Preliminary draft, not for quotation

U.S.-Asia trade: dynamic general equilibrium linkages [1]

Robert Koopman, Marinos Tsigas, Zhi Wang
U.S. International Trade Commission

and

Xin Li
National School of Development, Peking University

August 28, 2012

Abstract

This paper uses a recursive dynamic computable general equilibrium (CGE) model to simulate three scenarios against a baseline: (1) a decrease in the saving rate in China, (2) an increase in the saving rate in the United States, and (3) a structural change in global supply chains as manufacturing FDI shifts from China to other developing Asian countries. The paper aims to examine changes in the commodity and country composition of U.S.-Asia trade balances over time and provides an analysis of how the changing pattern of comparative advantage across the world might relate to supply chain segmentation of global commodity and services production, and the role of global supply chains in the changing distribution of the U.S.-China trade balance in of its sectoral composition and geographic location.

Corresponding author: Marinos Tsigas, email: marinos.tsigas@usitc.gov

[1] The views expressed in this paper are those of the authors alone. These views do not necessarily reflect the views of the U.S. International Trade Commission, any of its individual Commissioners, or the National School of Development at Peking University.

The authors are grateful to José Arturo Blancas Espejo, Rodolfo Daude Balmer, Ernesto Garcia Zuñiga, and Jaime A. de la Llata from the Instituto Nacional de Estadística, Geografía e Informática (INEGI) in Mexico for providing the 2003 input-output accounts for Mexico with separate domestic and Maquiladora accounts.

U.S.-Asia trade: dynamic general equilibrium linkages

1. Introduction

As U.S.–China economic ties expanded substantially over last two decades the U.S. trade deficit with China also increased from about $10 billion in 1990 to over $270 billion in 2011.[1] Most economists agree that bilateral trade balances should not be a focus of national policy because of the multilateral nature of international trade (Bergsten, 2006). However, as the bilateral trade balance is frequently headline news and a regular topic in the trade policy debate in the United States, a detailed analysis of the micro-economic factors that are driving the U.S.–China trade deficit, would help the public and policy makers to better understand the deeply rooted nature of bilateral trade issues and thus inform expectations as to what might happen in next decades due to changes in these underlying micro economic structures. We recognize the importance of macro-economic factors, such as savings and investment, which determine both countries' worldwide trade balances, and their potential interaction with micro aspects we examine, but in this paper we focus on the micro-economic factors.

The changing structure of global production chains in the past two decades appears to be a fundamental driving force underlying the U.S. trade deficit with China. Therefore the development of the U.S.-China trade balance in next decade will also likely depend on how the various global production chains evolve, undergoing restructuring and relocation of labor intensive operations to other low-cost countries as China continues to upgrade its industrial structures and move to medium- and high-tech and skill-intensive production lines. In this paper we provide a quantitative assessment of the micro economic aspects of the U.S.–China trade deficit based on a computable general equilibrium (CGE) framework that explicitly models transnational production chains and export processing zones in China and other major developing countries. This assessment can provide useful insights and long-term perspectives on the possible trajectories of the current biggest bilateral trade balance in the world. To the best of our knowledge, there is no comprehensive analysis of the changing commodity composition and geographical location of the U.S. trade deficit and its underlying micro economic driving forces in the current literature. We intend to fill this void in this paper which addresses the following two issues:

1. What is the potential impact of labor intensive industries moving out of China, especially the impacts on the distribution of U.S. trade deficit in both its commodity composition and geographic location over the next decades?
2. What is the potential impact of an appreciation of China's real exchange rate, a decline of Chinese saving rates, and a change in the U.S. government budget deficit on major U.S. and

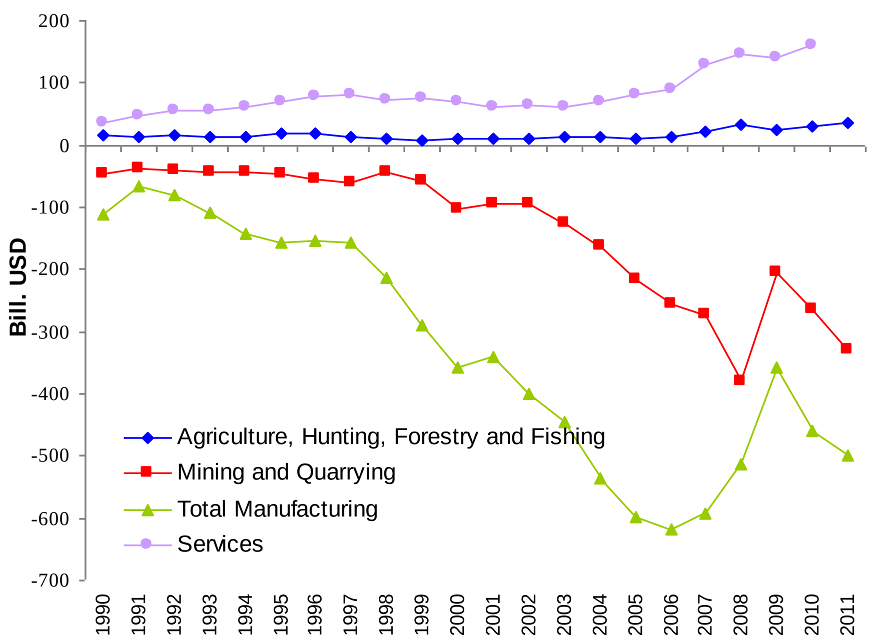
[1] Source: U.S. Department of Commerce, Bureau of the Census, Foreign Trade.

Chinese industries, especially the impacts on the commodity and geographic composition of U.S. trade deficit?

2. The evolution of bilateral trade balances: the United States and China

Often discussions of the U.S.-China economic relationship in the press focus on the aggregate and bilateral U.S. trade deficit. Using a simple break out of the broad sectoral composition of the U.S. worldwide, and U.S.-China, trade balance, the driving factors of this increasing and substantial deficit start to emerge. **Figure 1** shows that U.S. has run huge worldwide trade deficits in mineral and manufacturing products, but has enjoyed a trade surplus in agricultural products and services since 1990. The sharp increase in the U.S. trade deficit in manufacturing goods occurs in the late 1990s, it accelerates after China joined the WTO in 2001, and it reaches its peak in 2006.

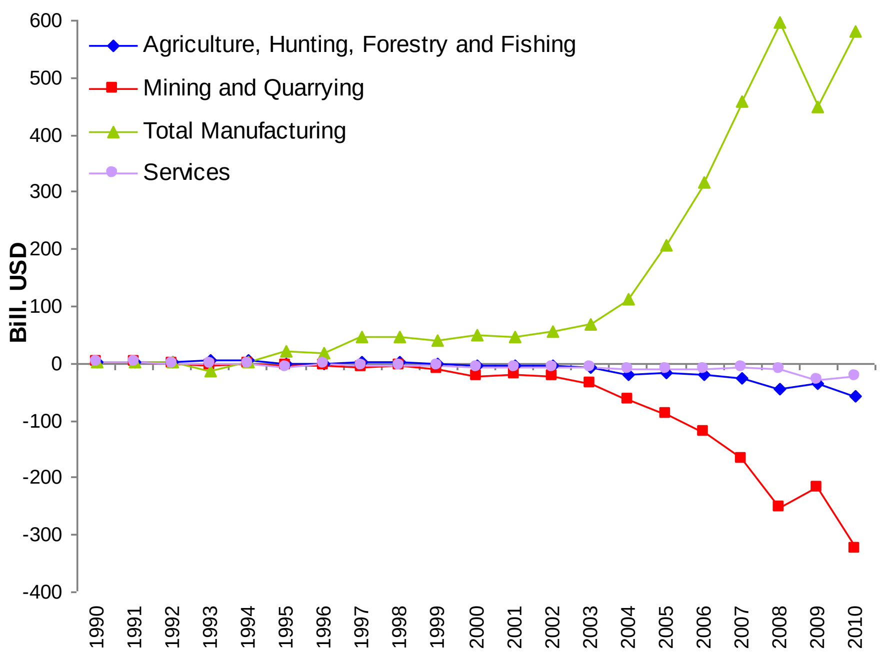
Figure 1 Broad Sector Trade Balance between the United States and Rest of the World



Source: The merchandise data are from U.S. Department of Commerce, Bureau of the Census, the service data is from U.S. Bureau of Economic Analysis (BEA).

In contrast to the United States, China has run a trade deficit in agricultural products and services with the world, but has enjoyed a large surplus in manufacturing products (**Figure 2**). Like the United States, China also has run a large trade deficit in mineral products. The dramatic increase in manufacturing products surplus and the growing deficit in mineral products seems to have happened simultaneously around 2002, the year after China joined the WTO. **Figure 3** demonstrates clearly that the U.S.-China trade deficit is concentrated in manufacturing products and that the U.S. actually enjoys a surplus in agricultural products and services similar to its trade balance with the world. U.S.-China trade in mineral products is basically balanced over the last two decades. The sharp increase of trade deficit with China in manufactured products also occurs around China's accession to the WTO. Other than a decline in 2009 due to the global financial crisis, the bilateral deficit appears to continue its upward trend despite the RMB's, the Chinese currency, approximate 31 percent nominal appreciation between July 2005 and the end of 2011.[2] It is apparent that more fundamental structural forces appear to be playing a role offseting and dominating the effect of the exchange rate appreciation.

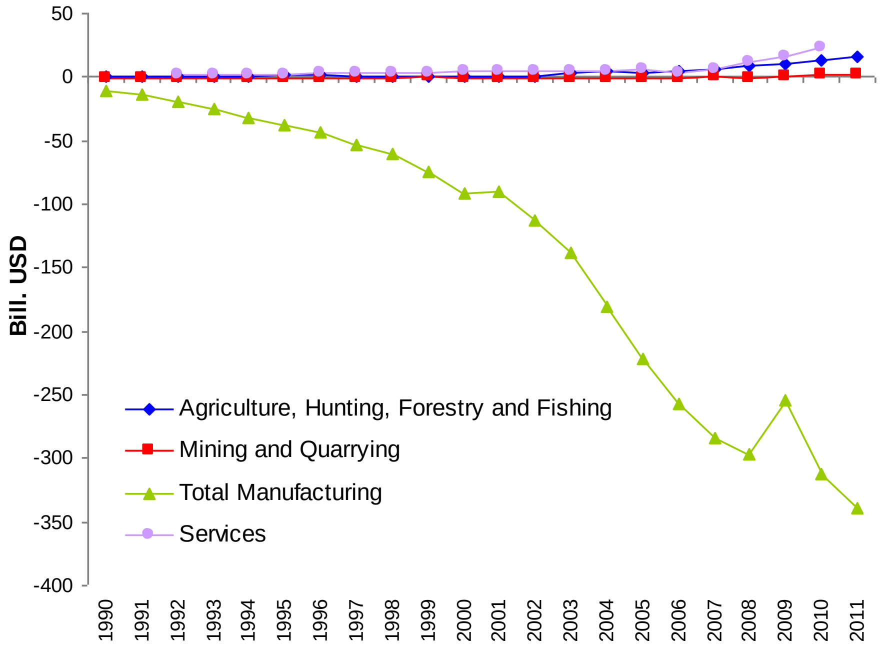
Figure 2 Broad Sector Trade Balance between China and Rest of the World



Source: WTO

[2] Source: *China Monthly Economic Indicators*, National Bureau of Statistics, PRC. Based on estimates from Conference board, the real exchange rate of China has appreciated by about 45% during the same period.

Figure 3 Broad Sector Trade Balance between the United States and China



Source: U.S. Department of Commerce, Bureau of the Census and BEA

Examining the changing geographical distribution of the U.S. trade deficit measured in traditional gross trade data in manufacturing products over the past two decades helps us to identify a major driver of the large and growing U.S.-China trade deficit. **Table 1** reports the share of U.S. major trading partners' contribution to the U.S. trade deficit in manufactured goods between 1990 and 2010. We see clearly that the dramatic increase in the U.S. manufacturing trade deficit with China is largely a result of the movement of production facilities from other industrialized countries (mainly Japan and the Asian NICs) to China. That is, various products that used to be made in Japan, Taiwan, Hong Kong, Singapore and Korea, as well as other industrialized countries around the world, and then exported to the United States, are now being made in China (in many cases, by foreign invested firms in China) and exported to the United States. For example, in 1990, Japan and the four Asian Tigers were the source of more than 75% U.S. worldwide trade deficit in manufactured products, by 2010 their share declined to only about 15%. U.S. manufactured trade with the four Asia tigers was actually in balance in 2010. Over the same period, China's share of the U.S. trade deficit increased from 10% to about 70%. In other words, while China was becoming an increasingly important source of manufactured goods, the relative importance of the rest of

Table 1 The share of U.S. trade deficit in manufacturing products with major trading partners (%)

	1990	1995	1998	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Canada	6.4	5.9	2.7	5.9	6.2	5.0	4.1	4.9	3.8	2.1	0.8	-2.8	-7.8	-6.2
Japan	49.6	45.3	33.4	24.9	22.0	19.1	16.2	15.5	15.0	15.5	15.4	16.6	14.7	15.2
Four Asia NICs	26.1	11.1	13.4	9.4	8.2	6.6	6.4	5.8	4.0	3.4	2.9	2.4	3.6	-0.3
Germany	10.5	10.2	11.3	8.4	8.6	8.9	8.8	8.6	8.6	7.9	7.7	8.7	8.1	8.0
Mexico	-2.0	5.7	5.4	3.5	6.0	6.6	5.7	4.8	4.2	5.2	7.2	5.7	6.8	8.1
ASEAN5	7.3	15.0	16.8	13.1	12.3	11.6	10.4	10.1	11.1	11.7	11.1	12.3	14.4	13.1
China	10.3	24.2	28.2	25.6	26.7	28.1	31.1	33.6	37.2	41.7	48.0	58.0	71.4	67.4
G7exU.S.A	70.1	66.6	53.5	45.0	43.0	39.4	36.2	35.5	34.1	31.8	30.8	30.7	21.1	23.0
Rest of OECD	0.3	0.6	3.8	13.5	16.4	17.2	18.3	17.8	16.8	14.5	12.1	6.7	0.2	2.1
ROW	-1.2	-10.0	-8.3	2.1	0.1	0.6	2.0	1.9	1.1	-2.2	-5.8	-12.0	-16.8	-23.0

Notes: A negative share represents a country that run a trade deficit in manufacturing products with the United States.
Four Asia NICs includes Taiwan, Singapore, Korea and Hong Kong.
ASEAN5 includes Indonesia, Malaysia, Philippines, Thailand, and Viet Nam.
Rest of OECD excludes Mexico, Japan, Korea, Germany and the United States.
Source: Data of 1990-2009 are from BTD, OECD 2011ed. Data of 2010 are from BTDIbyE, 2012ed.

the industrialized world as a whole was declining, because many firms in these economies were shifting their export-oriented manufacturing and assembly facilities to China via their FDI to China.

Over the past two decades, production has become internationally fragmented and specialized firms in different countries take part in the production process of a product but at different stages of the value-added chain. This globalized production system allows more in-depth specialization and brings efficiency gains as countries specialize in the segments of the production process in which they have a comparative advantage. The dramatic increase of trade in goods belonging to the same industry but at different stages of production reflects the reorganization of production on a worldwide basis. The re-distribution of FDI along such a segmented production chain according to changing comparative advantage of different geographic locations is a central feature of economic globalization. In fact, the large amount of FDI flows to China in the 1990s, especially after China's WTO entry represents the relocation of the downstream labor-intensive stage of manufacturing production to China. China, with its large pool of low-wage unskilled labor, has increasingly become the location of choice for the final assembly of a full array of manufactured goods, especially electronic and information technology products. Goods that are assembled from imported parts and components, or processing exports, accounted for more than half of China's manufactured exports and about two thirds of the manufactured goods China has exported to the United States since the 1990s. When these goods were exported from

China to the United States, traditional trade data counts their entire value as imports from China. On average, however, about half of the value of these so-called processed exports in fact originates outside China, mostly in other industrialized economies, including the United States itself (Koopman, Wang and Wei, 2008, 2012). Therefore, the structural change of global value chain and the increasing role of China as the final assembler in various global production networks since the 1990s' is a clear driving force for the growing U.S. manufacturing trade deficit with China.

Along with China, other emerging economies, such as Mexico and the ASEAN countries, have been increasingly integrated into global production networks over the last two decades and have increased their share of the U.S. global trade deficit in manufactured goods (**table 1**). Meanwhile those developing countries not tightly integrated into the global value-chain appear to have contributed very little to the U.S. manufacturing trade deficit since 1990. The U.S. actually runs an increasing trade surplus in manufactured products with rest of the developing world since 2006. These facts suggest that the development of various global production chains are a fundamental driving force of the growing U.S. bilateral trade deficit with China in manufactured products during past two decades. Therefore, as Bergsten suggested in his 2006 Congressional Testimony**,** "The United States must understand that it will continue to run a sizable bilateral deficit with China, as recorded in the conventional statistics, largely because of the growing internationalization of production with China as the final assembly point for many products." Global fragmentation of production has been a driving market force. To minimize cost, enterprises (especially multinationals) tend to locate each segment of their business in places that have a cost advantage. Once one gains a cost advantage by moving certain segments of its production activities to China (or other low cost, efficient sources), others follow in order to remain competitive in the world market. Understanding this point is also important to accurately project the possible trend and prospective outcome of U.S.-China trade balance as it evolves over the next decade.

As labor intensive industries mature and labor cost rise in China, rising costs will likely force China to graduate from labor-intensive industries, upgrading its industrial structure to a higher ladder in the global value-chain. In such a process, various labor intensive operations will leave China, as they did in Japan's labor-intensive industries during the 1970s and in the four Asian Tigers' labor-intensive industries during the 1980s. This process has already begun in China and is showing up in China's trade statistics. The appreciation of the Chinese currency since July 2005 has accelerated this process. **Table 2** reports the composition of China's manufactured goods exports. It shows that the share of labor intensive-manufactures steadily declined over the past two decades, from 60.8% in 1992 to 26.6% in 2010. At the

Table 2 The composition of China's manufactured exports and trade surplus (1992-2010)

	The share of manufacturing exports (%)			The share of manufacturing trade surplus (%)		
	Lab-intensive manufacturing	Cap-intensive manufacturing	Tech-intensive manufacturing	Lab-intensive manufacturing	Cap-intensive manufacturing	Tech-intensive manufacturing
1992	60.8	26.9	12.3	993.6	-786.8	-106.8
1993	60.5	26.5	13.0	456.0	-316.7	-39.3
1994	58.9	27.0	14.1	1102.0	-890.9	-111.1
1995	51.9	32.4	15.8	226.8	-128.3	1.5
1996	50.9	31.8	17.4	270.8	-181.5	10.7
1997	50.0	32.2	17.7	128.4	-36.6	8.3
1998	47.4	32.6	20.0	122.9	-28.1	5.3
1999	45.5	32.7	21.8	155.1	-49.4	-5.7
2000	42.6	33.8	23.6	152.5	-45.3	-7.2
2001	41.1	33.5	25.5	171.4	-58.4	-12.9
2002	38.7	32.5	28.7	170.4	-65.8	-4.7
2003	35.3	32.1	32.5	181.1	-82.9	1.8
2004	31.5	33.9	34.6	131.8	-43.8	12.0
2005	30.0	34.5	35.5	88.8	-4.5	15.7
2006	28.7	36.0	35.3	72.8	11.5	15.7
2007	27.3	39.5	33.3	60.3	24.4	15.4
2008	25.9	42.5	31.6	51.4	31.7	16.9
2009	27.9	38.1	34.1	63.6	16.0	20.4
2010	26.6	39.8	33.6	61.2	18.6	20.2

Note: The industry classification of labor-intensive manufacturing is ISIC rev.3.1 "15+16+17+19+20+21+22+36+37"; capital-intensive manufacturing includes ISIC rev.3.1 "23+24ex2423+25+26+27+28+29+31+34+351+352+359"; technology-intensive manufacturing includes ISIC rev.3.1 "2423+30+313+32+33+353". The three categories in the table 2 are according to the classification of manufacturing industries in BTDIbyE database. The "labor-", "capital-" and "technology-" represent "Low-technology manufactures", "Medium-high & Medium-low technology manufactures" and "high-technology & Information/communication technology manufactures" respectively in BTDIbyE.
Source: The data for 1992-1994 are from BTD 2008ed, OECD. The data for 1995-2010 are from BTDIbyE, 2012ed, OECD.

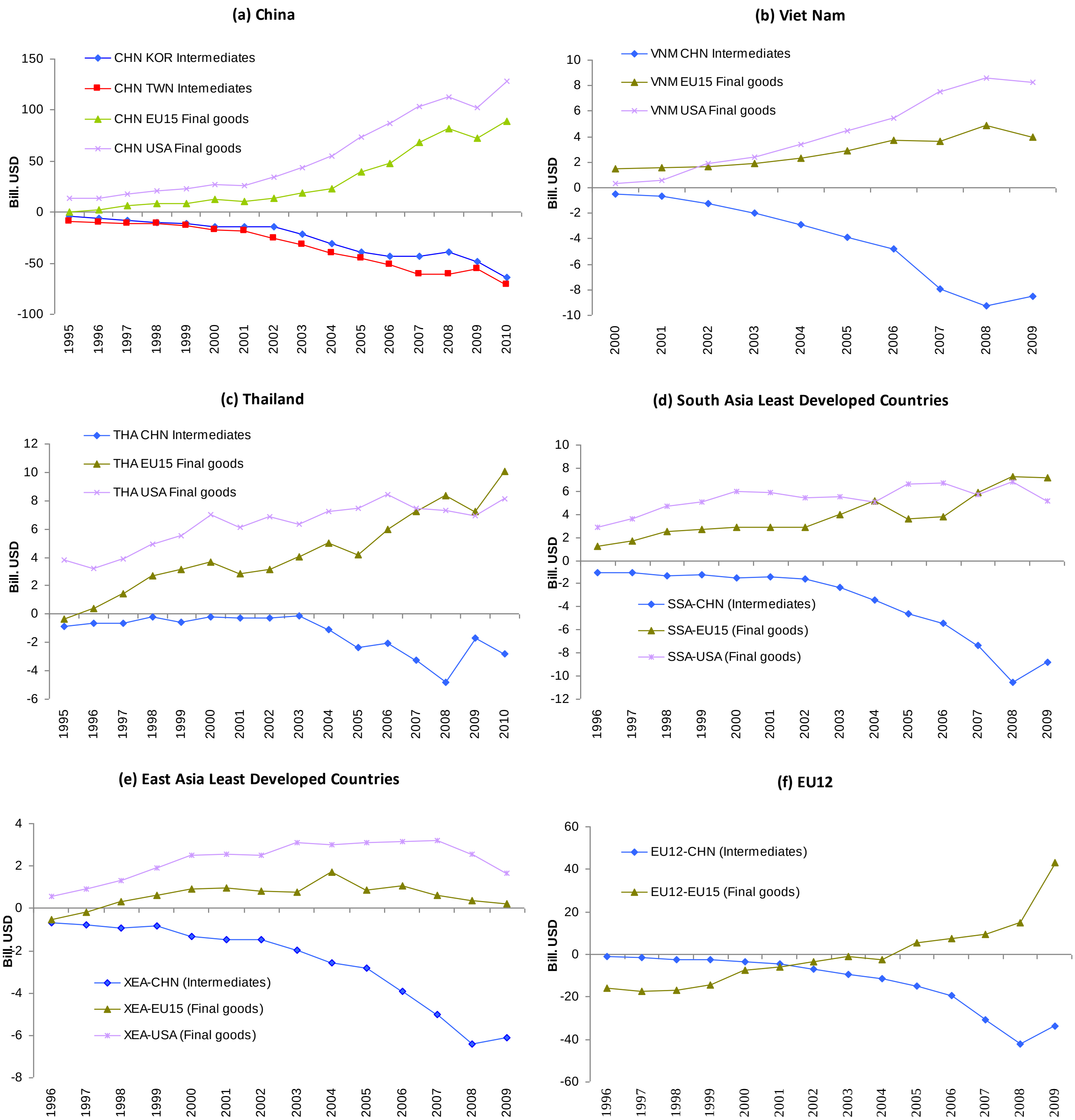
same time, the share of capital- and technology-intensive products has become dominant in China's manufactured exports. Although labor-intensive products still constitute over 60% of China's surplus in manufactured goods trade, capital- and technology-intensive products also shifted from a deficit to a surplus in recent years and now constitute about 40% of China's worldwide surplus of manufactured goods as of 2010. The changing distribution of global FDI and international segmentation of production since the 1990s and the role foreign invested firms have played since China's WTO accession were key factors driving structural change in China and the rapid industrial structure upgrading process in China. FDI combined with segmented production processes facilitated China's integration into various global production networks. As a result, China has not only become more competitive as a net exporter of labor-intensive goods, but also emerges as a net exporter in most capital-intensive manufactured products just a few years after its WTO accession, with a continued strong trend over last decade.[3]

As this trend continues and China starts to graduate from the labor-intensive assembling operations, where might labor intensive production be relocated? What might be the effects of such a re-structuring of global value-chains on other economies in the world and its implications for the U.S.-China trade balance? Some recent statistical evidence may give us a hint. **Figure 4** plots a group of triangle trade relationship in manufactured goods for China and its major trading partners. In each of the six sub-graphs in **Figure 4**, there are one or two intermediate manufactured goods supplying countries, a final manufactured goods assembling country, and one or two final goods importing (consuming) countries.

These graphs show that although China still runs large trade surpluses in final goods with the older EU countries and the United States and a simultaneous large trade deficit in intermediate goods with other industrialized countries, it has already become an important supplier of manufactured intermediate goods for many lower wage countries in its neighborhood, such as Viet Nam, Laos, Cambodia, south Asian less developed countries and even Thailand and some new EU member countries. All those developing economies run surpluses of manufactured final goods with the United States or older EU counties, or both, similar to China. Despite the fact that China is still a global center of final assembly for many manufactured products, there appear to be some labor intensive final assembly activities already migrating from China to other low cost countries.

[3]The prediction on the impact of China's WTO accession made by Wang (2003a and 2003b), especially its impact on China's industrial upgrade and trade structure change are largely consistent with what really happened in the first decades of China in the WTO. Wang had predicted based on his CGE model simulation that "China will be a net exporter of most manufacturing products, including low-end capital-intensive products as a long-term trend, and will emerge as the world's largest and cheapest manufacturing center in the years to come." "The infusion of foreign funds, technology, and marketing expertise after its WTO accession and further integration with Taiwan will enhance China's prospective as a high-volume, low-price producer of almost all manufactured products in the coming decades."

Figure 4 Trade balance in manufactured products among different countries and their major trading partners: Final goods assembling activities is starting to transfer out of China

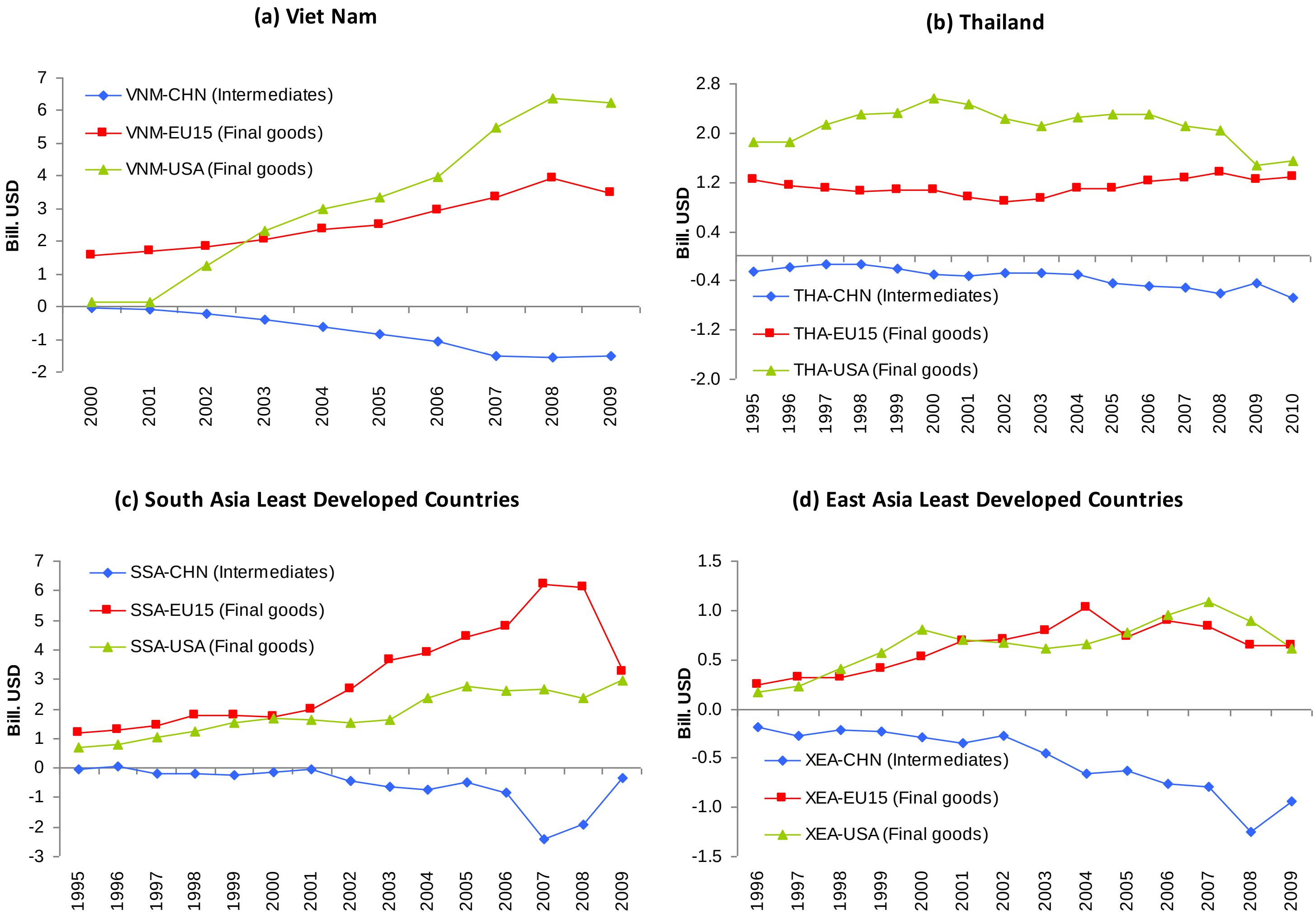


Note: The industry classification of Manufacturing is ISIC rev.3.1 15T37. **EU15** includes Belgium, Denmark, Germany, Ireland, Greece, Spain, France, Italy, Luxembourg, Netherlands, Austria, Portugal, Finland, Sweden and United Kingdom. **EU12** includes Bulgaria, Czech, Estonia, Cyprus, Latvia, Lithuania, Hungary, Malta, Poland, Romania, Slovenia and Slovakia. **SSA** includes Nepal, Bhutan, Pakistan, Bangladesh, Sri Lanka and Maldives. **XEA** includes Lao, Cambodia, Mongolia and North Korea.
Source: China, Viet Nam, Thailand are from BTDIbyE, OECD, 2012ed. EU12, South Asia Least Developed Countries and East Asia Least Developed Countries are from UN Comtrade.

Figures 5 and 6 break manufactures into broad sectors according to OECD technology intensity definitions and plot several triangular trade relationships at the sector level. They indicate that the first wave of labor-intensive production relocation from China to other developing countries mainly occurs in low-tech products such as garments, footwear and toys, while most middle high and high-tech industries are currently continuing to choose China as the final point of assembly operations for their products. To gain insights on how such trends might evolve over the next decade, and their impact on the U.S.-China trade balance, a modeling framework is needed.

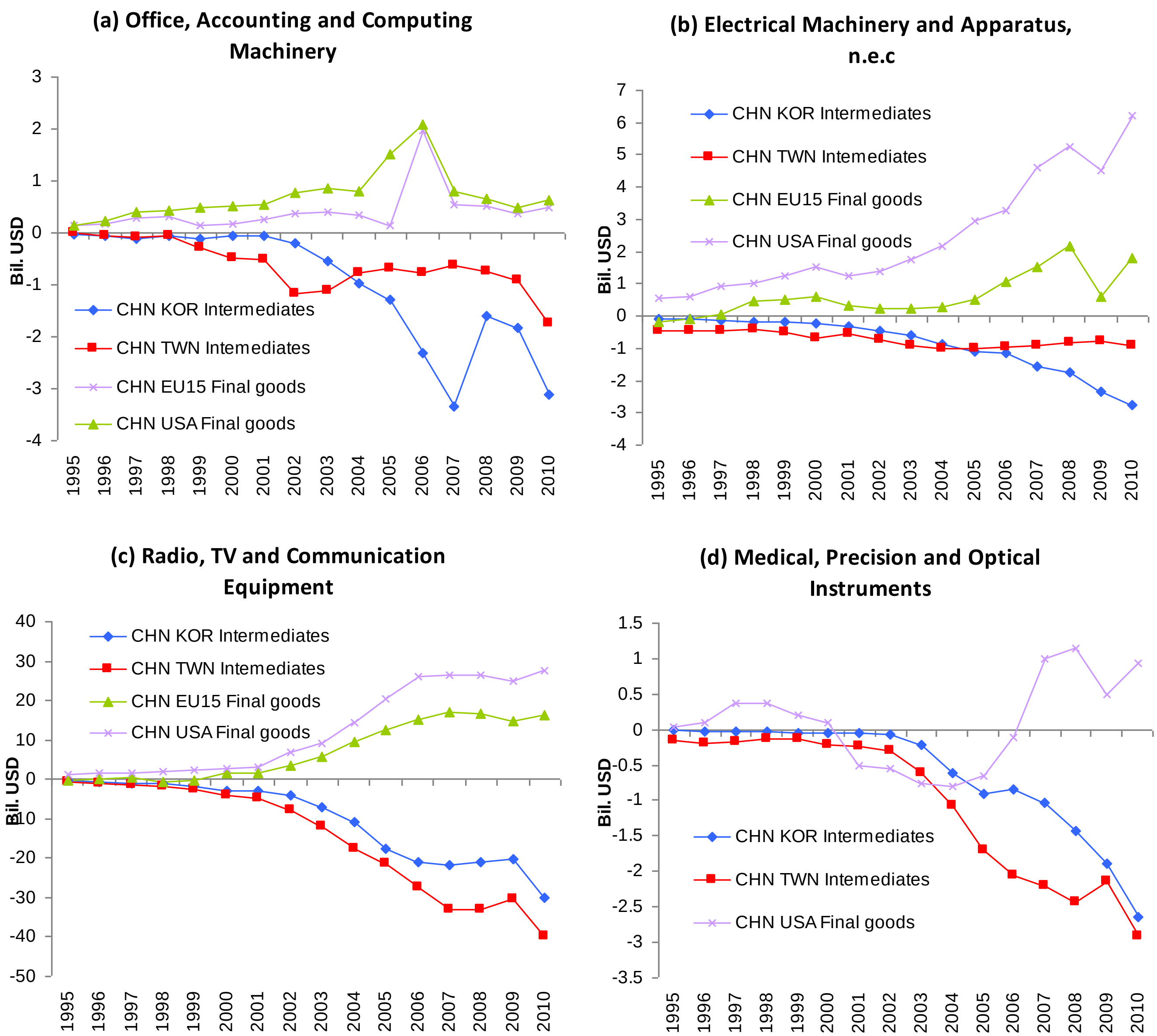
The rest of the paper is organized as follows. Section 3 specifies the dynamic CGE model we use and highlights its differences from the standard GTAP model (Hertel, 1997) and database (Narayanan, Aguiar and McDougall, 2012). Section 3 also discusses the major data sources and the calibration of the baseline. Section 4 describes the simulation design and reports the major simulation results. Section 5 concludes.

Figure 5 Trade balance in manufactured products among different countries and their major trading partners: China starts transfer out final goods production in labor-intensive industries (ISIC rev.3.1 17-19) to other developing countries



Source: BTDIbyE, OECD 2012ed.

Figure 6 Trade balance in manufactured products among different countries and their major trading partners: Final goods production in technology-intensive industries continue transfer from industrial countries to China



Note: the industry classified as "Office, Accounting and Computing Machinery" is ISIC rev.3.1 30; the industry classified as "Electrical Machinery and Apparatus, n.e.c." is ISIC rev.3.1 31; the industry classified as "Radio, Television and Communication Equipment" is ISIC rev.3.1 32; the industry classification of "Medical, Precision and Optical Instruments" is ISIC rev.3.1 33; Source: BTDIbyE, OECD, 2012ed.

3. CGE modeling framework

The multiregional CGE model used in this paper is similar to models widely used to analyze the impact of trade and trade policies (Shoven and Whalley, 1984 and 1992; Francois and Shiells; Hertel, Ianchovichina, and McDonald). The model incorporates considerable detail on sectoral output and trade flows, both bilateral and global. The model may be linked to a macroeconomic model generating macro scenarios. Given a macro scenario, this dynamic CGE model may then be used to determine the implied trade flows and sectoral structural adjustments for each region in a recursive dynamic framework that are consistent with the macro scenarios. Under assumptions for a likely path of future world economic growth, the CGE model may generate the pattern of production and trade resulting from world economic adjustment to the economic shocks specified in the alternative scenario.

This CGE-based analysis provides a tool to identify China's general equilibrium real exchange rate and to quantitatively evaluate the probable impacts of an appreciation of China's real exchange rate on major U.S. industries and the U.S. trade balance. The model also generates the trends of distribution in commodity composition and geographic location of U.S. trade deficit during the simulation period in response to real exchange rate realignment or macroeconomic policy changes in the United States and China.

The CGE simulation model used in this paper can be thought of consisting two parts. The first part is a comparative-static CGE model that simulates changes within a given year. The second part of the CGE model provides the inter-temporal linkages and simulates changes between years. We first discuss the comparative-static model and then the inter-temporal linkages.

3.1 The comparative-static CGE model

The model has a focus on the United States and China as well as their top trade partners. Twenty six regions and 41 production sectors in each region are specified to represent the world economy (**table 3**). China and Mexico have export processing zones and these zones are modeled as separate economies. Thus the total number of economies in the model is 28.

For each economy in the model we specify a utility function for its representative household and production functions for its producing sectors. Subject to transportation costs, the representative household and producing sectors engage in commodity and services trade with households and producing sectors in all other regions in the model. The representative household represents private and government expenditures.

All economic agents are price-takers and their demands for commodities and primary factor services are based on cost minimizing and utility maximizing behavior subject to production function and budget constraints. Producing sectors produce a single commodity. Intermediate and final demand users of commodities and services are assumed to differentiate a commodity and services by its region of origin, i.e., the *Armington specification* is applied (Armington 1969a and 1969b).

On the final demand side of the model, households purchase commodities and services and they save part of their income, which consists of returns to primary factors and net tax collections. In each region, aggregate investment in new capital goods is represented by the output of a “capital goods” sector. Globally, the sum of household savings is equal to the sum of investment expenditures.

Integrated into this treatment of production, demand, and trade, are policies which have regional and global impacts. These policies affect the equilibrium computed by the model and when they change they induce behavioral changes by producers and consumers in all regions. Commodity and services prices in each region are determined by market clearing through international trade.

Welfare and household demands. It is assumed that preferences are separable, which allows expressing total utility as a function of sub-utilities, which in turn have deeper sub-groupings within them. At the top of the utility tree, regional welfare is derived from private household expenditures, government expenditures, and savings. It is assumed that the simulations do not change the distribution of regional income across private and government expenditures, and savings. This assumption is implemented by applying a Cobb-Douglas function to describe substitutions between the three components of welfare. Currently, there is no economic mechanism that links government expenditures to government revenues. Household demands for composite commodities are specified with Cobb-Douglas functions.

Industrial sector demands. Producing sectors demand two types of inputs: primary factors and intermediate inputs. The primary factor composite is a CES aggregate of unskilled labor, skilled labor, and capital. The elasticity of substitution between primary factors is industry specific. There is no substitution between the primary factor composite and intermediate inputs, i.e., a Leontief technology is assumed.

International trade. The main features of the model treatment of trade are the Armington assumptions discussed earlier. In this model the determination of the sourcing of imports is placed at the producer and consumer level instead of at the national level. Thus in this model we have substituted the standard GTAP assumption that affects bilateral trade (i.e., sourcing of imports for the economy as a whole) with a micro-based determination of bilateral trade (i.e., sourcing of imports at the agent level).

Table 3. Regions and sectors in the CGE model

Regions	Sectors
1 China	1 Crops
2 China - export processing zones	2 Livestock
3 Hong Kong	3 Forestry
4 Taiwan	4 Fishing
5 Japan	5 Coal
6 Korea	6 Oil and gas
7 Indonesia	7 Minerals nec
8 Philippines	8 Meat and dairy products
9 Malaysia	9 Other foods
10 Singapore	10 Beverages and tobacco products
11 Thailand	11 Textiles
12 Vietnam	12 Wearing apparel
13 India	13 Leather products
14 Australia, New Zealand	14 Wood products
15 Canada	15 Paper products, publishing
16 United States	16 Petroleum, coal products
17 Mexico	17 Chemical, rubber, plastic products
18 Mexico - export processing zones	18 Mineral products nec
19 Brazil	19 Ferrous metals
20 European Union - 12	20 Metals nec
21 European Union - 15	21 Metal products
22 Russia Federation	22 Motor vehicles and parts
23 South Africa	23 Transport equipment nec
24 Rest of high income countries	24 Electronic equipment
25 Rest of South America	25 Machinery and equipment nec
26 Rest of Asia	26 Manufactures nec
27 Rest of East Asia	27 Electricity
28 Rest of the world	28 Gas manufacture, distribution
	29 Water
	30 Construction
	31 Trade
	32 Transport nec
	33 Water transport
	34 Air transport
	35 Communication
	36 Financial services nec
	37 Insurance
	38 Business services nec
	39 Recreational and other services
	40 Public Admin., Defense, Educ., Health
	41 Dwellings

Placing the sourcing of imports at the agent level reduces the power of the terms-of-trade effects. Our database differentiates the sourcing of imports for producers from the sourcing of imports for households.

There are two additional mechanisms in the model that affect the international linkages in the model. The specification of both of these mechanisms draws on the GTAP model (Hertel and Tsigas). First, a global sector demands services from each regional transportation services sector, to provide a composite service which is used for shipping commodities across regions. In value terms, each region's relative contribution to the global transportation sector does not change due to the simulation performed. It is also assumed that shipping services are required in fixed proportions with the quantity of a particular commodity shipped along a particular route.

The second global sector intermediates between regional savings and regional investment. This global sector has a portfolio of regional net investments which are offered to regional households to satisfy their demand for savings. Regarding the regional composition of net investment, the model assumes that there is a negative relationship between the (expected) regional rate of return on capital and the amount of investment undertaken in a region.

Primary factor mobility. Each region has fixed endowments of skilled and unskilled labor, and capital. Labor services and services from existing capital stock are assumed to be intersectorally perfectly mobile, but region specific. This implies that all sectors, in a region, face the same market price for labor services and the same market price for capital services. It is assumed that labor and capital can move freely between the export processing zone and the rest of the economy in China and Mexico.

3.2 Intertemporal linkages in the CGE model

The comparative-static model discussed thus far is used to simulate changes within a given year t. To simulate changes between years t and t+1, our simulation framework incorporates physical capital accumulation for the economy as a whole:

$$K_{r,t+1} = (1 - D_r)\times K_{r,t} + I_{r,t}$$

where $K_{r,t}$ is the quantity of capital available for use in region r during year t;

$I_{r,t}$ is the quantity of new capital created in region r during year t; and

D_r is the rate of capital depreciation in economy r and it is treated as a parameter.

The level of new capital goods or investment $I_{r,t}$ is determined by the comparative-static model and under the assumption of static expectations we generate a "baseline" which describes the evolution of the world economy in the absence of the change that we wish to analyze. Our baseline runs from 2007 to 2030 and projections for land availability, labor, population and GDP growth rates. Population and labor and land availability are exogenous variables in the CGE model. Thus these variables are shocked in every year according to the projections we use. Gross domestic product, however, is an endogenous variable in the CGE model. To target GDP, we change the closure of the model and allow an economy-wide technology parameter to adjust accordingly.

The simulation of a shock that we wish to analyze generates a "policy" line. The policy simulations include the baseline population, labor and land shocks used to generate the baseline simulations; the shocks for the economy-wide technology parameter that was determined in the baseline simulations; and the shocks that we wish to analyze. For a particular variable, e.g., total U.S. exports, the distance between the "policy" line and the "baseline" is the effect of the shock that we wish to analyze. The policy shocks that we simulate in this paper occur during 2013. Thus the first year that the policy line deviates from the baseline is 2013.

3.3 Data used in the CGE model

A world production or supply chain can be seen as a distribution of value-added shares among countries in a particular global industry. Within the supply chain or production network, each producer purchases inputs and then adds value, which then becomes part of the cost of the next stage of production. The sum of the value added at every stage in the supply chain equals the value of final goods produced by the chain. To precisely define such supply chains across many countries one needs to be able to quantify the contribution of each country to the total value added generated in the process of production (supply) of final products. In this regard, an inter-country input-output (ICIO) table provides the information that allows us to model the value-added generation process among related countries at the aggregate industry level.[4] ICIO tables trace inter-country transactions in intermediate inputs and final uses separately, match bilateral trade flows in major end use categories to input-output relations. Therefore ICIO tables include more detailed source/destination, and supply/use information than Multi-Country Input-Output (MCIO) tables, which are the core of most multi-region CGE model databases such as the GTAP database.

In short, ICIO tables not only provide the origin and destination of international trade flows for each industry, but they also specify every intermediate and/or final use for all such flows. For example, from the ICIO table we will not only know how many electronics were produced in China and how many were shipped to the United States, but also we can distinguish how many of Chinese electronics were

[4] There are product-level approaches to estimate the value embedded in an product and quantify how it is distributed across the supply chain from design and branding to component manufacturing to assembly to distribution and sales, for example see Jason Dedrick, Kenneth L. Kraemer, Greg Linden, (2008).

used as intermediate inputs by particular U.S. sectors and how many of them were demanded by U.S. private households or for capital formation. However, global ICIO tables are very rare because of their significant data required to compile them, as well as differences in statistical classifications across countries.

Available ICIO tables, such as the Asian international IO table compiled by the Institute of Development Economies (IDE) in Japan (Inomata, S., 2005), cover only a select set of Asian economies and treat the European Union and other countries as exogenous blocks. In addition, there is no accounting for processing trade information in any of the currently available MCIO and ICIO datasets. Therefore, in order to implement the CGE model with explicitly specified supply chains and export processing zones in developing countries such as China, a new database has to be developed first.

We have constructed a 2007 global IO table based on version 8 of the GTAP database and processing trade information from China and Mexico. This database is discussed in detail in Tsigas, Wang, and Gehlhar, 2012. The initial allocation of bilateral trade flows in the GTAP database into intermediate and final uses is based on the UN BEC (Broad Economic Categories) method. We use China's expanded IO table with a separate account for processing exports from Koopman, Wang and Wei (2008) and the 2003 Mexico IO table with separate domestic and Maquiladora accounts from the Instituto Nacional de Estadística, Geografía e Informática (INEGI).[5] We integrate China and Mexico's IO tables with version 8 of the GTAP database by a quadratic mathematical programming model to minimize the deviation between the resulting new data set and the original GTAP data. The new database covers 26 countries and 41 sectors (see **table 3**) and was used to calibrate our CGE model.

Our baseline runs from 2007 to 2030 and it incorporates IMF projections for labor, population and GDP growth rates (World Economic Outlook database Sept. 2011 version). Projections for skilled and unskilled labor were developed from ILO information. Population and labor and land availability are exogenous variables in the CGE model.

[5] For more details about the Mexican data see De La Cruz, J.; R. B. Koopman; Z. Wang; and S. J. Wei, 2011.

4. Simulated scenarios and effects

4.1 Specification of simulations

Using this recursive dynamic CGE model, three "policy" scenarios are simulated against the baseline:

(1) the national saving rate in China declines from 44 percent to 36 percent. In particular, a negative shock is applied to the $dpsave_{China}$ parameter (the savings distribution parameter) in the GTAP model (see p. 21 in McDougall, 2003);

(2) the national saving rate in the United States increases from 5.6 percent to 7.2 percent. In this simulation, a positive shock is applied to the $dpsave_{USA}$ parameter; and

(3) productivity improvements in unskilled labor employed in selected industries/economies. In this scenario we simulate an increase in the output of selected sectors in selected Asian economies due to productivity improvements originating in the sector-specific employment of unskilled labor. As a result of the simulated change in the productivity of unskilled labor, FDI would shift from China to the selected economies. The selected sectors and economies are shown in **table 4**.

Table 4. Sectors/economies with simulated improvement in unskilled labor productivity in scenario 3

		Economies					
		Indonesia	India	Malaysia	Philippines	Thailand	Vietnam
Sectors	Textiles	×	×			×	
	Wearing apparel	×	×			×	×
	Leather products	×	×			×	×
	Wood products	×	×			×	×
	Motor vehicles and parts					×	
	Electronic equipment			×	×	×	
	Manufactures nec	×	×	×		×	×

4.2 Simulated effects

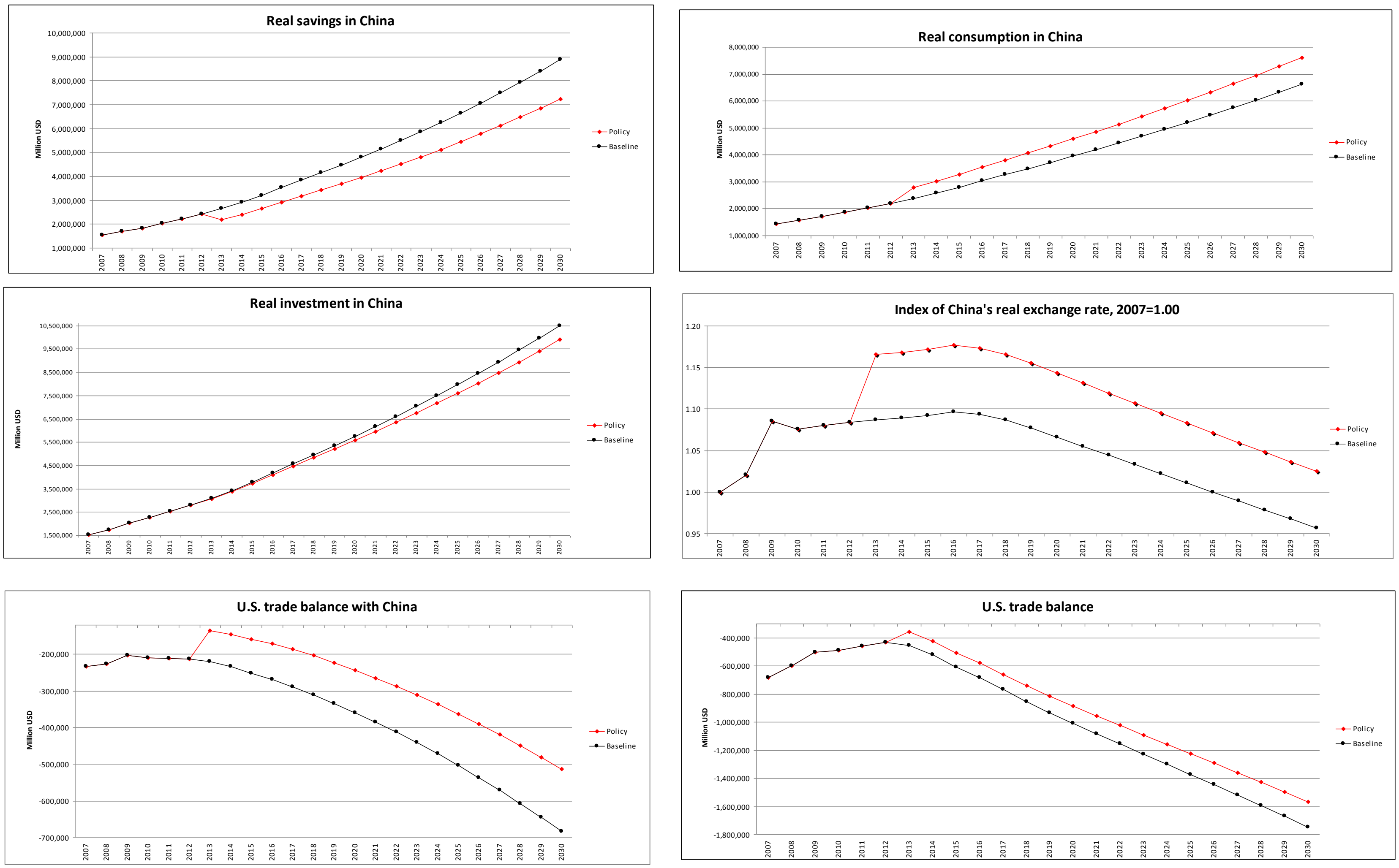
Selected simulated results from scenarios 1 to 3 are presented in **figures 7 to 9**. Our three scenarios are not yet calibrated to produce the same effect for a particular variable of interest, e.g., U.S. trade balance, or China's real exchange rate, thus differences in a particular effect across the three scenarios do not imply that a policy change is more effective than any other policy change examined.

Scenario 1: the national saving rate in China declines from 44 percent to 36 percent. Figure 7 shows that as real savings in China decline and real consumption increases relative to the baseline, real investment in China would decline relative to the baseline. The decline in Chinese real investment, however, is smaller than the decline in Chinese savings because the decline in global savings causes investment in all regions to decline.

A consequence of a lower of level of savings in China is an increase in China's real exchange rate relative to the baseline and improvement in the U.S. trade deficit with China relative to the baseline. The improvement in the U.S.-China trade deficit relative to the baseline is lasting and it persists in the long run. However, by 2019 the U.S. trade deficit with China has returned to its pre-change 2013 level. The global U.S. trade balance also becomes less negative relative to the baseline as a result of the appreciation of China's real exchange rate. In every year, the improvement in the global U.S. trade deficit relative to the baseline is larger than the improvement in the U.S.-China trade deficit.

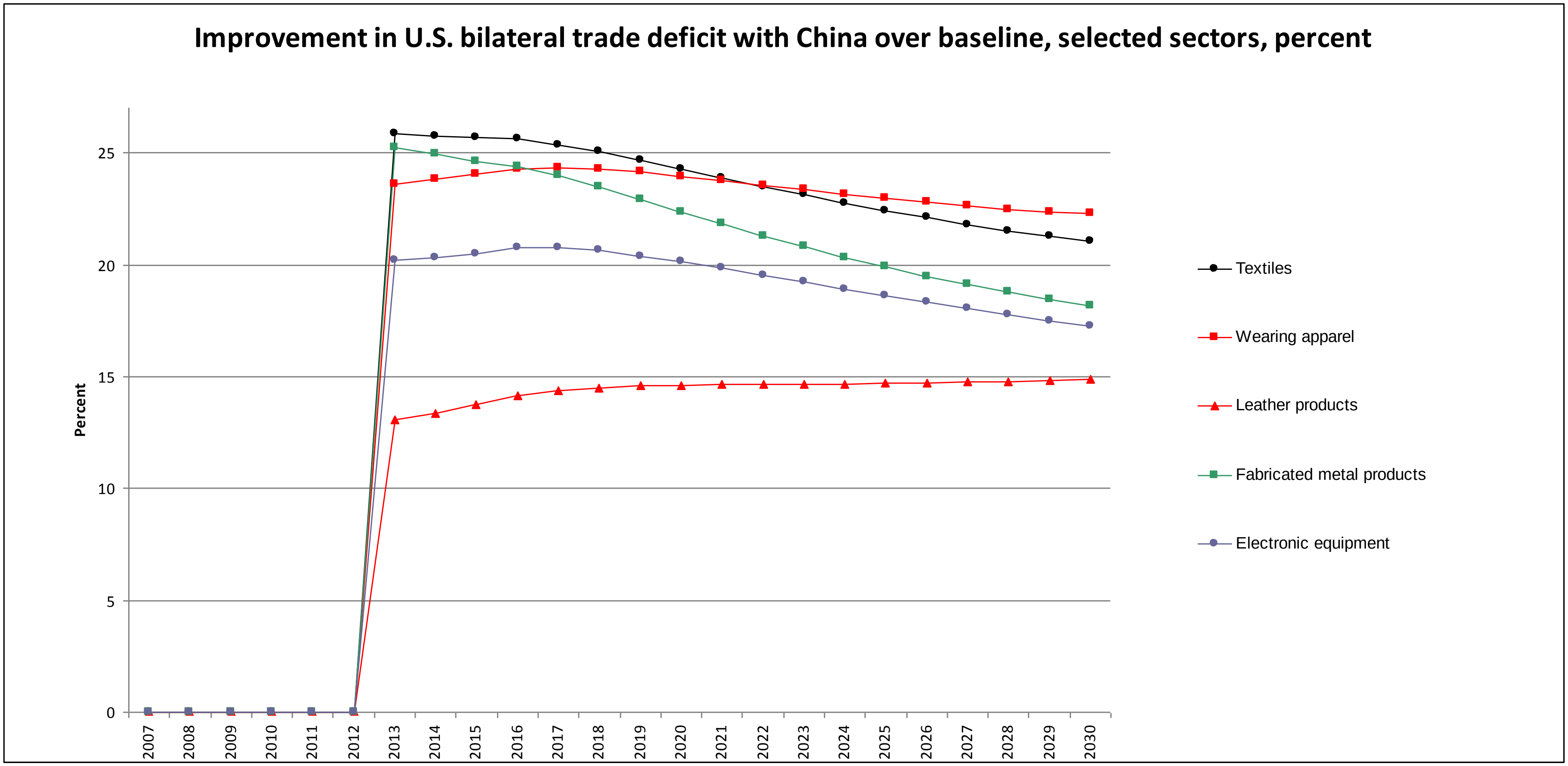
The last panel in figure 7 shows that there is some differentiation in the U.S.-China balance of trade results at the sector level. For example the U.S.-China balance of trade improves relative to the baseline by more than 25 percent for textiles and fabricated metal products in the beginning of the simulated change. The gains in the U.S. bilateral balance of trade for these two sectors erode over time but they remain at 20 percent or more relative to the baseline. On the other hand, the improvement in the U.S.-China balance of trade for leather products is somewhat less than 15 percent during 2013-30 relative to the baseline.

Figure 7 Selected simulated effects from a decline in China's saving rate from 44 percent to 36 percent



....continued

Figure 7 Selected simulated effects from a decline in China's saving rate from 44 percent to 36 percent, continued

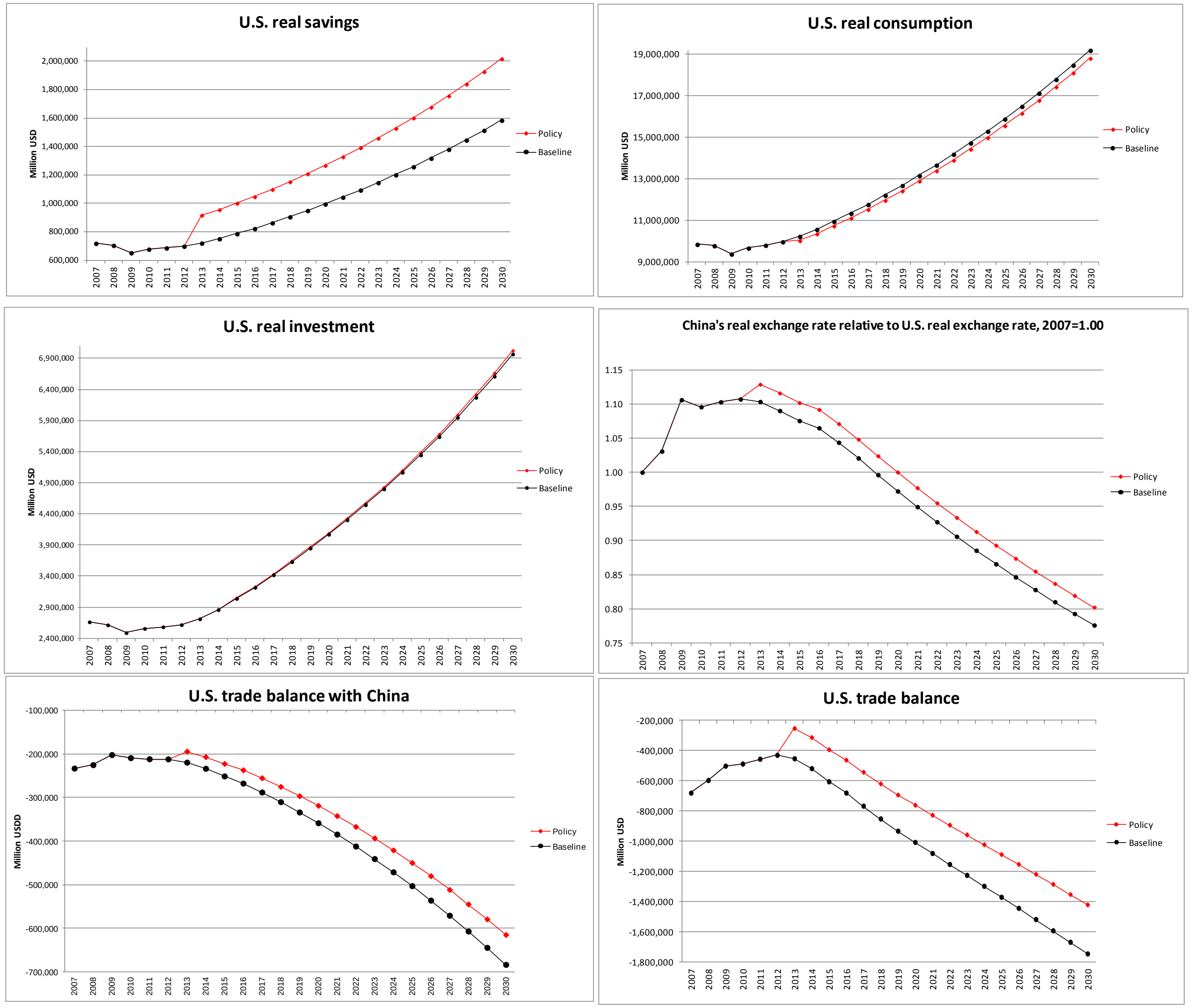


Scenario 2: the national saving rate in the United States increases from 5.6 percent to 7.2 percent. Figure 8 shows that as U.S. savings increase, consumption declines and investment increases relative to the baseline. As in scenario 1, the change in U.S. savings affects global savings which then affects investment in all regions. Thus the increase in U.S. investment is smaller than the increase in U.S. savings relative to the baseline.

As a consequence of a higher level of savings in the United States, the U.S. real exchange rate would decline relative to the baseline and the Chinese real exchange rate would increase relative to the baseline. The real exchange panel in figure 8 shows that the policy change would cause an appreciation in China's real exchange rate relative to that of the United States.

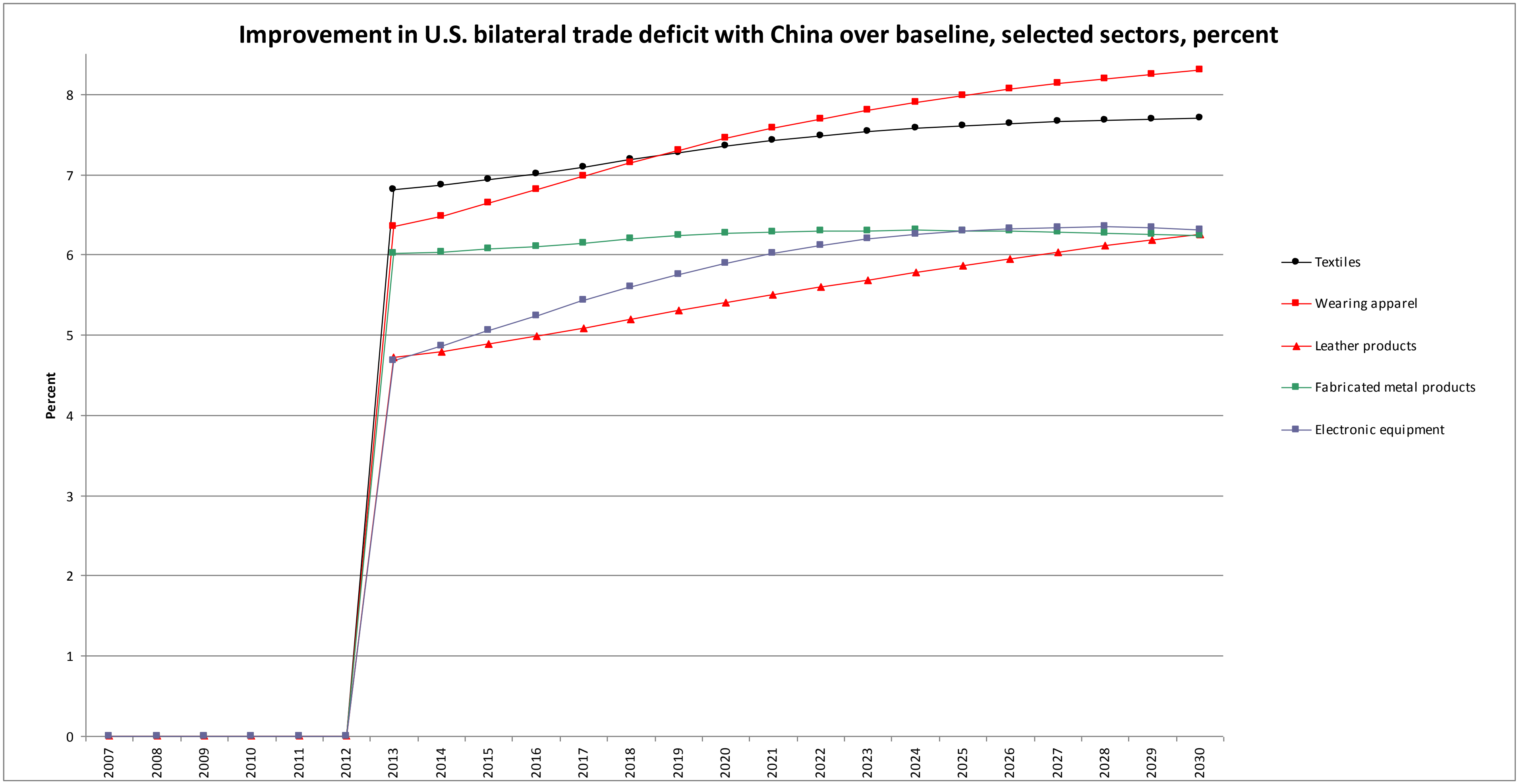
As in scenario 1, the last panel in figure 8 shows that there is differentiation in the U.S.-China balance of trade results at the sector level. The magnitude of the improvement in the U.S.-China trade balance for these particular sectors is smaller under scenario 2 than under scenario 1 because in scenario 1 the simulated change originated in China and Chinese prices were affected the most, while in scenario 2 the simulated change originated in the United States and Chinese prices were affected as much as all other non-U.S. prices.

Figure 8 Selected simulated results from a decline in the U.S. saving rate from 5.6 percent to 7.2 percent



… continued

Figure 8 Selected simulated results from a decline in the U.S. saving rate from 5.6 percent to 7.2 percent, continued

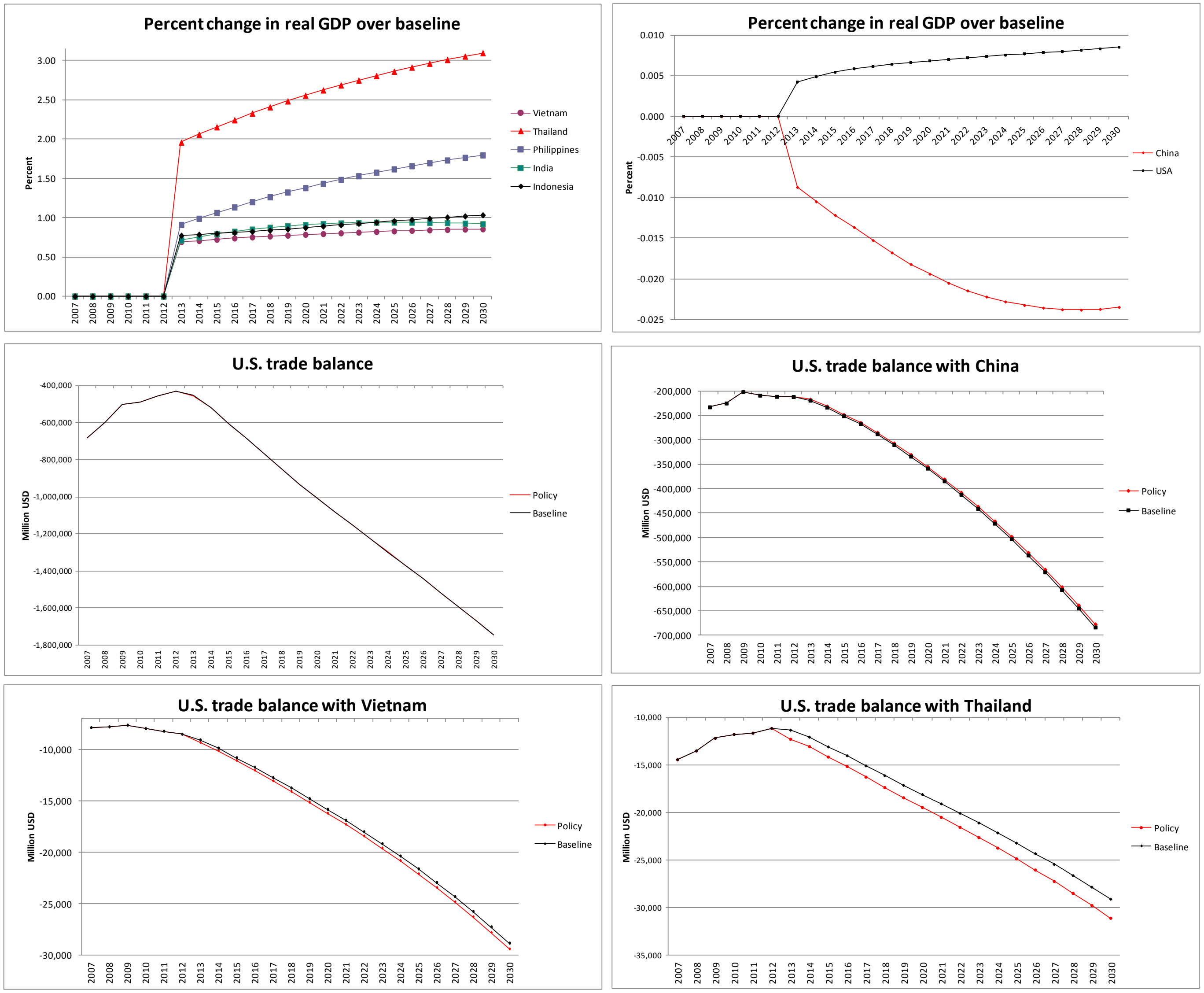


Scenario 3: productivity improvements in unskilled labor employed in selected industries/economies. Figure 9 shows that as unskilled labor becomes more productive in the selected industries in Vietnam, Thailand, the Philippines, India and Indonesia, the real GDP of these economies improves relative to the baseline. Thailand is the economy that experiences the largest GDP gains relative to baseline while Vietnam's GDP improves the least relative to baseline among the economies is this scenario. The relative GDP improvements are driven by several factors, the most important of which is the share of the selected industries in these economies.

U.S. GDP improves while Chinese GDP slightly declines relative to baseline because the U.S. is an importer of these products and benefits from lower prices while China is an exporter of these products and is hurt from lower prices. It is not evident from figure 9, but in the long-run the U.S. trade balance improves by a little more than $1 billion relative to baseline. In the long run the U.S.-China trade balance improves by more than $6 billion relative to baseline while the U.S. trade deficit with Vietnam declines by $0.5 billion relative to baseline.

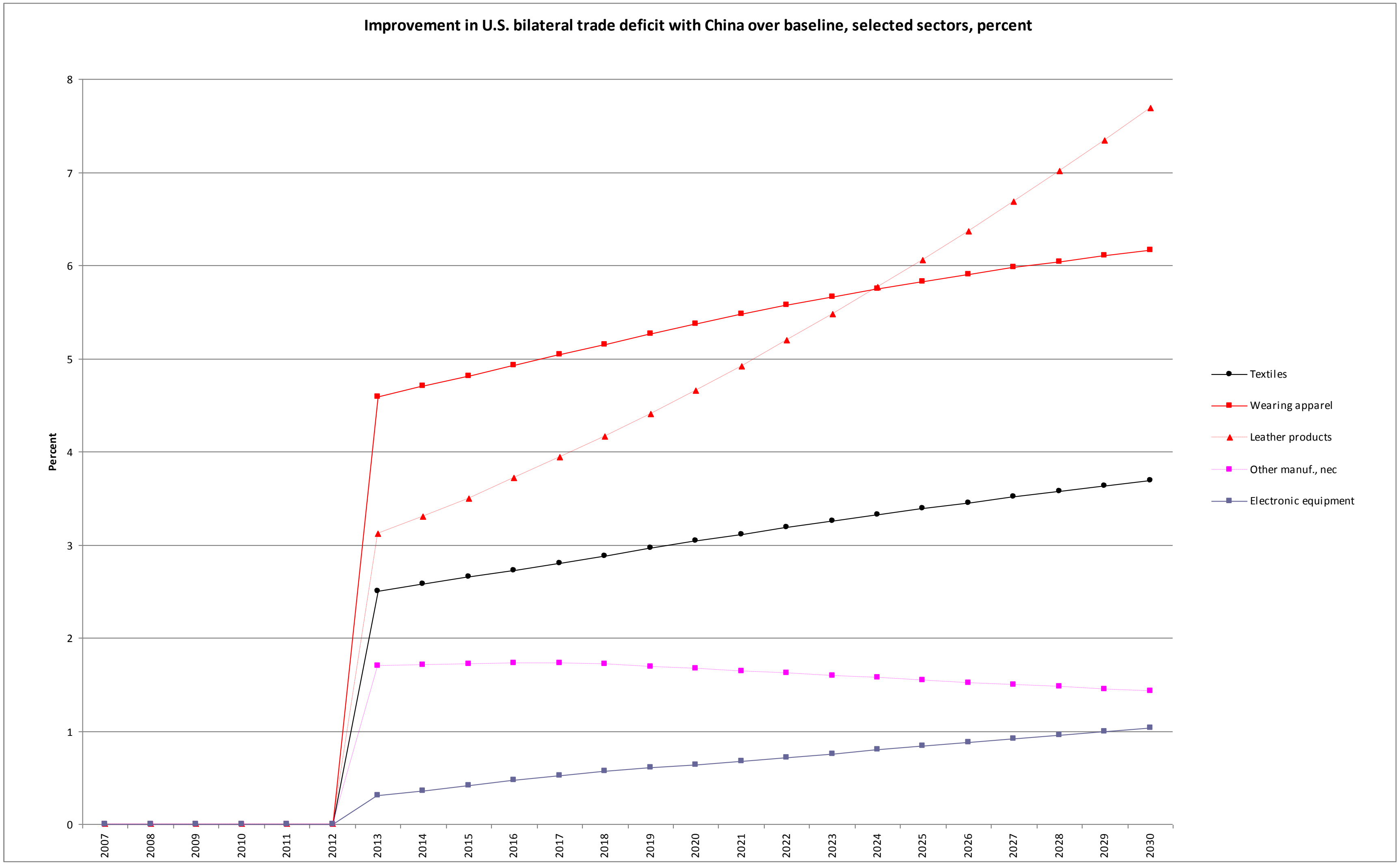
As in scenarios 1 and 2, the last panel in figure 9 shows that there is differentiation in the U.S.-China balance of trade results at the sector level. The magnitude of the improvement in the U.S.-China trade balance for these particular sectors is smaller under scenario 3 than under scenarios 1 and 2.

Figure 9 Selected simulated results from a 50 percent productivity improvement from the employment of unskilled labor in selected sectors/countries



…continued

Figure 9 Selected simulated results from a 50 percent productivity improvement from the employment of unskilled labor in selected sectors/countries, continued



5 Summary and conclusions

This paper provided a quantitative analysis of the U.S.–China trade balance based on a dynamic CGE framework that explicitly models transnational production chains and export processing zones in China and Mexico. To the best of our knowledge, there is no comprehensive analysis of the changing commodity composition and geographical location of U.S. trade deficit and its underlying driving forces in the current literature. We intend to fill this void in this paper addressing the following two questions. First, what is the impact of a decline of Chinese saving rates, and a decline in the U.S. propensity to consumer on major U.S. and Chinese industries, especially their impact on the commodity and geographic composition of the U.S. trade deficit? Second, what is the impact of labor intensive industries as they migrate out of China to other economies in the world, especially the distribution of U.S. trade deficit in both commodity composition and geographic locations during next decades? We aim to answer these questions with a recursive dynamic CGE model. Three scenarios were simulated against the baseline: (1) a decrease in the saving rate in China, (2) an increase in the saving rate in the United States, and (3) a structural change in global supply chain as manufacturing FDI shifts from China to other developing Asian countries.

References

Armington, P.S., 1969a, "A theory of demand for products distinguished by place of production," IMF Staff Papers 16(1): 159-178.

Armington, P.S., 1969b, "The geographic pattern of trade and the effects of price effects," IMF Staff Papers 16(2): 179-201.

Bergsten, C. F., 2006, "China's Trade Surplus with the United States," attachment to "The US Trade Deficit and China," testimony before the Hearing on US-China Economic Relations Revisited, Committee on Finance, United States Senate, March 29, http://www.iie.com/content/?ID=27.

Dedrick, J., K. L. Kraemer, and G. Linden, 2008, "Who Profits from Innovation in Global Value Chains? A Study of the iPod and notebook PCs." Paper presented at the Sloan Industry Studies Annual Conference, Boston, MA, May.

De La Cruz, J.; R. B. Koopman; Z. Wang; and S. J. Wei, 2011, *Estimating Foreign Value-added in Mexico's Manufacturing Exports*, U.S. International Trade Commission, Office of Economics Working Paper No. 2011-04A, April, http://www.usitc.gov/publications/332/EC201104A.pdf.

Francois, J. and Shiells, C., editors, 1994, Modeling Trade Policy: Applied General Equilibrium Assessments of North American Free Trade, Cambridge University Press, New York, NY.
Hertel, T.W., editor, 1997, Global Trade Analysis: Modeling and Applications, Cambridge Univ. Press.

Hertel, T.W.; Ianchovichina, E.; and McDonald, B., 1997, "Multi-Region General Equilibrium Modelling," Chapter 9 in Applied Trade Policy Modelling: A Handbook, Francois, J. and Reinert, K.A., editors, Cambridge Univ. Press.

T. Hertel and M. Tsigas, 1997: "Structure of GTAP," chapter 2, *Global Trade Analysis: Modeling and Applications*, T. Hertel, editor, Cambridge Univ. Press, January.

Inomata, S., 2005, "Towards the Compilation of a Consistent Asian International I-O Table—The Report of the General Survey on National I-O Tables", Discussion Paper No.030, Institute of Developing Economics, Japan External Trade Organization; http://www.ide.go.jp/English/Publish/Download/Dp/030.html.

International Labor Office, "LABORSTA" internet database, "Economically Active Population, Estimates and Projections 1990-2020 (EAPEP)" and "Main Statistics (annual): employment general level, by economic activity".

International Monetary Fund, 2011, World Economic Outlook Database, September.

Instituto Nacional de Estadística, Geografía e Informática (INEGI), "2003 input-output accounts for Mexico with separate domestic and Maquiladora accounts," unpublished worksheets.

Koopman, R., W. Powers, Z. Wang, S.-J. Wei, 2010, "Give Credit Where Credit Is Due: Tracing Value Added in Global Production Chains." NBER WP No. 16426.

Koopman, R., Z. Wang, and S.-J. Wei, 2008, "How Much of Chinese Exports is Really Made in China? Assessing Domestic Value-Added When Processing Trade is Pervasive," NBER, WP 14109.

Koopman, R., Z. Wang and S.-J. Wei, 2011, "A World Factory in Global Production Chains: Estimating Imported Value Added in Exports by the People's Republic of China," in R. Barro and J.-W. Lee, eds, *Costs and Benefits of Economic Integration in Asia*, Oxford University Press.

Koopman, R., Z. Wang and S.-J. Wei, 2012, "Estimating domestic content in exports when processing trade is pervasive." Forthcoming, *Journal of Development Economics*.

McDougall,R., 2003, A New regional Household Demand System for GTAP, GTAP Technical Paper 20, revision 1, Center for Global Trade Analysis, Purdue University, September.

Narayanan, B., A. Aguiar and R. McDougall, Editors, 2012, *Global Trade, Assistance, and Production: The GTAP 8 Data Base*, Center for Global Trade Analysis, Purdue University; https://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=3772.

Noland, M., L.-G. Liu, S. Robinson and Z. Wang, 1998, *Global Economic Effects of the Asian Currency Devaluations* by Institute of International Economics, Washington DC.

Shoven, J.B. and Whalley, J., 1984, "Applied General-Equilibrium Models of Taxation and International Trade: An Introduction and Survey," Journal of Economic Literature 22:1007-1051, September.

Shoven, J.B. and Whalley, J., 1992, Applying General Equilibrium. Cambridge University Press.

Tsigas, M., Z. Wang, and M. Gehlhar, 2012, "How a Global Inter-Country Input-Output Table with Processing Trade Account Can be constructed from GTAP Database," Paper Presented at the 15th GTAP Conference on Global Economic Analysis, International Trade Center, Geneva June 28, 2012, https://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=3784.

Wang, Z., 2003a, "Impact of China's WTO Accession on the Patterns of World Trade." *Journal of Policy Modeling* 25(1): 1-41, January.

Wang, Z., 2003b, "WTO Accession, 'Greater China' Free Trade Area and Economic Integration across the Taiwan Strait", *China Economic Review*, 14(3): 316-349, October.