x}{x}$.

Moreover, it can be demonstrated that the equilibrium conditions (2) - (5) require

$$1+\widehat{\omega}_v = \sum_j \frac{\beta_{vjs}\left(\frac{1+\widehat{\omega}_v}{1+\widehat{b}_{vs}}\right)^{-\theta_s}}{\sum_i \alpha_{ijs}\left(1+\widehat{Me}_{is}\right)\left(\frac{1+\widehat{\omega}_i}{1+\widehat{b}_{is}}\right)^{-\theta_s}}\left(1+\widehat{\omega}_j\right) \tag{13}$$

$$1 = \sum_s \gamma_{is}\left(1+\widehat{Me}_{is}\right) \tag{14}$$

where $\beta_{ijs} \equiv \frac{T_{ijs}}{\sum_n T_{ins}}$ and $\gamma_{is} \equiv \frac{\sum_n \frac{(\sigma_s-1)(\theta_s+1)}{\theta_s\sigma_s}T_{ins}}{\sum_n\sum_t \frac{(\sigma_t-1)(\theta_t+1)}{\theta_t\sigma_t}T_{int}}$. If one wage is chosen as the numeraire, this represent a system of $N(S+1)-1$ equations in $N(S+1)-1$ unknowns whose coefficients depend on σ_s, θ_s, and trade flows only. Given estimates of σ_s and θ_s and data on trade flows only, the full general equilibrium adjustment in relative wages and entry can therefore be computed for any N and S. Conveniently, no information is required on the remaining model parameters L_i, fe_{is}, τ_{ijs}, and f_{ijs}. These general equilibrium adjustments can then be substituted into equation (12) to compute the welfare effects of productivity shocks. Notice that no further parameter estimates are required for this computation since $\mu_{js} = \frac{\sum_i T_{ijs}}{\sum_i\sum_s T_{ijs}}$.[4]

2.5 Illustrative examples

To understand the nature of the general equilibrium adjustments as well as the determinants of the signs of the spillover effects, we now turn to some illustrative examples. These examples all focus on the special case of two countries ("China" and the "US") and two industries (1 and 2), and examine the effects of a 10% productivity improvement in industry 1 of China.

To illustrate the nature of the general equilibrium effects, it is sufficient to focus on a fully symmetric example in which industry expenditure shares and import expenditure shares are equal across countries and industries.[5] Table 1 presents the general equilibrium adjustments implied by equations (13) and (14) for a particular example of this sort. Notice that the

[4]Before taking the model to the data, we also introduce an exogenous trade surplus parameter along the lines of Eaton and Kortum (2002) to deal with the aggregate trade imbalances observed empirically. We discuss the resulting generalizations of equations (12) - (14) in the appendix.

[5]In terms of our formal notation, industry expenditure shares are given by μ_{js} and import expenditure shares are given by $\frac{T_{ijs}}{\omega_j L_j}$.

productivity growth in industry 1 of China leads to 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 of China become positive and expected profits from entering into industry 1 of the US become negative, as firms from industry 1 of China become relatively more competitive. As a consequence, there is entry into industry 1 of China bidding up wages in China so that there is also exit out of industry 2 of China. Also, there is exit out of industry 1 of the US depressing wages in the US so that there is also entry into industry 2 of the US. Both the entry into industry 1 of China as well as the increase in wages in China reduce the expected profits from entering into industry 1 of China back to zero. Similarly, both the exit out of industry 1 of the US as well as the reduction in wages in the US increase the expected profits from entering into industry 1 of the US back to zero. Moreover, the counteracting entry and wage effects in industry 2 of both countries ensure that the expected profits from entering into industry 2 remain zero.

To illustrate the determinants of the terms of trade effects (i.e. the combination of the direct price and relative wage effects), it is necessary to allow for variations in the pattern of inter-industry trade. We therefore maintain the assumption of identical industry expenditure shares but allow for varying import expenditure shares. In particular, we contrast two cases. In the first case, China is a net exporter in industry 1; and in the second case, China is a net importer in industry 1. Table 2 presents a particular example of this sort. Column 1 shows the direct price effect on the US, column 2 the relative wage effect on the US, and column 3 the production relocation effect on the US, all as defined by equation (10). Column 4 then gives the net welfare effect on the US as implied by equation (12).[6] The two rows cover the two different cases. Notice that the US gains from China's productivity growth if it is biased towards China's export-oriented industry but loses from China's productivity growth if it is biased towards China's import-oriented industry, just as in the classic analyses. This is

[6] The general equilibrium responses are again computed from equations (13) and (14). Since equation (10) is a linear approximation to equation (12), the individual effects do not exactly add up to the overall effects.

because the positive direct price effect on the US gets filtered through a large industry import share if it occurs in China's export-oriented industry but through a small industry import share if it occurs in China's import-oriented industry while the negative relative wage effect on the US always gets filtered through the same overall import share since the wage growth affects both industries at the same time.[7]

To illustrate the determinants of the production relocation effects, it is necessary to allow for industries to be of differential importance in consumption. We therefore revert to the case of identical import expenditure shares but allow for varying industry expenditure shares. In particular, we contrast two cases. In the first case, industry 1 is more important in consumption; in the second case, industry 2 is more important in consumption. Table 3 present a particular example of this sort. Recall that the productivity growth in industry 1 of China makes China gain entrants in industry 1 at the expense of the US, and makes the US gain entrants in industry 2 at the expense of China. Notice that these production relocations harm the US in the first case but benefit the US in the second case. Intuitively, the US always loses from the production relocations in industry 1 since the decrease in average productivity due to exit in the US outweighs the increase in average productivity due to entry in China, given that we (realistically) assume US goods to account for a larger share of US expenditure. At the same time, the US always gains from the production relocations in industry 2 since the increase in average productivity due to entry in the US outweighs the decrease in average productivity due to exit in China by the same token. The net effect depends on the industry expenditure shares. The US gains if industry 2 is more important in consumption than industry 1, as in the second case, but loses if industry 2 is less important in consumption than

[7] One subtle difference to the classic analyses is that the US gains more from China's productivity growth if it is biased towards China's export-oriented industry than it loses from China's productivity growth if it biased towards China's import-oriented industry. Indeed, it is easy to verify that the US also gains if China's productivity growth is unbiased in the sense that 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 is always export-biased in a Krugman model since each country always specializes in a unique set of varieties. Essentially, the properties of a Krugman model at the industry-level are similar to the properties of a Ricardian model at the country-level since both feature complete specialization.

industry 1, as in the first case.[8]

In summary, we can therefore expect the global spillover effects of China's productivity growth to be positive if it is positively correlated to China's comparative advantage and if it is negatively correlated to industry importance as measure by industry expenditure shares. Of course, the magnitudes of the spillover effects are also influenced by the overall importance of international trade as well as third-party terms-of-trade and production relocation effects.

3 Empirical application

We now apply this framework to China, asking what would have happened to real incomes around the world if nothing but China's productivity had changed. We first use Chinese plant level data to estimate productivity growth at the 2-digit industry level. We then use the estimates of Chinese productivity growth along with data on world trade flows to measure the effect of Chinese productivity growth on world real income.

3.1 Estimating $\widehat{b}_{is}$

We proceed in two steps to estimate productivity growth in China. We first estimate the productivity growth rate of the representative establishment $\widehat{\widetilde{\varphi}}_{iis}$ in each 2-digit Chinese industry. We use the fact that the price and revenue of the representative plant are given by $p_{iis}\left(\widetilde{\varphi}_{iis}\right) = \frac{\sigma_s}{\sigma_s-1}\frac{\omega_i}{\widetilde{\varphi}_{iis}}$ and $r_{iis}\left(\widetilde{\varphi}_{iis}\right) = \frac{\theta_s\sigma_s}{\theta_s-\sigma_s+1}\omega_i f_{iis}$, respectively. Assuming that the fixed costs of production f_{iis} are unchanged, the growth rate of representative productivity can thus be calculated from $1+\widehat{\widetilde{\varphi}}_{iis} = \frac{1+\widehat{r_{iis}\left(\widetilde{\varphi}_{iis}\right)}}{1+\widehat{p_{iis}\left(\widetilde{\varphi}_{iis}\right)}}$. The representative price is a quantity share weighted average of prices in the domestic market charged by firms in the industry, which we can approximate by a standard industry price deflator.[9] In turn, the revenue of the repre-

[8] This production relocation effect is closely related to the effect identified by Venables (1987) in the context of a Krugman (1980) model and by Demidova (2008) in the context of a Melitz (2003) model. A key difference is that our model does not feature a freely traded numeraire good. As a consequence, entry into one industry always comes at the expense of exit out of other industries in our setup.

[9] Specifically, $p_{iis}\left(\widetilde{\varphi}_{iis}\right) = \int_{\varphi^*_{iis}}^{\infty} p_{iis}\left(\varphi\right)\frac{x_{iis}(\varphi)}{x_{iis}(\widetilde{\varphi}_{iis})} g_{si}\left(\varphi|\varphi > \varphi^*_{iis}\right)d\varphi$.

sentative plant is even simpler as it is just an average of revenues of domestic sales.[10] The growth rate of representative productivity can thus be measured as $1+\widehat{\widetilde{\varphi}}_{iis} = \frac{1+\widehat{\widetilde{r}}_{iis}}{1+\widehat{D}_{is}}$, where $\widehat{\widetilde{r}}_{iis}$ denotes the growth rate of average revenue and $\widehat{D}_{is}$ denotes the growth rate of the industry price deflator. Intuitively, we know that the growth rate of productivity is proportional to the growth rate of factor prices minus the growth rate of average prices. In turn, since average revenues from domestic sales are proportional to domestic factor prices, the growth rate of productivity is simply given by the growth rate of average revenues minus the growth rate of average prices.

We then estimate the shift in the productivity parameters $\widehat{b}_{is}$ from our estimate of $\widehat{\widetilde{\varphi}}_{iis}$. It can be shown that $b_{is} = \left(\frac{\theta_s}{\theta_s-\sigma_s+1}\right)^{\frac{1}{1-\sigma_s}} \left(\frac{\theta_s-\sigma_s+1}{\sigma_s-1}\frac{fe_{is}}{f_{iis}}\lambda_{iis}\right)^{\frac{1}{\theta_s}} \widetilde{\varphi}_{iis}$ where $\lambda_{iis} \equiv \frac{T_{iis}}{\sum_m T_{ims}}$ is an inverse measure of trade openness. Assuming that $\widehat{fe}_{is} = \widehat{f}_{iis}$, we can estimate $\widehat{b}_{is}$ from $1+\widehat{b}_{is} = \left(1+\widehat{\widetilde{\varphi}}_{iis}\right)\left(1+\widehat{\lambda}_{iis}\right)^{\frac{1}{\theta_s}}$. Intuitively, we infer $\widehat{b}_{is}$ from $\widehat{\widetilde{\varphi}}_{iis}$ by adjusting for the effect changes in openness have on representative productivity (the Melitz (2003) effect). In sum, we compute $\widehat{b}_{is}$ as

$$1+\widehat{b}_{is} = \frac{1+\widehat{\widetilde{r}}_{iis}}{1+\widehat{D}_{is}}\left(1+\widehat{\lambda}_{iis}\right)^{\frac{1}{\theta_s}} \tag{15}$$

where $\widehat{\widetilde{r}}_{iis}$ is the growth rate of average revenue, $\widehat{D}_{is}$ is the growth rate of the industry price deflator, and $\widehat{\lambda}_{iis}$ is the growth rate of the inverse measure of openness.

3.2 Data and parametrization

To implement our methodology, we need industry-level data on external trade flows for all countries, internal trade flows for all countries, domestic mean revenues for China, and price deflators for China.

To estimate Chinese productivity growth, we use the plant level data from the Chinese Annual Survey of Industrial Production from 1992 through 2008.[11] This data is a census of all state-owned plants and non-state plants with more than 5 million Yuan (about $600

[10] Specifically, $r_{iis}(\widetilde{\varphi}_{iis}) = \int_{\varphi^*_{iis}}^{\infty} r_{iis}(\varphi)\, g_{si}(\varphi|\varphi > \varphi^*_{iis})\, d\varphi$.

[11] We define the productivity growth rate for 1992 as the productivity change between 1992 and 1993 et cetera.

thousand dollars) in revenues collected by China's National Bureau of Statistics.[12] The raw data consists of slightly over 100 thousand plants in the beginning of the sample to over 300 thousand plants by 2008. The information from this data that we use are gross output and exports at the plant level. With this data, we compute domestic sales for each plant as gross output minus exports for each plant. We then compute mean revenues from domestic sales for each 2-digit sector (22 sectors in total) for the years 1992 through 2008. Price deflators at the 2-digit level are obtained from the China Statistical Yearbook.

We use the United Nations trade data to estimate external bilateral trade from 1992 through 2007.[13] We reclassify the industries in the trade data to 2-digit industries following the classification used by the Chinese National Bureau of Statistics. As for internal trade flows, we directly measure this for China and the US as industry gross output minus industry exports. We obtain the Chinese data from the Annual Survey of Industrial Production and the US from the NBER-CES Manufacturing Industry Database (after reclassifying the four digit U.S. industries to 2-digit Chinese industries). For the other countries, we do not have detailed industry data so we have to resort to using aggregate data to back out the implied internal trade flows. The procedure we use is as follows. We estimate aggregate consumption in manufacturing as gross output in manufacturing minus total exports plus total imports.[14] We then use the data on sectoral consumption shares in China and the US (for which we have data) to fit a regression line of the sectoral consumption share on GDP/worker for China and the US. We then use the coefficient on GDP/worker from this regression to predict the share of each sector in total consumption for the countries for which we do not have detailed industry data. We then use this predicted share along with the estimate of aggregate consumption to back out an estimate of sectoral expenditures in these countries. With the estimate of sectoral expenditure, we estimate internal trade as sectoral consumption minus net exports

[12] See Hsieh and Klenow (2009) for additional details on this dataset.

[13] This data was generously made available to us by Robert Feenstra, Gordon Hanson, and John Romalis.

[14] We use data from the World Development Indicators for aggregate value-added in manufacturing. Following Dekle, Eaton, and Kortum (2006), we assume that manufacturing value added is 31.2% of gross output.

in the sector. We then aggregate the countries into 17 countries/regions.[15]

Finally, we assume that the shape parameter of the Pareto distribution of productivity is $\theta = 5$ for all sectors and the elasticity of substitution between the varieties in each sector is $\sigma = 3$ for all sectors.[16]

3.3 Results

Table 4 reports the share of manufacturing imports from all countries in domestic manufacturing expenditure by country. Excluding China, this share has increased from 20.8% to 32.0% over the sample period on average. Table 5 presents the share of manufacturing imports from China in domestic manufacturing expenditure by country. Excluding China, this share has increased from 0.5% to 3.8% over the sample period on average. While manufacturing imports from China therefore only account for 2.4% of total manufacturing imports in 1992 on average, they already account for 11.9% of total manufacturing imports in 2007 on average, reflecting the rising importance of China to the world economy.

To measure the welfare effects of China's productivity growth, we estimate China's annual industry productivity growth rates $\widehat{b}_{is}$ from 1992 through 2007.[17] We take geometric averages over all years to attenuate possible measurement error and assume that the productivity growth rate in each year is simply the average growth rate from 1992 through 2007. Figure 1 plots the distribution of productivity growth rates across industries. Productivity growth rates are typically large and also vary substantially across industries. The median productivity growth rate is 15% and the interquartile range is $(12\%, 17\%)$. Figures 2 and 3 relate the productivity growth rates to industry net exports and industry expenditure shares in China for 1994 and 2005. Importantly, there is almost no correlation visible in either figure which

[15] The countries/regions are Argentina, Brazil, Canada, China, France, Germany, India, Italy, Japan, Mexico, Russia, United Kingdom, United States, Africa, other Asia (including Australia), other Europe, and other Latin America. We have no trade data for Russia until 1996 so that we focus on the remaining countries/regions in earlier years.

[16] Eaton et al (2008) estimate $\theta = 4.87$, which falls between related estimates in the literature.

[17] Recall that we define the productivity growth rate for 1992 as the productivity change between 1992 and 1993 et cetera.

indicates that the predicted global spillover effects of China's productivity growth will not be large.

Using these estimated productivity growth rates and the trade data in each year, we then predict the annual adjustments in wages $\widehat{\omega}_i$ and the number of entrants $\widehat{Me}_{is}$ in across the world from 1992 through 2007 from equations (13) and (14).[18] Since we assume that productivity growth in each year is the average productivity growth rate from 1992 through 2007, the variation in these general equilibrium adjustments across years is due to changes in the pattern of trade. Figure 4 plots the distribution of wage adjustments relative to China's wage across all countries for the years 1994 and 2005. Not surprisingly, wages of all the other countries fall relative to China's wage as a consequence of Chinese productivity growth. The figure also indicates that the relative wage change becomes smaller and more dispersed over time. Figure 5 plots entry in China against China's productivity growth for the years 1994 and 2005. As can be seen, the model predicts entry into industries with higher productivity growth rats and exit from industries with lower productivity growth rates.

Table 6 presents the predicted change in real income from Chinese productivity growth from 1992 through 2007 calculated from equation (12). Table 6 gives the year by year estimates of the welfare effects on China and the world, as well as the cumulative change in welfare over the entire time period (in the last row). The first column gives the effect of Chinese productivity growth on Chinese welfare. Cumulatively, China experiences a more than ninefold welfare increase over the sample period. The second column gives the effect of Chinese productivity growth on world welfare, defined as an output weighted average of welfare growth of the countries/regions in our data (the term $\overline{\widehat{V}}$ defined above). Not surprisingly, since the share of China in the world economy is rising over this period, the effect of Chinese productivity growth on average world welfare growth increases from 0.61% in 1992 to 2.03% in 2007. The third column presents the average welfare growth of the other countries in the world (other than China). The average growth rate of welfare in the other countries also in-

[18] We actually use generalizations of equations (13) and (14) which allow for aggregate trade imbalances. These equations are discussed in the appendix.

creases over time, from 0.012% in 1992 to 0.053% by 2007. Cumulatively, the average welfare in the rest of the world increases by around half a percentage point from 1992 through 2007. The fourth column calculates the share of the welfare gains to the rest of the world divided by the welfare gain to the world. Since China became more integrated with the rest of the world over this time period, the share of the world welfare gains from Chinese productivity growth that "accrued" to the rest of the world also rises, from 1.9% in the beginning of the period to 2.6% by the end of the period.

Table 7 presents the cumulative welfare gain (from 1992 through 2007) from Chinese productivity growth for individual countries/regions. Chinese productivity growth is "responsible" for a 0.33% improvement in U.S. welfare from 1992 through 2007. For the other countries, the welfare improvement is generally large for countries in Asia (0.87% in Japan and 1.42% for the other Asian countries) and small for the countries in Latin America (0.12% for Argentina, 0.05% for Brazil, and essentially zero for the other Latin American countries). The surprisingly exception to the pattern in Latin America is Mexico, where our estimates suggest that Mexico's welfare improved by 0.61% due to Chinese productivity growth. This is surprisingly because of the widespread perception that Mexico "competes" in the same product space as China so the effect of Chinese productivity growth would have lowered Mexico's terms-of-trade. For example, Hanson and Robertson (2010) use the results from a gravity model of trade to estimate the effect of Chinese export growth on the demand for Mexico's products, and generally find that China's productivity growth (as measured by its exports) would lower the demand for Mexican exports by 2% to 4%. This effect may be present, but what our estimates capture are three additional effects of Chinese productivity growth on Mexican welfare. First, we capture the effect of Chinese productivity growth on prices of Mexican imports from China. Second, our general equilibrium framework captures the equilibrium response of relative wages in Mexico (relative to US) and the effect of the relative wage change on the terms-of-trade. Third, we measure the effect of Chinese productivity growth on the entry and exit of firms in all the countries and industries in the world.

We now turn to tables that decompose the net welfare change. As equation (12) shows, the net welfare change is a nonlinear combination of the effect of Chinese productivity growth on the terms-of-trade and the production reallocations. Because of the nonlinear nature of these effects, there is no clean way to decompose the net welfare change into the effect stemming from changes in the terms-of-trade and the entry and exit of firms. However, when the productivity change is small, the welfare change can be approximated as the sum of the terms-of-trade effect and the production reallocation effect using equation (10). Although this equation is not entirely correct for large changes in productivity, we use it to compute the implied net welfare change given our estimates of the change in wages and entry and exit of firms along with data on the productivity growth in China and the trade shares. We then calculate the implied share of the hypothetical welfare change due to the two effects (changes in the terms-of-trade and production reallocation). Table 8 then presents the product of these hypothetical shares and the actual welfare changes shown in Tables 6 and 7. Again, we remind the reader that this decomposition is imperfect because it is only valid for small productivity changes and the productivity growth we have witnessed in China averages 15% per year. With that caveat firmly in mind, the first column in Table 8 presents the % change in the welfare (cumulative from 1992 to 2007) due to changes in the terms-of-trade. The second column presents the estimated welfare change due to entry and exit of firms for all the countries and industries. As can be seen, both the terms-of-trade effect as well as the production relocation effect can be significant.

Table 9 turns to a decomposition of the terms-of-trade effect into changes in the country's terms-of-trade relative to China and the terms-of-trade relative to the other countries of the world. The first column presents the welfare change due to changes in the country's terms-of-trade relative to China. This is simply the sum of Chinese productivity growth in each sector and the change in the country's wage relative to China's wage, summed up across all sectors using China's share in the country's expenditure basket (equation (10)). The second column presents the welfare change due to changes in the country's terms-of-trade relative to the other countries in the world. This effect captures the effect of Chinese productivity growth on wages of the other countries. As can be seen, both the bilateral as well as the multilateral terms-of-trade effect can be significant.

4 Conclusion

How does a country's productivity growth affect worldwide real incomes through international trade? Given the economic rise of China, this classic question is of particular relevance today. Can other countries reap some of the benefits of China's productivity growth?

In this paper, we revisited this classic question in the context of modern trade theory and quantified the effect of China's productivity growth on worldwide real incomes. We first identified the channels through which productivity growth externalities travel in 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). We then estimated China's productivity growth at the industry level and used our model to quantify what would have happened to real incomes throughout the world if nothing but China's productivity had changed. Our estimates suggest that the cumulative spillover effect of China's productivity growth was a 0.48% increase in the average real income of the rest of the world. This implies that 2.2% of the cumulative worldwide gains from China's productivity growth accrued to the rest of the world.

Our analysis is very much a first pass at this question. To capture more of the complexities of the world, it could be extended in a number of ways. For example, one could introduce differences in factor endowments and factor intensities to also shed light on the effects of China's productivity growth on within-country inequality. Moreover, one could allow for non-traded goods and intermediate goods to assess the magnitudes by which non-traded goods dampen and intermediate goods magnify the spillover effects of China's productivity growth. Finally, one could depart from our assumption that the labor supply facing the manufacturing sector is fixed. If labor supply increases in response to productivity growth, this is likely to generate additional terms-of-trade gains for the rest of the world by dampening the relative increase in Chinese wages. At the same time, it is likely to imply additional production relocation losses for the rest of the world by allowing China's manufacturing sector as a whole to expand at the expense of other countries. We leave these extensions for future work.

Our framework could also be applied to analyze the spillover effects of other shocks. While we have focused on the worldwide effects of China's productivity growth, it could also be used to study the effects of the growth implosion in Sub-Saharan Africa or the productivity slowdown of Western Europe and the US since the 1970s. As another example, it could be applied to look at changes in trade policy. For example, Ossa (2011) uses it to analyze the spillover effects of tariff changes and their implications for multilateral trade negotiations.

5 Appendix

Introducing exogenous trade surplus parameters NX_j into the budget constraints yields the following generalizations of equations (12) - (14):

$$1+\widehat{V}_j=\prod_s\left(\sum_i\alpha_{ijs}\left(\left(1+\widehat{b}_{is}\right)\left(\frac{1+\widehat{\omega}_j}{1+\widehat{\omega}_i}\right)\right)^{\theta_s}\left(1+\widehat{Me}_{is}\right)\Psi_j^{\frac{\theta_s\sigma_s-\sigma_s+1}{\sigma_s-1}}\right)^{\frac{\mu_{js}}{\theta_s}} \tag{16}$$

$$1+\widehat{\omega}_v=\sum_j\frac{\beta_{vjs}\left(\frac{1+\widehat{\omega}_v}{1+\widehat{b}_{vs}}\right)^{-\theta_s}}{\sum_i\alpha_{ijs}\left(1+\widehat{Me}_{is}\right)\left(\frac{1+\widehat{\omega}_i}{1+\widehat{b}_{is}}\right)^{-\theta_s}}\left(1+\widehat{\omega}_j\right)\Psi_j \tag{17}$$

$$1=\sum_s\gamma_{is}\left(1+\widehat{Me}_{is}\right)\Omega_i \tag{18}$$

where $\Psi_j\equiv\left(\frac{\omega_jL_j}{\omega_jL_j-NX_j}-\frac{NX_j}{\omega_jL_j-NX_j}\left(1+\widehat{\omega}_j\right)^{-1}\right)$ and $\Omega_j\equiv\frac{1-\left(\sum_s\frac{\theta_s-\sigma_s+1}{\theta_s\sigma_s}\mu_{js}\right)\left(1-\frac{NX_j}{\omega_jL_j}\right)}{1-\left(\sum_s\frac{\theta_s-\sigma_s+1}{\theta_s\sigma_s}\mu_{js}\right)\left(1-\frac{NX_j}{\omega_jL_j}\right)\Psi_j}$ are adjustment terms which reduce to 1 if $NX_j=0$. NX_j can be computed from observed industry net exports NX_{is} using the relationship $NX_j\equiv\sum_s\frac{(\sigma_s-1)(\theta_s+1)}{\theta_s\sigma_s}NX_{is}$. The factor $\frac{(\sigma_s-1)(\theta_s+1)}{\theta_s\sigma_s}$ is necessary since the model also features endogenous aggregate net exports in general due to the assumption that the fixed cost of exporting are paid in destination country labor which generates international transfers of income.

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6 Tables

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

$\widehat{\omega}_{CH} - \widehat{\omega}_{US}$	$\widehat{Me}_{CH,1}$	$\widehat{Me}_{CH,2}$	$\widehat{Me}_{US,1}$	$\widehat{Me}_{US,2}$
4.14%	21.48%	-21.48%	-22.41%	22.41%

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 10% in both countries and industries, theta1=theta2=5, and sigma1=sigma2=3.

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

	Price	Wage	Relocation	Total
$NX_{CH,1} > 0$	1.5%	-0.82%	-0.11%	0.83%
$NX_{CH,1} < 0$	0.5%	-0.83%	-0.01%	-0.17%

Notes: Entries are predicted growth rates in US real income due to the direct price effect (column 1), the relative wage effect (column 2), and the production relocation effect (column 3) from 10% productivity growth in China in industry 1 following equation (10). Column 4 calculates net welfare gain following equation (12). 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 5% in industry 1 and an import expenditure share of 15% in industry 2 with the US being the mirror image so that China is a net exporter in industry 1. In the second row, China is assumed to have an import expenditure share of 15% in industry 1 and an import expenditure share of 5% 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

	Price	Wage	Relocation	Total
$\mu_1 > \mu_2$	0.5%	-0.39%	-0.29%	0.11%
$\mu_1 < \mu_2$	0.5%	-0.45%	0.29%	0.15%

Notes: Entries are predicted growth rates in US real income due to the direct price effect (column 1), the relative wage effect (column 2), and the production relocation effect (column 3) from 10% productivity growth in China in industry 1 following equation (10). Column 4 calculates net welfare gain following equation (12). Simulation assumes that nominal incomes are the same in both countries, import expenditure shares are 5% in both countries and industries, theta1=theta1=5, and sigma1=sigma2=3. In the first row, industry 1 is assumed to have an expenditure share of 60% in both countries. In the second row, industry 1 is assumed to have an expenditure share of 40% in both countries.

TABLE 4: Share of Imports in Domestic Expenditure

	1992	2000	2007
China	16.0%	16.3%	19.9%
United States	13.5%	21.0%	25.2%
Argentina	6.4%	12.5%	16.8%
Brazil	4.7%	12.7%	9.6%
Canada	34.5%	46.1%	48.7%
France	28.8%	43.0%	49.9%
Germany	21.7%	33.8%	39.4%
India	10.3%	17.3%	21.3%
Italy	19.3%	30.7%	35.7%
Japan	4.8%	8.7%	12.2%
Mexico	22.0%	41.3%	36.2%
Russia	n/a	11.3%	20.1%
United Kingdom	27.3%	39.6%	42.1%
Africa	36.9%	35.3%	51.3%
Other Asia	26.3%	28.8%	38.1%
Other Europe	33.0%	41.2%	41.1%
Other Latin America	23.0%	19.2%	23.9%

Notes: Entries are total manufacturing imports/domestic expenditures on manufacturing goods. We have no trade data for Russia until 1996.

TABLE 5: Share of Chinese Goods in Domestic Expenditure

	1992	2000	2007
China	84.0%	83.7%	80.1%
United States	0.9%	2.0%	4.7%
Argentina	0.2%	0.6%	1.9%
Brazil	0.0%	0.4%	1.0%
Canada	0.8%	1.6%	4.3%
France	0.5%	1.4%	2.9%
Germany	0.6%	1.3%	3.2%
India	0.2%	1.1%	5.2%
Italy	0.3%	0.8%	2.5%
Japan	0.4%	1.6%	3.9%
Mexico	0.3%	0.7%	3.3%
Russia	n/a	0.7%	2.6%
United Kingdom	0.7%	2.0%	3.6%
Africa	0.8%	2.0%	6.9%
Other Asia	1.5%	2.1%	8.3%
Other Europe	0.7%	1.6%	3.5%
Other Latin America	0.3%	1.0%	2.5%

Notes: Entries are manufacturing imports from China/domestic expenditures on manufacturing goods. We have no trade data for Russia until 1996.

TABLE 6: Welfare Gain from China's Productivity Growth

	China	World	Rest of World	Share Rest of World
1992	14.0%	0.61%	0.012%	1.9%
1993	13.8%	0.67%	0.014%	2.1%
1994	13.9%	0.73%	0.016%	2.1%
1995	14.1%	0.89%	0.018%	2.1%
1996	14.3%	1.02%	0.018%	1.7%
1997	14.4%	1.13%	0.022%	2.0%
1998	14.7%	1.16%	0.023%	1.9%
1999	14.9%	1.20%	0.024%	2.0%
2000	14.8%	1.25%	0.028%	2.3%
2001	14.2%	1.49%	0.032%	2.1%
2002	14.2%	1.52%	0.041%	2.7%
2003	13.9%	1.53%	0.046%	3.0%
2004	15.8%	1.47%	0.042%	2.9%
2005	16.2%	1.70%	0.043%	2.6%
2006	16.9%	1.84%	0.050%	2.7%
2007	17.0%	2.03%	0.053%	2.6%
1992-2007	969.0%	22.45%	0.484%	2.2%

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. 1992-2007 welfare gain (last row) is cumulative welfare gain from 1992 to 2007.

TABLE 7: Welfare Gain from China's Productivity Growth 1992-2007

United States	0.33%
Argentina	0.12%
Brazil	0.05%
Canada	0.82%
France	0.17%
Germany	0.75%
India	0.37%
Italy	0.14%
Japan	0.87%
Mexico	0.61%
Russia	0.29%
United Kingdom	0.23%
Africa	0.30%
Other Asia	1.42%
Other Europe	0.22%
Other Latin America	-0.04%

Notes: Entries are cumulative welfare gains from 1992 to 2007 from China's productivity growth. We have no trade data for Russia until 1996 so that Russia's gain refers to the years 1996 to 2007 only.

TABLE 8: Welfare Change Due to Terms-of-Trade and Production Relocation

	Terms-of-Trade	Relocation
United States	0.76%	-0.43%
Argentina	0.04%	0.08%
Brazil	-0.67%	0.72%
Canada	0.49%	0.33%
France	0.47%	-0.30%
Germany	1.16%	-0.40%
India	1.10%	-0.72%
Italy	0.43%	-0.29%
Japan	-0.03%	0.90%
Mexico	1.61%	-1.0%
Russia	0.28%	0.01%
United Kingdom	0.97%	-0.74%
Africa	0.28%	0.03%
Other Asia	1.26%	0.16%
Other Europe	0.33%	-0.11%
Other Latin America	0.78%	-0.82%

Notes: Entries are cumulative welfare gains due to terms-of-trade changes and production relocations (entry and exit of firms). The covariance between the terms-of-trade effect and production reallocation effect is evenly distributed between the two terms.

TABLE 9: Welfare Change Due to Bilateral and Multilateral Terms-of-Trade

	Terms-of-Trade vis-a-vis China	Terms-of-Trade vis-a-vis Rest of World
United States	0.82%	-0.06%
Argentina	0.10%	-0.06%
Brazil	-0.28%	-0.39%
Canada	0.61%	-0.12%
France	0.40%	0.06%
Germany	0.77%	0.39%
India	0.65%	0.45%
Italy	0.29%	0.14%
Japan	0.20%	-0.23%
Mexico	1.12%	0.49%
Russia	0.21%	0.07%
United Kingdom	0.72%	0.25%
Africa	0.45%	-0.18%
Other Asia	0.73%	0.53%
Other Europe	0.42%	-0.09%
Other Latin America	0.35%	0.43%

Notes: Entries are cumulative welfare gains due to terms-of-trade changes vis-a-vis China and terms-of-trade changes vis-a-vis the Rest of the World. The covariance between the bilateral and multilateral terms-of-trade effect is evenly distributed between the two terms.

7 Figures

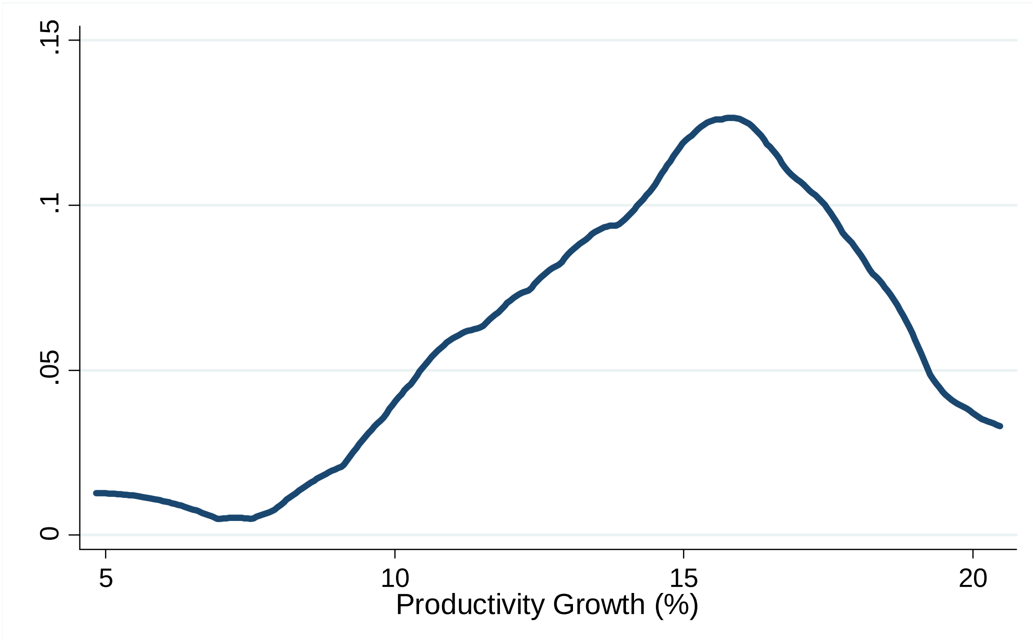

Figure 1: Distribution of Productivity Growth Across Manufacturing Industries in China

Notes: Each observation is the average productivity growth rate in a Chinese 2-digit manufacturing industry from 1992 through 2007.

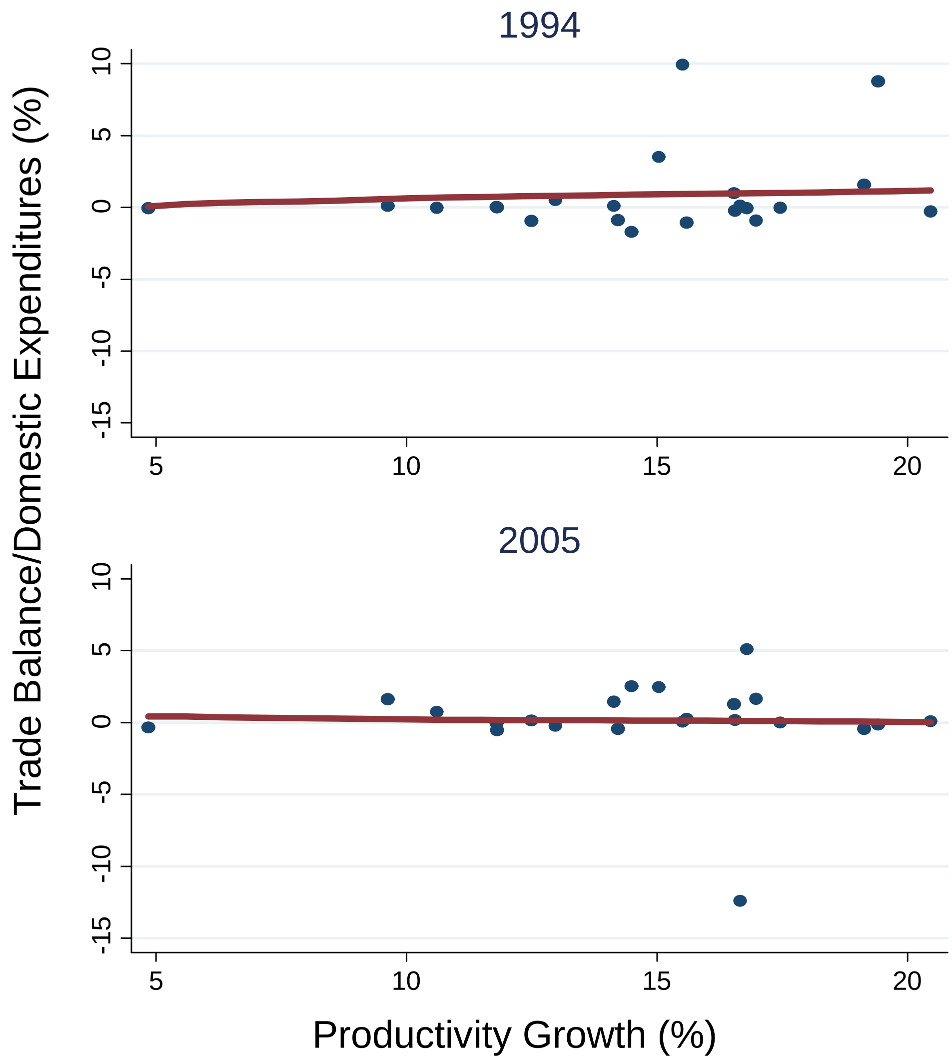

Figure 2: Industry Productivity Growth and Industry Net Exports in China

Notes: Each dot in the figure represents a Chinese 2-digit industry. The line is the non-parametric relationship (bandwidth=5) between the industries' trade balances (normalized by domestic expenditures) and productivity growth rates.

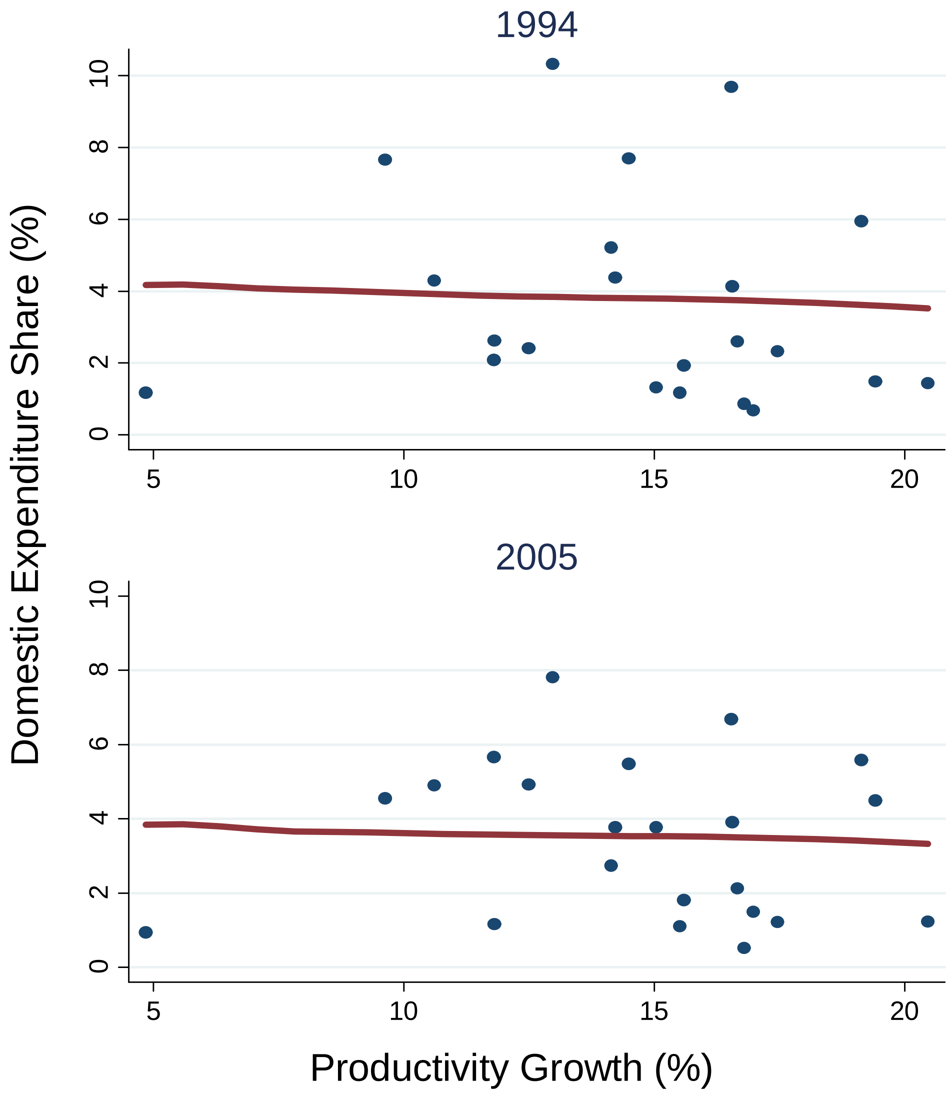

Figure 3: Industry Productivity Growth and Industry Expenditure Share in China

Notes: Each dot in the figure represents a Chinese 2-digit industry. The line is the non-parametric relationship (bandwidth=5) between the industries' domestic expenditure shares and productivity growth rates.

Figure 4: Distribution of Changes in Predicted Wages Relative to China's Wage

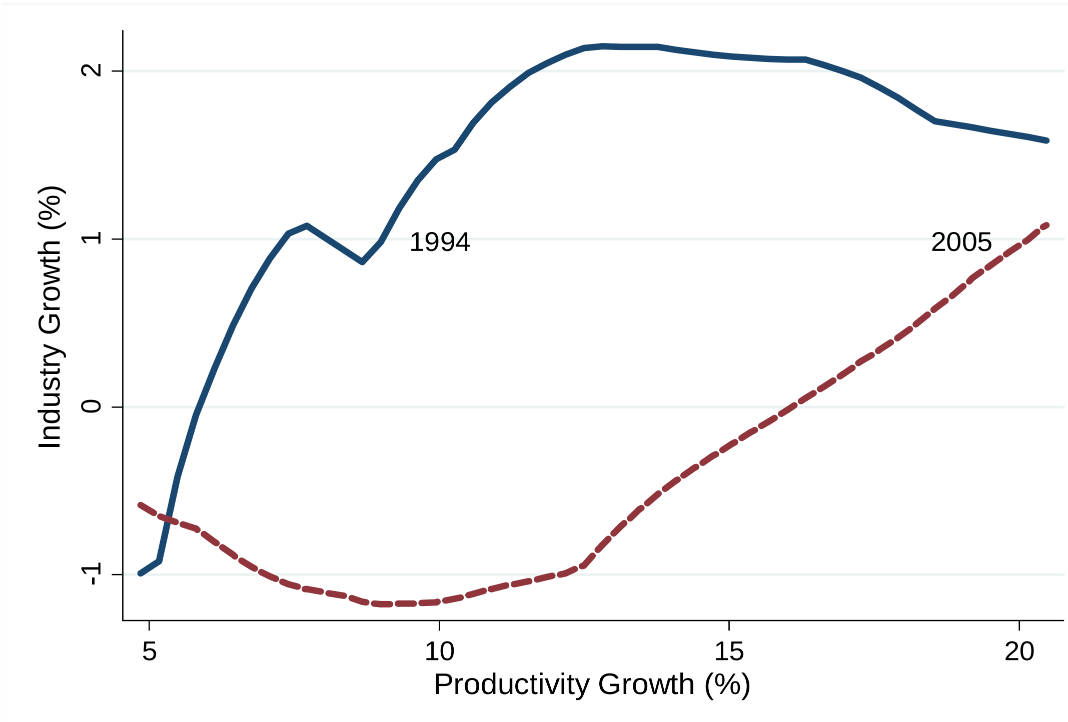

Figure 5: Industry Entry/Exit and Productivity Growth in China