PRELIMINARY, DO NOT QUOTE WITHOUT THE AUTHOR'S PERMISSION

The Implications of China's Pattern of Growth for the Rest of the World

by

Stephen Tokarick*

April 2017

Abstract

Detailed estimates of the pattern of growth in China—capital accumulation, labor input growth, and changes in total factor productivity by sector—are used along with a global model of production and trade for 18 regions and 24 sectors to estimate how these developments affect other countries. The results show that the annual average TFP growth in China over the period 1982-2000 harms some economies, such as Korea and Japan, by reducing the prices of some key export goods, while benefiting other economies, such as Russia and sub-Saharan Africa, by improving their terms of trade. TFP growth in China also reduces output, employment, and real wages in some manufacturing sectors in the United States, the Euro Area, and Japan. In contrast, capital accumulation in China results in only welfare gains for most countries.

Keywords: technological change, welfare, terms of trade

JEL Classification codes: C68, F11, O33

---

*Tokarick: Senior Economist, International Monetary Fund, Research Department, Washington, D.C. 20431. E-mail: stokarick@imf.org. Phone: 202-623-7590. The views expressed in this paper are solely the views of the author and do not necessarily reflect the views of the International Monetary Fund, any of its Executive Directors, or its Management.

I. Introduction

The rapid growth of the Chinese economy in recent years has sparked a great deal of discussion in policy circles over how this growth has affected other countries and how they might address any adverse consequences of China's expansion. China's growth performance in recent decades has raised concerns that it has displaced exports from economies that export similar products, namely manufactured goods, in third markets. Hanson and Robertson (2010) examined how China's growth affected exports from ten economies whose export structures overlap considerably with China's in the manufacturing sector.[1] They found that China's growth reduced exports from these ten economies between 1995 and 2005, but the magnitude of the decline was rather modest, between 0.8 and 1.6 percent. Freund and Ozden (2006) found that China's growth has had a significantly negative impact on exports from Latin America, particularly Mexico, and the Caribbean region.

While there is some evidence to suggest that China's expansion has adversely affected the exports of some developing and middle-income countries, how has it affected advanced economies, economies that presumably have more "sophisticated" export structures? Husted and Nishioka (2012) note that the observed increases in China's import penetration in various countries' import markets have come largely at the expense of lower exports from Japan and the United States. As Schott (2008) has shown, the sophistication of China's exports has grown rapidly over the last three decades in the sense that China's export structure has become more

[1] The ten economies studied included Hungary, Malaysia, Mexico, Pakistan, the Philippines, Poland, Romania, Sri Lanka, Thailand, and Turkey.

Table 1. Export Profiles of China, United States, European Union, Japan, and Germany, 2009

Product	China		United States		European Union		Japan		Germany	
	% of Exports	% of World Exports	% of Exports	% of World Exports	% of Exports	% of World Exports	% of Exports	% of World Exports	% of Exports	% of World Exports
Data Processing Machinery	5.6	71.4	0.4	4.4	0.3	4.0	0.2	1.3	0.4	4.8
Radio and television equipment	3.3	33.4	0.6	4.4	0.6	7.9	0.0	0.2	0.2	1.4
Parts for data processing equipment	2.4	22.7	1.2	10.4	0.5	6.0	0.4	1.8	0.3	2.6
Integrated circuits	1.9	8.0	3.0	9.9	0.8	4.2	4.5	8.3	0.8	2.8
Parts of telephones	1.8	29.5	0.5	6.4	0.5	10.5	0.7	5.0	0.2	2.5
Parts for liquid crystal display devices	1.6	34.5	0.1	1.8	0.0	0.4	0.6	5.9	0.0	0.5
Electric apparatus for telephones	1.6	26.7	1.0	13.9	0.5	9.5	0.3	2.2	0.4	5.4
Transport vessels	1.3	29.7	0.0	0.0	0.2	6.2	2.4	24.9	0.1	1.7
Reception apparatus for TVs	1.1	18.6	0.2	2.7	0.2	3.8	0.1	0.4	0.1	1.9
Input/output units for automatic data processing	1.1	41.9	0.2	6.1	0.1	4.2	0.2	2.7	0.1	3.3
Petroleum oils from bituminous minerals (not crude)	1.0	2.6	3.8	7.6	4.2	12.8	1.7	2.0	1.2	2.6
Machinery for printers	0.9	32.0	0.2	5.7	0.2	6.6	0.3	4.7	0.2	6.0
Video recording devices	0.9	58.6	0.0	2.5	0.0	1.9	0.0	0.7	0.0	1.4
Semi-conductor devices	0.9	27.8	0.3	6.3	0.1	4.5	0.9	12.2	0.4	11.8
Storage units for data processing equipment	0.9	18.8	0.4	7.4	0.2	4.9	0.1	0.7	0.2	3.7
Video cameras	0.8	27.1	0.2	4.3	0.1	4.3	1.6	24.9	0.2	5.2
Static converters	0.8	28.7	0.3	7.5	0.3	14.1	0.2	3.5	0.3	11.2
Footwear	0.7	64.1	0.0	0.9	0.0	2.0	0.0	0.1	0.0	3.5
Printed circuits	0.7	28.2	0.2	5.5	0.1	2.8	0.5	8.2	0.1	2.5
Systems related to TV receivers	0.7	17.7	0.3	6.3	0.2	5.9	0.9	10.8	0.2	4.0
Total	29.9		12.9		9.1		15.6		5.4	

Source: U.N. COMTRADE Database. Shares are computed using data on export values by country at the six-digit level of disaggregation, Harmonized system.

similar to that of advanced countries. Table 1 presents a profile of the export structure of China for 2009, and it shows that there is some overlap between its own export structure and that of the United States, the European Union, Japan, and Germany. Table 1 lists the top twenty export products of China for 2009 in terms of their shares in total Chinese exports and these accounted for thirty percent of China’s total exports. Most of these products fall into the broad category of electrical and non-electrical machinery, especially related to data processing equipment. As shown in table 1, China’s export structure overlaps with that of the United States, the European Union, Japan, and Germany in the product categories of data processing machinery and equipment and integrated circuits, and certain types of oils. China’s exports overlap particularly with Japan in the categories of integrated circuits, transport vessels, and video cameras. Thus, if China were to acquire superior technology or experience rapid productivity growth in these sectors, the advanced countries mentioned above might be worse off.

The principal channel through which growth in China affects the rest of the world is through changes in the prices of goods exported and imported by China—the terms of trade. In simplest terms, the pattern of growth and technological change in China has increased exports from certain sectors, which reduced the prices of these goods on world markets. For countries that compete with China in third markets in these product categories, growth in China represents a terms-of-trade deterioration and a source of welfare loss. This is the channel that Samuelson (2004) emphasized in a paper in which he demonstrated how a technological improvement in an export sector in China might affect the United States in the situation where China and the United States exported similar products. Alternatively, countries that are net importers of the goods exported by China at lower prices experience a terms-of-trade improvement and a welfare gain. Even though net-importing countries gain in a welfare sense as a result of growth in China, there would be distributional impacts inside these countries. For example, domestic output and employment would decline, as greater imports from China displace domestic production. This will also affect returns to factors of production.

The concern about China's impact on the rest of world has been mostly focused on the expansion of China's exports, but little attention has been focused on the effects that would arise through increased demand for imports by China. Growth in China will raise the demand for imports, which would raise the prices of these goods for exporting countries—a terms of trade improvement for exporters and a terms-of-trade deterioration for China. Thus, the net impact of China's growth on the rest of world depends on how China's growth affects both exports and imports by sector in China and the prices of these goods on world markets. Samuelson's demonstration that the United States could be harmed by technological progress in China was cast in the context of a model in which changes in the international terms of trade were clear cut. We use a multi-sector, multi-region model in which the changes in the international terms of trade that result from factor accumulation and TFP growth in China are more complex and depend on the full pattern of trade and income changes across countries.

This paper uses a numerical, general equilibrium model of the world economy to estimate how the profile of China's growth in recent years has affected the rest of the world, focusing especially on advanced economies. In particular, the paper uses detailed estimates of the anatomy of China's growth between 1982 and 2000 and asks what the impact would be on the world economy if the factors underlying the pattern of growth in China over the last 30 years were to continue into the future. The estimates contained in Cao, Ho, Jorgenson, Ren, Sun, and Yue (2009) for changes in input usage (labor and capital) and for total factor productivity (TFP) at a disaggregated level by sector are employed to disentangle the economic effects of these developments on the rest of the world. The model delineates 18 separate countries and regions of the world economy with each region producing 24 goods using two primary factors of production (labor and capital) and both domestic and imported intermediate inputs.

Three simulations are conducted with the model. In the first, the detailed estimates of changes in sectoral TFP contained in Cao et al. (2009) are used to assess the impact of these changes on the rest of the world. To gain some insight on these effects, we ask: what would be the impact on the rest of the world if sectoral TFP in China were to grow at the same average annual rate that occurred in China between 1982 and 2000. That is, we simulate the impact of one year of "average" TFP growth. The results show that some economies would be harmed mainly as a result of declines in the international prices of key manufacturing goods. In particular, TFP growth in China between 1982 and 2000 was strong in the electrical and non-electrical machinery sectors. If this trend were to continue, Chinese exports of these goods would rise and international prices would decline, which would represent a terms-of-trade deterioration for competing exporters of these products, such as Korea and Japan. On the contrary, TFP growth in China between 1982 and 2000 was strongly *negative* in the oil extraction sector. If this pattern continued, net-exporters of oil products, such as Russia would be better off, while net importers would be harmed. Taken together, if the pattern of TFP growth in China were to continue, the rest of the world would be worse off, although the magnitude of the losses would be rather small, but cumulating these changes over the entire period from 1982 to 2000 would generate large impacts. TFP growth in China also reduces real wages in the United States, the Euro Area, and Japan. Of course, the world as a whole would be better off.

One of the conclusions of the work of Cao et al. (2009) is that the principal factor driving economic growth in China over the period 1982 to 2000 was the rapid accumulation of capital, rather than developments in sectoral TFP. In fact, Cao et al. (2009) estimate that aggregate TFP growth in China has slowed in recent years, becoming slightly negative between 1994 and 2000. Thus, in the second simulation, the consequences for the rest of the world of significant increases in the use of capital inputs by sector in China are evaluated. Previous work, such as Hsieh and Ossa (2010) and diGiovanni, Levchenko, and Zhang (2012) only evaluated the impact of TFP developments. This simulation demonstrates that the impact of capital accumulation in China on the rest of the world would differ, compared to the effects of changes in TFP. In particular, mainly oil-exporting countries would be harmed by this type of growth in China through a deterioration in their terms of trade. The main reason for this result is that with one or two exceptions, the sectors that experienced rapid accumulation of capital between 1982 and 2000 were sectors that experienced rather slow rates of TFP growth over the same time period. Capital accumulation in China increases sectoral outputs and reduces world prices, just as TFP growth would do, but for a different set of sectors. It turns out that the sectors that experienced rapid rates of capital accumulation in China between 1982 and 2000 were mainly nontraded sectors, plus the oil and gas extraction sector—an importable rather than an exportable sector. Rapid accumulation of capital in the oil sector would increase domestic output and reduce the demand for imports, which would represent a terms-of-trade deterioration for Russia, Mexico, and countries of the Middle East and North Africa (MENA) region.

The third simulation combines the impact of sectoral TFP growth, as well as changes in the usage of capital inputs by sector between 1982 and 2000 and labor force growth. These results show that the combination of TFP growth and factor accumulation would worsen the terms of trade for Korea, Japan, and India, as well as the advanced economies of the United States and the Euro Area. Other Asian economies benefit from the expansion in China's exports, as they are suppliers of intermediate inputs to China, especially in electronic and non-electronic machinery and equipment. The United States and the Euro Area would be worse off as a consequence a rise in the price of oil.

Section two discusses the analytics of the effects of capital accumulation and TFP growth. Section three summarizes the results of Cao et al (2009) who used a typical growth-accounting framework, to decompose China's aggregate growth performance into the portion due to factor accumulation (labor and capital), TFP growth, and factor re-allocation by sector. Section four describes the numerical model and the simulations, while section five presents the results. Section six concludes.

II. Economic Effects of Factor Accumulation and Technological Change

To highlight the economic impact of factor accumulation and technological change, suppose there are two countries (home and foreign), and only the home country experiences growth and technological change. The budget constraint for the home country is:

$$G(p_E, p_M, v, a) + t_M p_M^* (E_M - G_M) = E(p_E, p_M, u) \qquad (1)$$

where $G(p_E, p_M, v, a)$ is the GDP function, which depends on the price of exports (p_E), the price of imports (p_M), a vector of factor supplies (v), and the level of technology (a). The term $t_M p_M^* (E_M - G_M)$ denotes tariff revenue, as t_M is the ad-valorem tariff rate on imports, p_M^* is the foreign price of imports, and $(E_M - G_M)$ is the quantity of imports, since E_M is the derivative of the expenditure function with respect to the price of imports and therefore domestic demand for the imported good while G_M is output of the imported good.

Differentiating equation (1) with respect to (v) and (a), as well as prices, choosing the world price of imports, p_M^*, as numeraire from the point of view of the home country (which is the price of exports of the foreign country), gives:

$$\begin{aligned}(E_U - t_M p_M^* E_{MU})dU &= \left[G_V - t_M p_M^* G_{MV}\right]dV + \left[G_a - t_M p_M^* G_{Ma}\right]da \\ &+ \left[(G_E - E_E) + t_M p_M^* (E_{ME} - G_{ME})\right]dp_E\end{aligned} \tag{2}$$

where a subscript next to the function *E* or *G* represents the partial derivative with respect to that variable.

The welfare impact of technological change in the home country on the foreign country is:

$$(E_U^* - t_M^* p_M^* E_{MU}^*)dU^* = \left[-(E_M^* - G_M^*) + t_M^* p_M^* (E_{MM}^* - G_{MM}^*)(1 + t_M^*)\right]dp_E \tag{3}$$

noting that here, p_E is the price of exports from the point of view of the home country or the price of imports from the point of view of the foreign country.

To simplify the discussion, suppose there are no tariffs initially. Then, the impact of technological change in the home country on both the home and foreign countries is given by:

$$E_U dU = G_V dV + G_a da + (G_E - E_E) dp_E \qquad (4)$$

$$E_U^* dU^* = -(E_M^* - G_M^*) dp_E \qquad (5).$$

From equation (4), factor accumulation and technological change in the home country affects home welfare through two channels: (i) a direct effect given by $G_V dV$ and $G_a da$; and (ii) a terms-of-trade effect given by $(G_E - E_E) dp_E$. The derivative of the GDP function with respect to (*V*) and (*a*) will be positive provided that technological change and factor accumulation raise GDP at constant prices, so this channel will raise real income at home. However, the terms-of-trade impact (ii) could be positive or negative. As shown by Bhagwati (1958), if the factor accumulation or technological change is biased toward a country's export sector, then it will deteriorate the country's terms of trade, i.e. $dp_E < 0$. Depending on the magnitude of the deterioration, the country could be worse off as a result of technological progress.

The impact of technological change in the home country on the foreign country comes through changes in the terms of trade, as shown by equation (5). The term $(E_M^* - G_M^*)$ represents the foreign country's imports. So, if the technological progress in the home country depresses the price of the goods that it imports, $dp_E < 0$, then the foreign country will be better off. In a more complex model with three trading countries instead of two, it would be possible for technological progress in one country to harm one of the others if the progress worsened the terms of trade of one of the other countries. To use a more concrete example, if China and the United States competed against each other in some third market, as Samuelson (2004) proposed, then technological progress in China could harm the United States if the progress deteriorated the U.S. terms of trade.

These general propositions become less clear-cut when distortions, such as import tariffs, are present. As shown in equation (2), when t_M is nonzero, there are two additional terms to consider. One is $t_M p_M^* (E_{ME} - G_{ME})$, which measures how a change in the home country's terms of trade affects tariff revenue. If exports and imports are substitutes in demand, then $(E_{ME} - G_{ME}) > 0$; therefore technological progress that worsens the home country's terms of trade ($dp_E < 0$) will make it ***more*** likely that the home country would be worse off. On the other hand, there is an additional effect to consider, given by $(G_a - t_M p_M^* G_{Ma})$. The term G_{Ma} captures how output of the import good is affected by the technological change. If it reduces output of imports, then that will tend to raise home welfare, as output of the import good is distorted by a non-zero tariff. Similar considerations arise with factor accumulation, as the term $\left[G_V - t_M p_M^* G_{MV}\right]$ could be positive or negative, at unchanged terms of trade. If the factor accumulation is biased toward production of the import good $G_{MV} > 0$, then welfare could decline if the magnitude of the rise in output of the import good is sufficiently large, as shown by Johnson (1967). On net, it becomes an empirical matter whether the country experiencing the technological change will gain or lose.

Whether the foreign country gains or loses from technological change in the home country still depends on how the terms of trade are effected when the foreign country has a non-zero tariff in place. With a non-zero tariff, the additional term to consider from equation (3) is $t_M^* p_M^* (E_{MM}^* - G_{MM}^*)(1 + t_M^*)$, which is unambiguously negative, since $(E_{MM}^* - G_{MM}^*)$ represents how the demand for imports changes when the price of imports is altered. So, with a non-zero tariff, technological change in the home country will benefit the foreign country if it reduces the price of the foreign country's imports. The foreign country could be worse off if it subsidized imports, i.e. if t_M^* were negative instead of positive. In this case, a reduction in the price of imports could increase subsidy expenditure. If this effect is large, welfare could decline.

III. Sources of Growth in China: 1982-2000

Using a growth accounting framework that has characterized the literature on measurement of TFP, Cao et al. (2009) have decomposed China's growth over the period 1982 to 2000 into its components: the growth of sector outputs, labor inputs, capital inputs, intermediate inputs, and TFP for 33 sectors. They assume that gross output in a given sector can be written as follows:

$$Y_{jt} = A_{jt} f(K_{jt}, L_{jt}, Z_{jt}) \quad (6)$$

where Y_{jt} denotes output of sector j at time t, A_{jt} is an index of total factor productivity (TFP) in sector j at time t, Z_{jt} is an index of intermediate input usage in sector j at time t. Log differentiating equation (6) gives:

$$\hat{Y}_{jt} = \alpha_{kjt}\hat{K}_{jt} + \alpha_{ljt}\hat{L}_{jt} + \alpha_{zjt}\hat{Z}_{jt} + \hat{A}_{jt} \quad (7)$$

where α_{kjt}, α_{ljt}, and α_{zjt} denote the weights attached to capital inputs, labor inputs, and intermediate inputs respectively used in sector j at time t. Therefore, using equation (7), Cao et al. (2009) calculate TFP growth by sector. Their results for TFP and factor inputs are contained in tables 2 and 3 below.

To highlight some of the main results shown in Table 2, Cao et al. (2009) estimate that aggregate TFP growth for the Chinese economy averaged 2.5 percent per year over the entire period of 1982 to 2000. TFP growth has been slowing, even turning slightly negative in the period 1994-2000, mainly due to slowdowns in the manufacturing and tertiary sectors while TFP growth in agriculture remained positive. The estimates show some rather large variation across sectors: for the entire period from 1982 to 2000, TFP growth averaged 5.6 percent per year in electrical machinery, but -10 percent per year in oil and gas extraction.

Table 2. China: Sectoral Total Factor Productivity Growth (percent per year)

	Total Factor Productivity				
Sector	1982–2000	1982–84	1984–88	1988–94	1994–2000
Primary industry	2.6	4.1	-1.4	2.2	5.0
Secondary industry	1.4	3.0	2.1	1.3	0.7
Coal mining	0.8	4.9	1.8	-3.1	2.6
Metal and non-metal mining	1.2	-1.9	0.8	-0.2	3.7
Oil and gas extraction	-10.0	-7.6	-18.1	-10.7	-4.6
Construction	-0.2	0.2	2.8	0.5	-3.2
Food products	0.2	0.8	0.8	1.9	-2.0
Textile mill products	1.6	0.9	4.0	-0.4	2.3
Apparel	2.7	5.6	6.4	3.9	-2.1
Lumber and wood	2.4	-2.7	4.2	5.0	0.1
Furniture and fixtures	3.4	1.3	3.3	5.8	1.9
Paper and allied	4.8	9.5	10.3	3.7	0.8
Printing, publishing	2.4	5.1	5.1	2.3	-0.2
Chemicals	1.6	4.7	2.2	2.2	-0.5
Petroleum, coal prod	-1.5	4.9	-15.7	-1.1	5.4
Leather	2.2	8.2	4.5	1.9	-0.9
Stone, clay, glass	2.2	1.3	2.7	0.8	3.7
Primary metal	1.6	3.2	-1.6	-1.8	6.5
Fabricated metal	2.9	4.4	4.1	3.5	0.9
Machinery, non-elect	4.1	9.1	6.9	2.3	2.5
Electrical machinery	5.6	6.4	8.6	4.9	4.0
Motor vehicles	2.9	10.0	5.4	1.8	0.0
Transportation equip	3.1	9.6	5.4	3.9	-1.3
Instruments	3.9	4.1	3.9	3.8	3.8
Rubber and plastics	2.4	8.1	3.4	2.8	-0.5
Misc. manufacturing	0.6	0.8	2.4	0.7	-0.7
Electric utilities	-2.0	2.0	0.0	-1.4	-5.1
Gas utilities	-2.7	-1.0	-5.2	-2.5	-1.8
Tertiary industry	-0.6	4.5	1.2	0.1	-3.5
Annual averages (all sectors)	2.5	9.1	3.3	2.6	-0.3

Source: Cao et al. (2009).

Other studies that estimated TFP growth on a sectoral basis in China, such as Hsieh and Ossa (2010) and Levchenko and Zhang (2011), found much different rates of TFP growth compared to those estimated by Cao et al. (2009). Hsieh and Ossa (2010) state that while there is considerable variation in TFP growth rates across sectors, the median productivity growth rate that they estimate is 15.68 percent and the interquartile range is 11.41 to 19.43 percent. Levchenko and Zhang (2011) estimated an average productivity growth rate of 14 percent over a ten-year period or about 1.3 percent per year, but they do not report the estimates on a sectoral basis. Both Hsieh and Ossa (2010) and Levchenko and Zhang (2011) used methods other than a growth accounting framework to estimate TFP growth in China. For example, Levchenko and Zhang (2011) used data on bilateral trade flows to estimate a structural gravity equation and then use data on input costs to back out underlying technology parameters. It is important to note that the estimates of TFP growth from the papers mentioned above are not consistent with TFP estimates that would be obtained from a standard growth accounting exercise. Using a standard growth accounting methodology, and using data for the period 1982 to 2000, capital for the Chinese economy grew by about 10 percent, labor by 1 percent and the shares of each of these in national income is about 0.5. Using an annual growth rate of output of 8 percent would imply average growth in TFP for the economy as a whole of 2.5 percent per year, with re-allocation effects lying between zero and 0.5 percent. Given the rapid rate of growth in capital over the period from 1982 to 2000, an average annual rate of growth of TFP of 14-15 percent is inconsistent with the data.

Table 3. China: Growth of Sector Output and Inputs (percent per year)

	Output		Capital Input		Labor Input		Energy Input		Material Input	
Sector	82–00	94–00	82–00	94–00	82–00	94–00	82–00	94–00	82–00	94–00
Primary industry	6.9	8.9	3.0	5.9	2.2	0.8	6.3	11.5	7.9	5.4
Secondary industry	11.4	10.2	6.7	9.2	3.3	2.6	9.7	12.0	13.3	11.5
Coal mining	7.2	6.7	5.7	6.9	0.5	-4.6	5.1	3.2	11.2	9.0
Metal and non-metal mining	10.3	8.3	7.4	5.0	0.2	-3.5	9.4	5.2	13.8	7.4
Oil and gas extraction	1.4	6.2	11.6	9.7	3.2	-0.8	10.6	18.5	11.7	13.3
Construction	9.2	9.1	8.8	15.7	4.5	8.9	11.8	29.0	10.8	11.8
Food products	9.8	7.1	8.5	7.8	4.3	3.4	11.5	6.7	10.3	10.1
Textile mill products	8.9	6.7	3.7	0.3	2.5	-4.0	7.7	3.0	8.6	6.5
Apparel	14.6	4.6	1.6	10.2	6.4	10.4	17.5	12.6	15.3	5.6
Lumber and wood	15.9	10.2	6.6	18.3	7.5	11.3	8.4	1.2	17.1	8.7
Furniture and fixtures	15.7	10.7	0.5	6.3	3.1	7.2	9.9	7.8	17.0	9.7
Paper and allied	18.9	11.4	6.7	13.0	2.7	-0.3	15.7	8.7	18.7	12.8
Printing, publishing	12.9	4.2	6.3	6.8	4.1	0.4	10.3	12.4	13.2	4.6
Chemicals	12.3	10.3	8.1	12.1	2.6	-1.9	6.9	9.0	13.6	12.5
Petroleum, coal prod	6.6	16.1	9.6	8.3	3.6	0.5	3.9	8.7	15.4	17.9
Leather	15.5	5.8	1.3	-3.1	7.5	13.9	14.6	8.0	16.5	7.0
Stone, clay, glass	14.2	9.8	8.7	6.4	0.9	-1.1	9.8	4.3	17.3	8.0
Primary metal	10.8	15.7	6.4	8.3	2.7	-1.6	5.9	9.6	11.8	10.9
Fabricated metal	12.9	8.8	2.2	5.0	1.9	4.0	10.1	10.0	13.5	8.9
Machinery, non-elect	13.3	9.7	0.4	2.5	0.4	-4.8	8.5	8.5	13.8	10.5
Electrical machinery	23.0	24.2	9.3	11.3	5.4	6.3	14.3	15.8	21.2	23.7
Motor vehicles	13.6	9.6	6.9	11.6	4.4	5.3	10.1	14.1	13.0	9.5
Transportation equip	14.4	9.9	5.0	13.2	4.8	3.5	4.1	6.6	14.4	12.3
Instruments	14.1	16.0	1.4	2.4	-0.9	-2.8	8.9	14.1	15.7	17.2
Rubber and plastics	10.9	9.8	-2.0	6.6	4.2	3.2	10.7	13.3	12.4	11.9
Misc. manufacturing	10.3	8.9	8.7	13.1	2.0	8.8	12.2	14.9	11.4	8.8
Electric utilities	9.4	9.3	11.2	17.9	7.3	9.8	8.4	11.4	17.7	15.6
Gas utilities	12.7	10.1	16.7	11.0	12.7	13.9	13.8	13.1	18.8	10.0
Tertiary industry	10.5	7.2	13.9	15.3	6.8	8.6	5.5	8.9	12.0	9.9

Source: Cao et al. (2009).

Perhaps the most striking feature of China’s growth performance between 1982 and 2000 was the relatively rapid growth in the use of capital inputs across all sectors with a few exceptions, such as leather, rubber and plastics, and non-electric machinery (Table 3). As well, the magnitude of the increases in capital inputs exceeded the rates of TFP growth. Output growth in the primary (agriculture) sector remained strong over the entire period

1982-2000, despite a slowdown in the use of labor inputs, reflecting a reallocation of labor to manufacturing and tertiary industries. Overall, the period from 1982 to 2000 can be characterized by aggregate output growth of about 8 percent per year, fueled mostly by rapid rates of capital input usage and relatively slow rates of labor inputs.

One feature of China's growth profile between 1982 and 2000 that has important implications for the simulation results is that the five sectors that experienced the fastest rates of capital input usage were the five sectors with the *slowest* TFP growth. Table 3 shows that the gas utilities, tertiary industries, oil and gas extraction, electric utilities, and petroleum and coal products sectors all increased their usage of capital inputs by annual averages that ranged between 9.6 and 16.7 percent. But, in these same sectors, TFP declined anywhere between 1.5 and 10 percent per year (Table 2). There were a few sectors that experienced rapid rates of *both* capital input usage and TFP, including electric machinery, paper, printing, and publishing, and stone, clay and glass. Three of the five sectors that experienced the fastest growth in the use of capital inputs (gas utilities, electrical utilities, and petroleum and coal products) are essentially nontraded, while the remaining two (tertiary and oil and gas extraction) are net-import sectors. In contrast, the sectors with the fastest rates of TFP growth were, with a few exceptions, sectors with a very high export orientation: electrical machinery, non-electrical machinery, transportation equipment, and fabricated metal. These three sectors alone accounted for about 47 percent of China's exports in 2007.

IV. Model, Data, and Simulations

We use a numerical general equilibrium model of the world economy (the GTAP model) along with the GTAP database for the year 2007 to assess the impact of different sources of growth in the Chinese economy on the rest of the world. The GTAP database contains detailed data for 57 sectors (i.e. commodity groupings) for 129 countries/regions. For our simulations, we aggregate the full database into 24 sectors, in order to match the sectoral breakdown contained in Cao et al. (2009) as closely as possible. We also aggregate the primary factor inputs into two: labor which is assumed to be perfectly mobile across all sectors, and capital, which is assumed to be sector specific.[2] Finally, we aggregate the 129 countries and regions into 18. The aggregation scheme is summarized in table 4.

The GTAP model is a multi-country, multi-sector numerical general equilibrium model in which regions are connected to each other through trade flows. The model is an equilibrium one in the sense that product and factor prices adjust to bring about equilibrium in markets. Firms choose the amounts of inputs—labor, capital, domestic intermediates, and imported intermediates—so as to minimize the cost of producing a given level of output. Consumers maximize utility, which gives rise to demand functions. The interaction of demand and supply in all markets determine prices.

The trade structure of the model is a combination of an Armington type approach with Hecksher-Olin features. The model employs the armington assumption in that it treats goods produced in different regions as imperfect substitutes for each other. In addition, the model possesses features of the Hecksher-Olin model in that each country/region has an

[2] This type of trade model is known as the Ricardo-Viner model. For a discussion of this type of production structure in trade theory, see Jones (1971), Dixit and Norman (1980), and Woodland (1982).

Table 4. Summary of GTAP Model Aggregation

Sectors (24)	Countries/Regions (18)	Primary Factors (2)
Primary industry	United States	labor
Coal mining	Australia, New Zealand, and Canada	capital
Metal and non-metal mining	Euro area	
Oil and Gas extraction	Non-euro EU countries	
Construction	Other European countries	
Food products	China	
Textile mill products	Korea	
Apparel	India	
Lumber and Wood	Japan	
Miscellaneous manufacturing	Rest of Asia	
Paper, printing, and publishing	Russia	
Chemicals, Rubber, and plastics	Brazil	
Petroleum and coal products	Rest of South America	
Leather	Mexico	
Stone, Glass, and clay	South Africa	
Primary metal	Sub-Saharan Africa	
Fabricated metal	Middle-East and North Africa	
Machinery, non-electric and instruments	Rest of World	
Electrical machinery		
Motor Vehicles		
Transport equipment		
Electric utilities		
Gas utilities		
Tertiary Industry		

Source: GTAP database, version 8; authors' aggregation.

endowment of primary factors (labor and capital) of production which are used to produce sectoral output and these endowments differ across countries and regions. These outputs use primary (and intermediate) inputs in variable proportions, which also differ across countries. For a detailed description of the GTAP model, see Hertel et al. (1997).

Given that the simulations focus on changes in technology, the production structure of the GTAP model is described briefly. For a given country/region, at the very top level of the production structure, output of good j is produced according to a CES function, which is an aggregate of value added in that sector and intermediate inputs:

$$Q_j = A_j \left[\alpha_j VA_j^{-\rho_j} + (1-\alpha_j) IT_j^{-\rho_j} \right]^{(-1/\rho_j)} \quad (8)$$

---

where Q_j is gross output in sector j in a given country/region, A_j is a constant, α_j is a distribution parameter associated with value added in sector j, VA_j, IT_j is an aggregate bundle of intermediate inputs used in sector j, and ρ_j is a parameter related to the elasticity of substitution between aggregate value added and intermediate inputs in sector j, σ_j, where $\rho_j = \frac{1-\sigma_j}{\sigma_j}$, for $\sigma_j \neq 0$.

At the second stage, value added is composed of two primary inputs: (i) labor; and (ii) capital, according to a CES function analogous to equation (8):

$$VA_j = AV_j \left[\beta_j L_j^{-\varepsilon_j} + (1-\beta_j) K_j^{-\varepsilon_j} \right]^{(-1/\varepsilon_j)} \quad (9)$$

where AV_j is a constant, β_j is a distribution parameter, L_j and K_j are labor and capital inputs used in sector j, and ε_j is a parameter related to the elasticity of substitution among the two primary factors.

Three simulations are performed with the GTAP model, starting from the structures of the economies of the world as they were in 2007. In the first, we evaluate the impact of sectoral TFP growth in China on the rest of the world. To do this, we use the annual average estimates of TFP growth by sector contained in Cao et al. (2009) for the period 1982 to 2000 and shown in column 1 of table 2. We implement these changes by altering value of the parameter A_j in equation (8). So, starting in 2007, we ask: what would the impact be on the rest of the world if sectoral TFP in China grew at the average annual rates that occurred over the period from 1982 to 2000. Similarly in the second simulation, we ask what the implication would be for the rest of the world if China increased its inputs of capital on a sectoral basis, at the same average annual rate as it did between 1982 and 2000 as shown in Table 3. Finally, our third simulation is a combines the first two simulations and adds growth in the labor force of 3.9 percent, as reported in Cao et al. (2009). Note these simulations evaluate the impact of the changes in TFP and factor inputs that took place in one average year between 1982 and 2000. These annual impacts would have to be cumulated to obtain the total impact over the period 1982 to 2000.

Our model differs in several respects from other models that have used to assess the impact of China’s growth on the rest of the world. First the model used in this paper takes into account all economic activity in a country: the model includes the agricultural, manufacturing, and service sectors of each economy. Hsieh and Ossa (2010) only include the manufacturing sector in their model and diGiovanni, Levchenko, and Zhang (2011) only include the agricultural and manufacturing sectors of economies—they omit the service sector. We feel this may overstate the impact of growth in China as it gives undue weight to the manufacturing sector. For many advanced countries, services account for upwards to 70 percent of GDP. Second, the model used in this paper allows sectoral output to be produced using imported and domestic intermediate inputs, as reported in the input-tables for each country. diGiovanni, Levchenko, and Zhang (2011) also allow for domestic and imported intermediate inputs, but they use the input-output coefficients contained in the U.S. input-output table for every country in their model.[3] Third, the model used in this paper uses allows factor intensities to differ across sectors within a country, as well as across countries, and thus, captures an important aspect of Hecksher-Olin type trade. The model used diGiovanni, Levchenko, and Zhang (2011) allows factor intensities to differ by sector within a country, however, they assume that factor intensities are the same across countries, namely, their production function parameters, α_j and β_j do not differ by country.

Finally, the model used in this paper includes various types of tax distortions, such as tariffs on imports and consumption taxes. As will be shown below, the results from one of the simulations demonstrate that second-best effects are quantitatively important. The models of both Hsieh and Ossa (2010) and diGiovanni, Levchenko, and Zhang (2011) do not contain any tax or tariff distortions.

V. Results

A. Impact of TFP Growth in China on the Rest of the World

[3] diGiovanni, Levchenko, and Zhang (2011) state that they evaluated the significance of this assumption by collecting country-specific input-output tables and noting that they were similar in structure to the U.S. input-output table at their level of aggregation.

The impact of TFP growth in China on all countries and regions in the model are summarized in table 5. China experiences a large welfare gain as a result of the pattern of TFP growth, despite a deterioration in its terms of trade. In terms of equation (4), the positive impact of TFP growth ($G_a da$) outweighs the magnitude of the terms-of-trade deterioration, so China does not suffer immiserizing growth. The negative TFP growth in the oil and gas sector reduces output of oil in China and thus, raises the demand for imported oil, which pushes up its price. Imports of oil represent about 11 percent of China's total imports and 6½ percent of world trade in oil. Hence, developments in China are likely to have some impact on international prices.

The impact of sectoral TFP developments in China on the rest of the world comes mainly through changes in the terms of trade for each country, which are complex. For example, the rise in the price of oil represents a terms-of-trade deterioration for net importing countries, such as the United States, the Euro Area, Japan, Korea, India, and the Rest of Asia. Of course, the net exporters, such as Russia, sub-Saharan Africa, and the MENA region benefit through a terms-of-trade improvement. Also, China experienced rather strong TFP growth in both the electrical and non-electrical machinery sectors, which comprise many of the export products listed in table 1. This development, which raises output and exports of these goods from China, lowers world prices and harms competing exporters such as Korea and Japan. Thus, the net impact of TFP developments on other countries depends on the several key factors: (i) how the TFP growth in China affects import demand and export supply of each good; (ii) the extent to which China is able to influence international prices by how much it imports and exports; and (iii) the net trade position of other countries.

Table 5. Impact of Changes in Sectoral TFP in China: 1982-2000.

	Equivalent Variation (EV) (millions of 2007 U.S. Dollars)	Equivalent Variation (EV) (percent of GDP)	Percentage change in Real private Consumption	Percentage change in the Terms of Trade	Percentage change in the Real Wage
United States	-11744.0	-0.08	-0.12	-0.40	-0.21
Australia, New Zealand, and Canada	3731.4	0.15	0.11	0.46	-0.09
Euro Area Countries	-17041.1	-0.14	-0.23	-0.32	-0.37
Non-euro EU	-2743.0	-0.06	-0.11	-0.07	-0.28
Rest of Europe	2413.1	0.20	0.14	0.32	-0.25
China	112635.0	3.22	2.89	-0.76	4.20
Korea	-4118.8	-0.39	-0.59	-1.00	-0.82
India	-2180.4	-0.18	-0.33	-0.68	-0.55
Japan	-7949.2	-0.18	-0.29	-1.06	-0.41
Rest of Asia	2989.5	0.13	0.12	0.13	0.02
Russia	9356.5	0.72	0.64	2.29	-0.11
Brazil	-11.3	0.00	-0.05	-0.16	-0.19
Rest of South America	2940.6	0.28	0.22	0.84	-0.02
Mexico	553.6	0.05	0.00	0.09	-0.25
South Africa	-265.6	-0.09	-0.17	-0.26	-0.29
Sub-Saharan Africa	6080.0	1.03	1.10	2.39	0.42
MENA	24220.7	0.96	0.91	2.16	-0.01
ROW	-347.1	0.21	-0.10	-0.07	-0.23

Sources: Model simulations.

The results from this simulation demonstrate that the three largest economies, the United States, the Euro Area, and Japan, would face adjustment issues in some sectors as a consequence of the pattern of TFP growth in China. In particular, although TFP growth in the electronic machinery sector in China lowers prices for consumers, it reduces output and employment in this sector in the three economies mentioned above and the magnitudes are rather large: in the United States, output would decline by 4 percent and employment by 5½ percent; in the Euro Area output would decline by 3 percent and employment by 5 ½ percent; and in Japan output would decline by 2 percent and employment by 3½ percent. Furthermore, real wages decline in these three economies, as the manufacturing sectors such as machinery, are labor intensive.

Welfare is also affected by how the price changes induced by TFP growth in China interact with existing distortions, i.e. second-best effects. For example, as noted, negative TFP growth in the oil sector in China raises the world price of oil. Several countries and regions, such as the United States, the Euro Area, and Japan, have consumption or excise taxes in place on petroleum products. By themselves, these taxes reduce consumer welfare by raising prices and reducing the amount of petroleum consumed. A rise in the world price of petroleum exacerbates the negative welfare impact of the tax because the price rise reduces consumption further.[4] The impact on welfare through this channel is quantitatively important for some countries, accounting for about 1½ billion of the welfare loss for the United States, 1.3 for Japan, and about 5 billion of the welfare loss for the Euro Area.

B. The Impact of Changes in the Usage of Capital Inputs in China

Table 6 shows the impact of the sectoral pattern of capital input usage in China on the rest of the world. The results from this simulation are notably different, compared to the impact of sectoral changes in TFP growth, because the pattern of capital input usage differs

---

[4] This channel is depicted in equation (3) by the term $t_M^* p_M^* (E_{MM}^* - G_{MM}^*)(1+t_M^*)$. In this expression, t_M^* is a tariff, rather than a consumption tax, but the economic forces at work are similar. Martin, Ianchovichina, and Dimaranan (2008) also find that this second-best effect arises in their model.

Table 6. Impact of Changes in Capital Inputs by Sector in China: 1982-2000.

	Equivalent Variation (EV) (millions of 2007 U.S. Dollars	Equivalent Variation (EV) (percent of GDP)	Percentage change in Real private Consumption	Percentage change in the Terms of Trade	Percentage change in the Real Wage
United States	2818.1	0.02	0.03	0.12	0.03
Australia, New Zealand, and Canada	-133.7	-0.01	0.00	0.00	0.01
Euro Area Countries	3148.3	0.03	0.04	0.06	0.05
Non-euro EU	550.6	0.01	0.02	0.03	0.04
Rest of Europe	-132.4	-0.01	0.00	-0.02	0.03
China	148126.3	4.24	4.73	-0.56	3.62
Korea	1132.4	0.11	0.14	0.26	0.15
India	591.9	0.05	0.05	0.19	0.05
Japan	1620.1	0.04	0.05	0.22	0.06
Rest of Asia	1354.4	0.06	0.08	0.12	0.12
Russia	-1061.5	-0.08	-0.08	-0.24	0.00
Brazil	429.5	0.03	0.04	0.24	0.02
Rest of South America	12.9	0.00	0.01	0.02	0.00
Mexico	-163.7	-0.02	-0.01	-0.04	0.01
South Africa	36.4	0.01	0.02	0.04	0.04
Sub-Saharan Africa	-563.5	-0.01	-0.11	-0.22	-0.04
MENA	-2502.5	-0.1	-0.10	-0.22	0.00
ROW	145.8	0.03	0.04	0.07	0.03

Source: Model simulations.

from the pattern of TFP growth in China. Thus, the sectoral changes in output and exports differ as well. As shown in Table 6, six countries would be worse off as a consequence of changes in capital input usage in China. One set of countries—Russia, Mexico, Rest of Europe, sub-Saharan Africa, and the MENA region—would be worse off as a consequence of lower oil prices. The principal reason for this is that the oil and gas extraction sector in

China increased its usage of capital inputs at a very rapid rate: an average of 11.6 percent a year between 1982 and 2000. This increases output of the oil sector and reduces imports, which reduces the world price of oil, and this represents a terms-of-trade deterioration for Russia, Mexico, Rest of Europe, sub-Saharan Africa, and the MENA region. Australia is also worse off because the demand, and therefore the prices, of its raw materials falls as output of raw materials, such as coal, increases in China following growth in capital inputs. All other countries are better off as the higher income in China translates into greater demand for exports from the rest of the world, which improves countries' terms of trade.

Importantly, three sectors that increased its use of capital inputs in China at rapid rates, the gas utility, tertiary (service), and electric utilities sectors in China are essentially nontraded. Thus, the rise in income in China generated by capital accumulation translates into higher demand for imports, which benefits the rest of the world, including the Rest of Asia, Japan, and Korea.

Although some countries and regions benefit from lower prices for imports, they would face adjustment as domestic output is displaced by greater imports from China. For example, the pattern of capital accumulation in China would reduce both output and employment in the electrical machinery and other manufacturing sectors in the United States, the Euro Area, and Japan by between 0.3 and 0.8 percent. Although the model used here is a full-employment one, these results imply that the advanced economies would face some adjustment to China's growth. This suggests that the three economies mentioned above, and other economies that face output declines in particular sectors, need to examine whether they have policies in place that encourage the mobility of factors of production across sectors.

C. Impact of Changes in TFP, Labor, and Capital inputs in China

Table 7 shows the impact of all types of changes in China combined on the rest of the world. As in the other simulations, China experiences a rather large welfare gain, as would be expected, given the magnitudes of factor accumulation, especially of capital. Of the seventeen countries/regions in the model other than China, nine gain through improvements in their terms of trade. In particular, oil exporters, such as Russia, Mexico, and the MENA region gain because the pattern of growth in China raises the price of oil, which improves their terms of trade. As a consequence, the oil importing regions, such as the United States and the Euro Area economies, experience a terms-of-trade deterioration. In addition, growth in China lowers the prices of motor vehicles and parts, and electrical and non-electrical machinery on world markets, which harms Korea and Japan, as these countries compete with China in these sectors. In particular, about 46 percent of Korea’s exports are from the two sectors of electrical and non-electrical machinery. As in the first simulation, which evaluated the impact of TFP growth in China, part of the welfare loss experienced by the United States, the Euro Area, and Japan is due to second-best effects arising from the higher price of oil in the presence of consumption taxes. Regions that supply intermediate inputs to the electrical machinery sector in China, such as Rest of Asia, experience a terms-of-trade improvement and a welfare gain.

Table 7. Impact of Changes in Sectoral TFP and Labor and Capital Inputs in China: 1982-2000.

	Equivalent Variation (EV) (millions of 2007 U.S. Dollars	Equivalent Variation (EV) (percent of GDP)	Percentage change in Real private Consumption	Percentage change in the Terms of Trade	Percentage change in the Real Wage
United States	-12471.0	-0.09	-0.13	-0.39	-0.25
Australia, New Zealand, and Canada	5934.0	0.25	0.21	0.79	-0.10
Euro Area Countries	-20627.2	-0.17	-0.27	-0.37	-0.45
Non-euro EU	-3416.7	-0.07	-0.13	0.08	-0.35
Rest of Europe	3055.3	0.25	0.20	0.43	-0.30
China	331652.3	9.49	9.6	-1.91	5.28
Korea	-4195.6	-0.40	-0.61	-1.00	-0.92
India	-2564.4	-0.21	-0.38	-0.73	-0.74
Japan	-8946.5	-0.20	-0.32	-1.16	-0.46
Rest of Asia	6053.4	-0.25	0.30	0.36	0.13
Russia	11495.2	0.88	0.80	2.88	-0.16
Brazil	884.6	0.06	0.02	0.30	-0.23
Rest of South America	4644.2	0.43	0.40	1.42	-0.01
Mexico	612.3	0.06	0.00	0.12	-0.33
South Africa	-67.6	-0.02	-0.09	-0.04	-0.33
Sub-Saharan Africa	7739.7	1.31	1.39	3.07	0.52
MENA	29462.4	1.16	1.13	2.66	-0.04
ROW	-288.0	-0.07	-0.09	0.00	-0.32

Source: Model simulations.

The pattern of growth described in this simulation would lead to changes in sectoral outputs and employment in the three largest economies, as shown in Table 8. In this simulation, growth in China would cause output and employment in the electrical machinery sector in both the United States and the Euro Area to fall by about 5 and 7 percent, while in

Japan, the declines would be about 3 and 4 percent. These results from this simulation seem to be broadly in line with those of Autor, Dorn, and Hanson (2012), who found that rising import competition from China had some rather large impacts on real wages and employment in the United States. This is not surprising given that according to Cao et al. (2009), TFP in the electrical machinery sector grew by 5.6 percent a year on average and capital inputs grew by 9.3 percent a year on average between 1982 and 2000. The pattern of growth in China also affects the real returns to labor and capital in the rest of the world. The real return to labor declines in most regions, with the exception of China, the Rest of Asia, and sub-Saharan Africa.

Table 8. Sectoral Impacts of Changes in Sectoral TFP and Labor and Capital Inputs in China 1982-2000

	United States				Euro Area Countries				Japan			
	Percent change in output	Percent change in labor input	Percent change in export volume	Percent change in import volume	Percent change in output	Percent change in labor input	Percent change in export volume	Percent change in import volume	Percent change in output	Percent change in labor input	Percent change in export volume	Percent change in import volume
Primary Industry	0.24	0.65	1.24	-0.07	0.36	0.58	0.99	-0.31	0.2	0.45	2.61	-0.81
Coal Mining	0.15	0.54	2.57	-1.32	0.32	0.69	1.61	-0.53	0.45	1.20	1.85	-0.25
Metal and non-metal mining	0.42	0.74	1.12	0.07	0.33	0.73	0.66	-0.03	0.35	0.94	2.32	0.30
Oil and gas extraction	0.25	1.46	4.31	-1.30	0.10	1.31	2.77	-0.43	0.31	1.90	1.75	-0.35
Construction	0.02	0.03	4.17	-1.56	-0.10	-0.17	3.75	-0.87	0.03	0.04	5.55	-1.23
Food products	0.09	0.14	2.32	-1.19	0.17	0.33	0.93	-0.39	0.04	0.09	4.94	-2.04
Textile mill products	0.14	0.18	0.39	-0.32	0.05	0.07	0.15	-0.24	0.76	0.93	2.26	0.00
Apparel	-0.08	-0.09	-0.10	-0.10	-0.21	-0.33	-0.34	-0.06	-0.24	-0.35	3.04	0.13
Lumber and wood	0.03	0.03	1.04	0.01	0.09	0.15	0.24	-0.12	0.54	0.85	2.48	-0.5
Paper, printing, and publishing	-0.05	-0.07	0.00	0.29	-0.04	-0.07	-0.04	-0.03	-0.06	-0.09	0.27	0.16
Chemicals, rubber, plastics	0.31	0.51	1.41	-0.66	0.26	0.47	0.46	-0.13	0.31	0.59	1.39	0.05
Petroleum, coal products	-0.86	-1.66	0.47	-0.62	-0.45	-1.23	-0.06	-0.51	-0.31	-0.80	3.83	-0.50
Leather	-0.08	-0.01	1.25	0.09	-0.04	-0.06	-0.03	-0.23	0.27	0.37	3.60	-0.49
Stone, clay, glass	0.28	0.38	2.71	-0.09	0.05	0.09	0.64	-0.13	0.49	0.83	4.57	-0.87
Primary metal	0.65	0.84	2.41	-1.15	0.35	0.55	0.57	-0.19	0.32	0.59	0.74	-0.19
Fabricated metal	-0.17	-0.21	1.03	-0.13	-0.09	-0.14	0.18	-0.15	0.29	0.42	2.94	-0.12
Machinery, non-electric, instruments	-0.21	-0.26	0.02	0.55	-0.46	-0.64	-0.52	-0.04	0.59	0.86	1.41	0.99
Electric machinery	-4.96	-6.9	-7.74	3.86	-4.00	-6.86	-4.98	0.40	-2.51	-4.03	-4.81	4.39
Motor vehicles	0.17	0.22	0.62	-0.08	-0.01	-0.02	0.04	-0.11	0.91	1.31	1.48	0.12
Transportation equipment	0.53	0.63	1.19	-0.05	0.21	0.28	0.57	0.04	1.01	1.30	2.23	0.44
Misc. manufacturing	0.16	0.19	1.00	-0.02	-0.1	-0.15	0.08	0.15	0.11	0.16	1.74	-0.09
Electric utilities	-0.10	-0.39	2.90	-1.53	-0.04	-0.11	0.69	-0.39	-0.29	-1.36	6.11	-2.22
Gas utilities	0.04	0.14	6.61	-3.32	0.66	1.52	2.86	-1.12	0.60	1.56	8.62	-1.84
Tertiary industry	0.01	0.01	2.4	-1.19	0.06	0.11	1.44	-0.61	0.01	0.01	3.30	-1.81

Source: Model simulations.

VI. Conclusion

The rapid growth of the Chinese economy over the last few decades has led many to ask how it has impacted other countries of the world. This paper has used information about the pattern of China's growth over the period from 1982 to 2000 and asked how other countries of the world would be affected if these past trends were to continue into the future. Several broad themes emerge from this analysis.

First, the exact type of growth matters a great deal for assessing the impact of growth in China on the rest of the world. As shown in this paper, the impact of TFP growth differs markedly from growth that is driven primarily by accumulation of capital because these two types of growth alter output and exports differently in China. Using the estimates contained in Cao et al. (2009) for the period of 1982 to 2000, the sectors that experienced the most rapid rates of TFP growth were mainly the highly export-oriented manufacturing sectors, while the sectors that increased their usage of capital inputs by the largest percentages were sectors that were nontraded (gas and electric utilities and services), and oil and petroleum products. One sector, the electrical machinery sector, experienced the highest rate of TFP growth (5.6 percent a year on average) and increased its use of capital inputs at a relatively rapid rate (average of 9.3 percent a year).

Second, the principal means through which growth in China would affect other countries is through changes in the terms of trade. While these changes led to welfare losses for some countries and regions, the magnitudes were not large, and in all cases less than 3 percent, depending on the simulation. However, the simulations used the average annual growth rates in TFP and capital inputs over the period from 1982 to 2000. Thus, the model results reported in this paper represent the medium-run effects of the changes in China that occurred in one year. To assess the impact of these changes over the entire period from 1982 to 2000, these annual changes would need to be cumulated and these could be large. Welfare changes across countries would not be driven exclusively by terms-of-trade movements however. As shown from the simulation results, second-best effects arising from existing distortions, as in the case of consumption taxes on oil products, are not just a theoretical nuance. Therefore, as a matter of policy, countries should be aware of how external developments interact with existing policies, i.e. tax distortions.

Finally, even in circumstances in which growth in China would make a country better off, that country may also face important distributional effects. In the case of the United States, the Euro Area, and Japan, the simulations revealed that while growth in China in certain sectors could make these countries better off by reducing the price of imports, these three countries would experience declines in output and employment, and hence some restructuring. Also, as the manufacturing sectors in the United States, the Euro Area, and Japan are labor intensive, growth in China reduces real wages in these countries. This highlights the need for the United States, the Euro Area, and Japan, and other countries that are importers of labor-intensive manufacturing goods, to facilitate the movement of resources across sectors. The simulations show that the reductions in output and employment in some manufacturing sectors, such as electrical and non-electrical machinery, in the United States, the Euro Area, and Japan, could be rather large, so policymakers in these countries should remove obstacles that impede the mobility of factors of production across sectors.

References

Autor, David H., Dorn, David, and Gordon Hanson, 2012, "The China Syndrome: Local Labor Market Effects of Import Competition in the United States," Cambridge MA: National Bureau of Economic Research Working Paper number 18054.

Bhagwati, Jagdish, 1958, "Immiserizing Growth: A Geometric Note," *Review of Economic* Studies, vol. 25, no. 3, (June), pp. 201-205.

Cao, Jing, Ho, Mun, Jorgenson, Dale, Ren, Ruoen, Sun, Linlin, and Ximing Yue, 2009, "Industrial and Aggregate Measures of Productivity Growth in China, 1982-2000," *The Review of Income and Wealth*, Series 55, Special Issue 1, (July), pp. 485-513.

di Giovanni, Julian, Levchenko, Andrei and Jing Zhang, 2012, "The Global Welfare Impact of China: Trade Integration and Technological Change," mimeo.

Dixit, Avinash, and Victor Norman, 1980, *Theory of International Trade*, Cambridge: Cambridge University Press.

Freund, Caroline, and Caglar Ozden, 2006, "The Effect of China's Exports on Latin American Trade With the World," Washington DC: World Bank.

Hanson, Gordon and Raymond Robertson, 2010, "China and the Recent Evolution of Latin America's Manufacturing Exports," in *China's Growing Role in World Trade*, edited by Robert Feenstra and Shang-Jin Wei, Chicago: University of Chicago Press and NBER, pp. 137-159.

Hertel, Thomas and Marinos Tsigas, 1997, "The Structure of GTAP," in *Global Trade Analysis: Modeling and Applications*, edited by Thomas Hertel, Cambridge: Cambridge University Press.

Hsieh, Chang-Tai, and Ralph Ossa, 2010, "A Global View of Productivity Growth in China," unpublished.

Husted, Steven and Shuichiro Nishioka, 2012, "China's Fair Share? The Growth of Chinese Exports in World Trade," University of Pittsburgh, mimeo.

Johnson, Harry, 1967, "The Possibility of Income Losses From Increased Efficiency or Factor Accumulation in the Presence of Tariffs," *Economic Journal*, vol. 77, pp. 151-54.

Jones, Ronald, 1971, “A Three-Factor Model in Trade, Theory, and History,” in *Trade, Balance of Payments, and Growth*, edited by J. Bhagwati, R. Jones, R. Mundell, and J. Vanek, Amsterdam: North Holland, pp. 3-21.

Levchenko, Andrei, and Jing Zhang, 2011, “The Evolution of Comparative Advantage: Measurement and Welfare Implications,” mimeo.

Martin, Will, Ianchovichina, Elena, and Betina Dimaranan, 2008, “Economic Development in Emerging Asian Markets: Implications For Europe,” *European Review of Agricultural Economics*, vol. 35, number 3, pp. 303-330.

Samuelson, Paul, 2004, “Where Ricardo and Mill Rebut and Confirm Arguments of Mainstream Economists Supporting Globalization,” *Journal of Economic Perspectives*, vol. 18, no. 3, (Summer), pp. 135-146.

Schott, Peter, 2008, “The Relative Sophistication of Chinese Exports,” *Economic Policy*, vol. 23, Issue 53, (January), pp. 5-49.

Woodland, Alan, 1982, *International Trade and Resource Allocation*, Amsterdam: North Holland.