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China's Gains from WTO Accession: Imports vs Exports

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Abstract

We examine the gains from Chinese accession to the World Trade Organization (WTO). We provide a new quantitative welfare measure by dividing the manufacturing sector into import and export sub-sectors. We then evaluate how the increased openness caused by China's accession to the WTO effects the importing and exporting sectors. We find surprisingly that the gains to the import sector are larger than the gains to the export sector. Moreover, the size and the dynamic pattern of such gains are different across sectors. Overall, sectors with larger intermediate input shares from import-competing industries and with domestic demands less sensitive to changes in trade costs have higher welfare gains from trade liberalization.

1. Introduction

Over the past two decades (after 1992), China has undergone substantial trade liberalization, becoming more open to trade and making the transition from a more traditional economy to a modern industrialized economy. Specifically, China reduced its tariff rate from the pre-1996 high rate of 33% to below 10% by 2005. China's trade dependence (measured by the ratio of exports and imports to gross domestic product (GDP)) has risen from about 35% prior to its accession to the World Trade Organization (WTO) to as high as 65% afterwards. In this paper, we analyze the welfare effects of this period of WTO-related trade liberalization. In particular, we focus on the question of whether the welfare gains from trade liberalization are due to gains in import or export industries. This is particularly relevant because China has undergone rapid structural transformation during this liberalization process.

More specifically, we summarize what happened to industry-level trade dependence. For simplicity, we focus on 18 two-digit manufacturing industries, where the classification of industries is defined in Table 1 and illustrated in the next section. When discussing the gains from trade in section 3 below we will see that wood, machinery, information and communications technology (ICT) and office industries experienced the largest increase in openness to trade. Additionally, by looking at sectoral output shares reported in Table 2, one can see that there has been a structural transformation from traditional industries such as food, textiles and minerals industries to the more modern machinery and ICT industries.

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Table 1. Industry Classification and the Corresponding ISIC Codes

Industry Classification	*Scode*	*ISIC code*
Primary: agriculture, hunting, forestry and fishing	A	A01–B05
Mining: mining and quarrying	Q	C10–C14
Food: foods and beverage	1	D15
Tobacco: tobacco	2	D16
Textile: textile	3	D17
Garment: textile wearing apparel, leather and related products	4	D18–D19
Wood: timber, wood products and furniture	5	D20
Paper: paper, media and printing	6	D21–D22
Petroleum: coke, petroleum and nuclear fuel	7	D23
Chemicals: chemicals, chemical products and medicines	8	D24
Rubber: rubber and plastics	9	D25
Minerals: non-metallic mineral products	10	D26
Metals: ferrous and non-ferrous metals	11	D27
Metal Products: fabricated metal products	12	D28
Machinery: general and special purpose machinery	13	D29
Transport: railroad, motor vehicles and transport equipment n.e.c.	14	D34–D35
Electrical: electrical machinery and equipment n.e.c.	15	D31
ICT: communication, computers and electronic equipment n.e.c.	16	D32
Office: office, medical, cultural and measuring instruments	17	D30 and D33
Others: manufacturing n.e.c. and recycling	18	D36–D37
Manufacturing: total manufacturing	M	D15–D37
Utility: electricity, gas and water supply	U	E40–E41
Construction: construction	N	F45
Tertiary: services	S	G50–Q99

Notes: The classification is based on NBS of China, http://www.stats.gov.cn/tjsj/tjbz/hyflbz/and OECD–STAN Structural Analysis Database, http://www.oecd.org/sti/ind/40729523.pdf. Transport industry corresponds to manufacture of motor vehicles and manufacture of transport equipment not elsewhere classified (n.e.c.).

The primary purpose of this paper is to examine the gains from Chinese accession to the WTO, both by comparing the post-WTO regime with the hypothetical state of autarky and by comparing it with the pre-WTO regime. Using techniques developed in Arkolakis et al. (2012) we provide a new, more detailed quantitative welfare measure by dividing the manufacturing sector into exporting and import-substituting subsectors. We then evaluate how the increased openness caused by China's accession to the WTO effects these sectors. Thus, we essentially can decompose the gains from WTO accession into those resulting from importing and those from exporting.

Here are the main findings of our paper. Compared to autarky, most of China's import industries incurred large gains from trade, while most of its exporting industries had modest gains. By looking at welfare gains moving from the pre-WTO to the post-WTO regimes most of China's import industries incurred large gains from trade whereas several of its exporting and relatively closed industries suffered losses.

Moreover, looking at the dynamic gains from trade, we find that most of China's gains from trade were incurred at the early stage from 1997 to 2002 when tariffs were

Table 2. Share of Total Output by Industries

Scode	*Industry*	*1997*	*2002*	*2005*	*2007*	*2010*
A	Primary	0.123	0.091	0.073	0.060	0.055
Q	Mining	0.034	0.033	0.034	0.036	0.039
1	Food	0.062	0.041	0.048	0.046	0.049
2	Tobacco	0.007	0.005		0.005	0.005
3	Textile	0.046	0.029	0.029	0.031	0.026
4	Garment	0.030	0.021	0.023	0.022	0.019
5	Wood	0.011	0.013	0.011	0.013	0.012
6	Paper	0.022	0.022	0.020	0.018	0.017
7	Petroleum	0.016	0.019	0.023	0.026	0.024
8	Chemicals	0.055	0.046	0.074	0.055	0.055
9	Rubber	0.021	0.022		0.020	0.020
10	Minerals	0.044	0.019	0.029	0.028	0.032
11	Metals	0.039	0.049	0.058	0.075	0.066
12	Metal products	0.025	0.019	0.019	0.022	0.020
13	Machinery	0.041	0.041	0.046	0.048	0.053
14	Transport	0.027	0.031	0.033	0.040	0.047
15	Electrical	0.033	0.023	0.030	0.033	0.037
16	ICT	0.019	0.041	0.052	0.050	0.045
17	Office	0.008	0.005	0.007	0.006	0.006
18	Others	0.014	0.009	0.009	0.013	0.011
U	Utility	0.022	0.028	0.041	0.041	0.038
N	Construction	0.087	0.090	0.074	0.077	0.082
S	Tertiary	0.212	0.301	0.267	0.235	0.245
	Total	1	1	1	1	1

Note: Due to the limited information from the data, there is a lack of sectoral divisions in food/tobacco and chemicals/rubber industries in 2005.

reduced sharply. Furthermore, by closely examining the pattern of trade vs the gains from trade, we find that across the pre-WTO and the post-WTO regimes, among import industries, ICT and office industries enjoyed sizable gains from trade throughout and expanded exports over time. However, chemicals and machinery had large reductions in import intensities and experienced short-lived gains from trade. In these import industries, the gains from trade (in all but the office industry) were primarily driven by enhanced importing.

Intuitively, according to comparative advantage, increased import concentration suggests greater demand for cheaper imports from abroad. As a result of this increased importing activity, prices fall and real incomes rise, leading to higher welfare gains. Underlying the import concentration measure, both import and export intensities have positive effects on the gains from trade. With lower tariffs on imports, households consuming importables spend less whereas producers using importables as intermediate inputs reduce costs. Both channels lead to higher welfare gains.

Moreover, such cost reduction may promote exporting even in some import-competing firms. However, some firms originally protected by tariffs may be harmed in the short run, although such detrimental effects may be offset by long-run upgrading of the incumbents or new entries of more productive firms. Overall, sectors with larger intermediate input shares from import-competing industries and with domestic

demands less sensitive to changes in trade costs will have higher welfare gains from trade liberalization.

The remainder of the paper is organized as follows. In section 2, we discuss China's trade liberalization process and the changes of trade patterns over time and across sectors. The gains from trade measure is presented in section 3. We then deliver our quantitative results in section 4, focusing on comparing gains from trade over time and across sectors, and with the underlying trade patterns. We further decompose the gains from trade by importing and exporting groups as well as by import and export intensities. Section 5 concludes.

2. Trade Liberalization and Trade Patterns

China's accession to the WTO in 2002 resulted in a large increase in international trade. In anticipation of WTO accession, liberalization began in the late 1980s. China committed to opening up to the global trading system by making a sequence of policy changes that included both a broad range of tariff reductions and important institutional reforms. China has liberalized trade by removing many explicit and implicit trade barriers. In particular, as part of China's accession negotiations, it has agreed to reduce tariffs in protected agricultural industries and to tighten up its regulations on the protection of intellectual property rights in accordance with WTO criteria.

In addition, established tariff-rate quotas to commodities have been decreased to allow for better market access. The tariff cuts are comprehensive and have had a profound impact on industrial development. Traditional rural agriculture that featured labor-intensive production has been greatly affected. There have also been important effects in some of manufacturing industries, for example automobiles and ICT. Accession to the WTO has facilitated the import of advanced technology and provided an opportunity to upgrade industrial competitiveness. The effects of these policy reforms is shown in Figure 1.

Figure 1 plots import intensities (imports/GDP), export intensities (exports/GDP) and the trade dependence ratio (the sum of import and export intensities.) Before WTO accession the export intensity was around 19% and the import intensity about 17%. Since 2002, these figures rose to over 30% for exports and 25% for imports prior to the recession in 2008. This shows that accession to the WTO resulted in more openness to trade. One can also see that China has enjoyed a significant trade surplus since 1994 and it continued to grow until the recession in 2008.

Between 1980 and 1996, China's effectively applied tariff rate averaged around 33%. By 1997, in anticipation of accession to the WTO, the average tariff rate was 17.5%. In 2002, when China officially joined the WTO, its effective tariff rate was 12.4% and it has been further reduced to below 10% since 2005. The average tariff-rate time series is plotted in Figure 2 for 1992–2010. The data show a rapid rate of liberalization in the 1992–1997 period followed by a more gradual, but steady reduction in tariffs since 1997. We next turn our attention to industry-level changes.

For convenience, we give a brief name to each of the sub-industries. For example, the chemicals industry (labeled as "scode 8") includes chemicals, chemical products and medicines industries, whereas the ICT sector (scode 16) includes communication, computers and electronic equipment industries. The complete list is given in Table 1, ordered by the scodes (with the corresponding International Standard Industrial Classification (ISIC) codes provided). Although we list all industries for the sake of completeness, the focus of our paper will be on the 18 manufacturing industries.

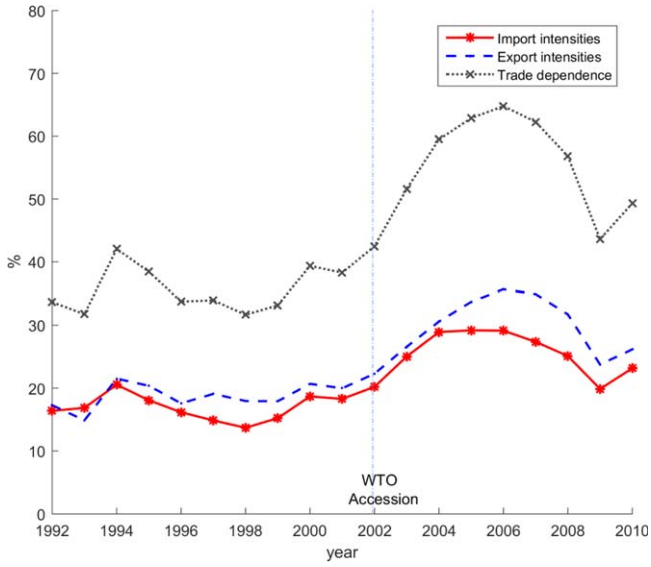

Figure 1. Import and Export Intensities and the Trade Dependence Ratios

Notes: The figures are computed from the OECD database along with the CEIC database, which collects the sectoral output data from various issues of CSY. The import (export) intensities are measured by the amount of import (export) divided by GDP. The trade dependence ratios are measured by the sum of import and export intensities.

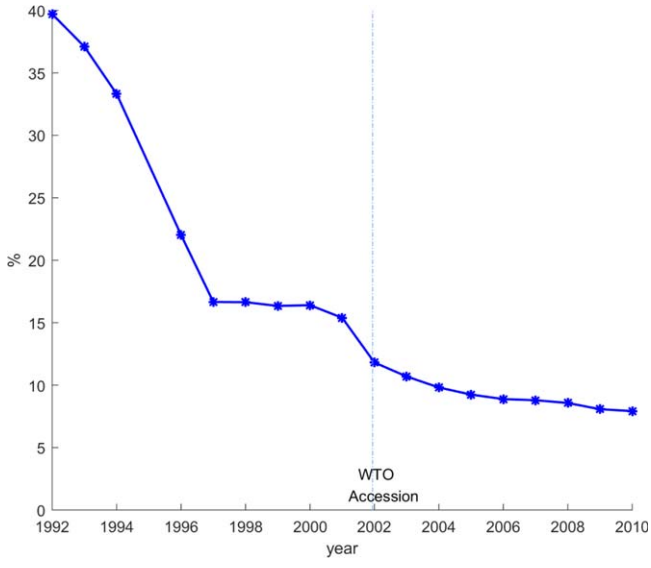

Figure 2. The Average Tariffs of Primary, Mining, and Manufacturing Industries

Notes: The figures are computed from the WITS-TRAINS database. The mean rate is obtained by taking a simple average of the effectively applied rates across all products of the 2-digit ISIC-Rev.3 industries.

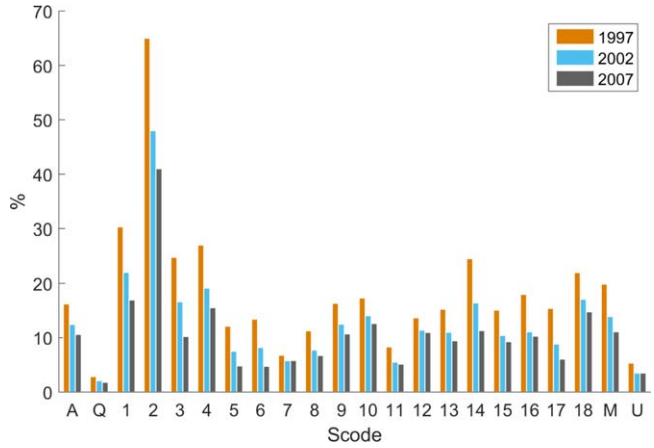

Figure 3. Tariff Rates by Industries in 1997, 2002 and 2007

Notes: The figures are computed from the WITS-TRAINS database. The series that we choose in the effectively applied rates at the two-digit level aggregation in terms of the ISIC-Rev.3 industry classification.

In order to study the industry-specific policy effects, we examine the industry-by-industry tariff-rate changes and discuss their effects. Figure 3 shows the effective tariff rates in each of the two-digit industries by their scodes in 1997, 2002 and 2007. We see that the levels of tariffs vary significantly across manufacturing industries. For example, in the benchmark year of 2002, the rate was as high as 48% in the tobacco industry and as low as 5.5% in the metal industry. In addition, we see that in every industry tariffs are reduced over time. The amount of tariff reduction varies across industries. From 1997 to 2007, we see drops of more than 50% in the textile, paper, transport, ICT and office industries (scodes 3, 6, 14, 16 and 17, respectively), whereas petroleum and metals industries (scodes 7 and 11) feature very modest reductions.

We next turn our attention to looking at the trade patterns in China from 1992 to 2010. We are interested in sectoral import and export intensities that are reported for the benchmark year 2002 in columns (3) and (4) of Table 3. The results may be best illustrated by Figure 4, which plots import and export intensities by sector. Notice that all industries import and export so the question arises as to what constitutes an import or an export industry. In industries such as mining, chemicals, machinery, ICT and office industries, which are above the 45° line we have more imports than exports. We will refer to these industries or sectors as "import" sectors. For the eight industries that are below the 45° line and have more exports than imports: textile, garment, wood, paper, rubber, metal products, electrical and others. We will call these sectors "export" sectors. Finally, the remaining sectors, which are close to the 45° line and have both import and export intensities lower than 10% (food, tobacco, petroleum, minerals, metals and transport), we will call balanced trade sectors.

In the last two columns of Table 3, we also provide the comparable import and export values measured by using an alternative source, the Organisation for Economic Co-operation and Development (OECD)-STAN database (for trade flows) along with the CEIC database provided by CEIC data company Ltd. (for sectoral output). As shown in Figure A1 in the Appendix, the relative positions of most industries do not change much using this different data source, though a few industries now have relatively large intensities; including some we have classified as balanced trade.[1]

Table 3. Export and Import Intensities by Different Data Sources

Source		*I-O table*		*OECD & CEIC*	
Scode	*Industry*	*Export*	*Import*	*Export*	*Import*
A	Agriculture	0.017	0.024	0.075	0.263
Q	Mining	0.043	0.162		
1	Food	0.068	0.040	0.112	0.064
2	Tobacco	0.017	0.012	0.010	0.001
3	Textile	0.302	0.134	0.361	0.166
4	Garment	0.419	0.065	0.909	0.071
5	Wood	0.169	0.048	0.214	0.123
6	Paper	0.140	0.078	0.060	0.172
7	Petroleum	0.043	0.068	0.066	0.103
8	Chemicals	0.083	0.223	0.122	0.319
9	Rubber	0.139	0.038	0.216	0.103
10	Minerals	0.072	0.034	0.106	0.042
11	Metals	0.030	0.103	0.067	0.193
12	Metal products	0.178	0.090	0.290	0.093
13	Machinery	0.101	0.241	0.248	0.400
14	Transport	0.068	0.104	0.094	0.129
15	Electrical	0.285	0.234	0.268	0.211
16	ICT	0.383	0.429	0.309	0.402
17	Office	0.878	0.954	3.326	2.356
18	Others	0.146	0.034	0.264	0.019
U	Utility	0.006	0.034	0.009	0.003

Notes: The intensities of export and import of sector i are measured by EX_i/Y_i and IM_i/Y_i in 2002 (benchmark year). The values in columns (3) and (4) are obtained from China's I-O table of 2002. In contrast, the data of the last two columns come from OECD-STAN (for export and import flows) and *China Statistical Yearbook* (for gross output). The values are adjusted by using yearly exchange rate of RMB to USD provided by the *China Statistical Yearbook*.

Using the data obtained from OECD and CEIC databases, the dynamic pattern of trade for each industry is depicted in Figure 5. The pattern suggests that our industrial divisions based on the relative import/export intensities are consistent over time, at least until around 2002. The differences between the two intensities persist, though the difference in values may change moving from the pre-WTO to the post-WTO regime. In most cases, the industries classified into importing and exporting categories do change their relative intensities over time. Two exceptions are the metals and machinery industries that experienced sharp declines in imports.

3. Gains from Trade

Consider a generalized Armington model with Spence-Dixit-Stiglitz preferences, constant markup over a single production input, labor with a linear cost function, and an import demand system with constant elasticity. A representative agent consumes goods with continuum of varieties (see, e.g., Helpman and Krugman, 1985). We assume iceberg trade costs. In line with Melitz (2003), factor markets are assumed perfectly competitive whereas goods markets are monopolistically competitive.

In particular, let π_i be the import penetration ratio in sector i and τ_i the trade cost. Denote the trade elasticities (or productivity distribution shape parameters) as ε_i,

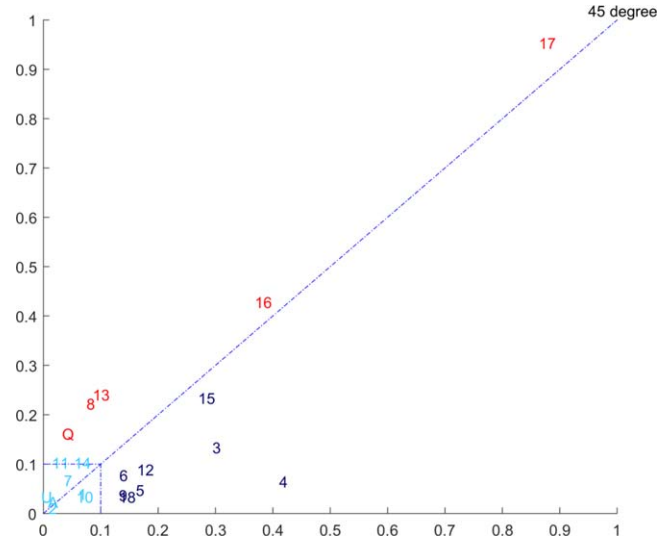

Figure 4. Export (X-axis) and Import (Y-axis) Intensities by Sectors

Notes: The figures are computed from the I-O table of 2002. Industries above the 45-degree line have more imports than exports and the other industries below the 45° line have more exports than imports.

which are typically negative. We impose the three macro-level restrictions as in Arkolakis et al. (2012): (i) trade in goods is balanced, (ii) the aggregate profit to revenue ratio is constant, and (iii) changes in bilateral trade costs yield a symmetric effect on relative import demand from different export countries. Then, the measure of welfare gains in such an economy in units of real income compared with autarky can then be derived as:

$$\hat{w}_i = 1 - \lambda_i^{-1/\varepsilon_i}, \tag{1}$$

where λ_i is the share of domestic expenditure. The welfare gains can be computed from the data since $\lambda_i = 1 - \pi_i$ and π_i under autarky is by construction zero. Equation (1) implies that the higher the import penetration ratio in a sector is, the greater the welfare gains will be (recall that $\varepsilon_i < 0$). Intuitively, using comparative advantage, increased import concentration suggests greater demand for cheaper imports from abroad. As a result of this trading outcome, prices fall and real income rises, leading to higher welfare gains. Moreover, equation (1) also indicates that, in industries with inelastic import demand, gains from trade liberalization by opening up the economy are greater.

The import penetration ratio π_i can be further decomposed using two key factors, import intensity m_i and export intensity x_i. Straightforward analysis implies:

$$\pi_i = \frac{m_i}{1 - x_i + m_i}. \tag{2}$$

One can show that $\partial \pi_i / \partial m_i > 0$ and $\partial \pi_i / \partial x_i > 0$. That is, an increase in either type of trade intensity, exports or imports, increases the import penetration ratio.

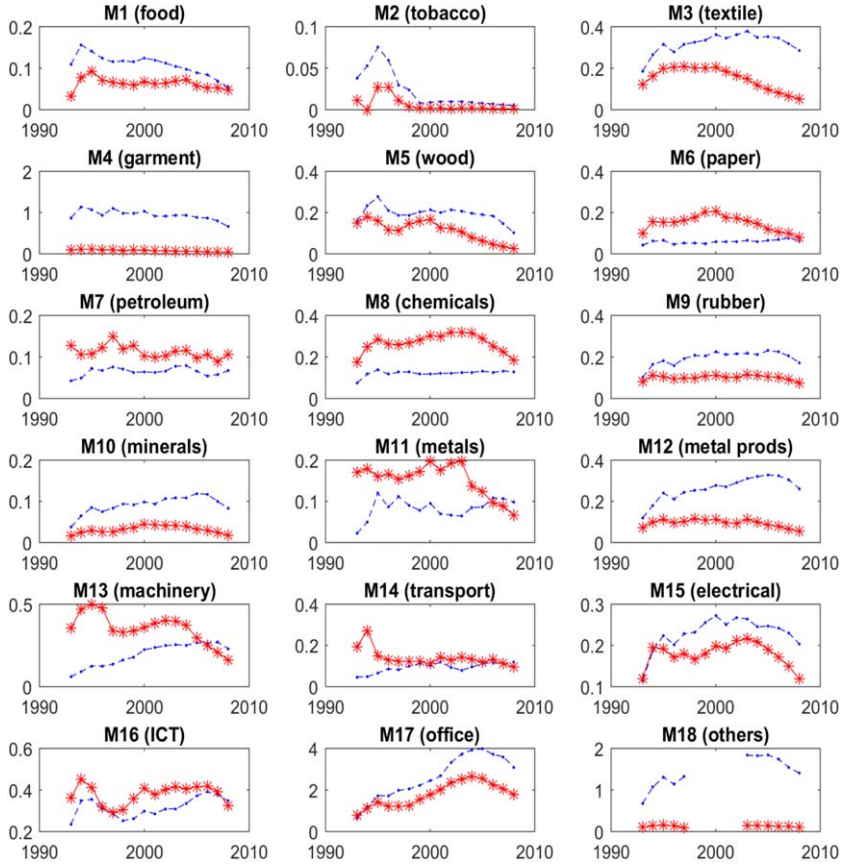

Figure 5. Import (Gray Starred Line) and Export (Black Dotted Line) Intensities by Sectors

Notes: The figures are computed from the OECD and CEIC databases. It suggests that our industry classification based on import relative to export intensities does not change over time.

As a consequence, given that $\varepsilon_i < 0$, one would expect increases in both import and export intensities to have positive effects on the gains from trade. Moreover, the extent to which import and export intensities affect the gains from trade depends negatively on the absolute value of trade elasticities. Intuitively, when an industry is more open (with greater import and the export intensities), the gains from trade are larger. If an industry have a lower trade elasticity, domestic demand is less sensitive to changes in trade costs, thus yielding higher welfare gains from trade liberalization.

To further elaborate on the nature of such welfare gains, let us differentiate between the direct and indirect channels from the prospective of consumers and producers. Consider a uniform reduction in tariffs on all imports. The direct channel is the familiar one in which imports are used for final consumption. In this case, the household spends less on a given amount of imports resulting in welfare gains. The indirect channels are for those industries that use these imports as intermediate goods. For these industries, production costs are lower, thereby generating larger profits and higher welfare gains. This can occur for both import and export industries. Thus, trade liberalization produces gains directly to consumers and indirectly through their effects on firms that use the imports as intermediate inputs.

Table 4. Trade Elasticity by Industries

Scode	*Industry*	*Trade elasticity*
A	Primary	−9.11
Q	Mining	−13.53
1	Food	−2.62
2	Tobacco	
3	Textile	−8.10
4	Garment	
5	Wood	−11.50
6	Paper	−16.52
7	Petroleum	−64.85
8	Chemicals	−3.13
9	Rubber	−1.67
10	Minerals	−2.41
11	Metals	−3.28
12	Metal products	−6.99
13	Machinery	−1.45
14	Transport	[–1.84, −0.39]
15	Electrical	−12.91
16	ICT	−3.95
17	Office	[–12.95, −8.71]
18	Others	−3.98
	Aggregate	−4.49

Notes: The trade elasticities of manufacturing industries (based on the ISIC industry classification) are derived from Caliendo and Parro (2015). Some of the industries considered in this paper, namely, transport and office, consist of multiple ISIC industries, and hence correspond to a broad range of trade elasticities. Meanwhile, some of them share the same values of trade elasticities (e.g. food and tobacco) because they are reported as a unified sector by Caliendo and Parro (2015).

Additionally, trade liberalization produces mixed effects from changes in levels of competition. Those import-competing firms originally protected by tariffs would face tougher competition from foreign firms. In the short run, this could lead to detrimental effects both for the intensive and the extensive (exit) margins. In the longer run, however, this could result in more productive incumbents and new entries of more productive firms. We suspect that the negative consequences will diminish in the longer run and more competitive firms can even result in long-run gains.[2]

Next, we turn our attention to computing the trade elasticities. It is clear that trade elasticities are crucial for the actual welfare computation. In the absence of the necessary bilateral trade information to compute them, we take the figures directly from Caliendo and Parro (2015) using the comparable ISIC industrial classification.[3] Their estimate is based on a variant of a gravity-type equation, which can be derived from a variety of conventional and modern trade models. Their measure of bilateral trade costs takes non-symmetric tariffs as well as symmetric geographic factors into account. In addition, they use cross-country data to estimate the industry-specific trade elasticities, and the data cover China and its main trading partners. The results based on 99% samples are attached in Table 4. Thus, the trade elasticities range from −0.39 (transport industry) to −64.85 (petroleum industry). Manufacturing industries featuring low trade elasticities (absolute value less than 3) and include food/tobacco, rubber, minerals, machinery and transport. Those with high trade elasticities (absolute value larger than 10) include wood, paper, petroleum, electrical and office industries.

Table 5. Import Penetration Ratios Based on I-O Tables

Scode	*Industry*	*1997*	*2002*	*2005*	*2007*	*2010*
Panel A: Import penetration ratio of main industries						
A	Primary	0.016	0.024	0.042	9.046	0.057
Q	Mining	0.104	0.145	0.175	0.266	0.269
M	Manufacturing	0.107	0.156	0.182	0.130	0.109
U	Utility	0.000	0.042	0.001	0.001	0.000
N	Construction	0.003	0.003	0.003	0.004	0.003
S	Tertiary	0.015	0.021	0.041	0.031	0.025
	Total	0.065	0.087	0.114	0.093	0.082
Panel B: Import penetration ratios of manufacturing sub-industries						
1	Food	0.037	0.041	0.038	0.042	0.039
2	Tobacco	0.015	0.012		0.003	0.004
3	Textile	0.104	0.161	0.122	0.046	0.039
4	Garment	0.078	0.100	0.072	0.047	0.040
5	Wood	0.057	0.055	0.056	0.031	0.036
6	Paper	0.108	0.083	0.101	0.061	0.054
7	Petroleum	0.119	0.066	0.250	0.067	0.066
8	Chemicals	0.152	0.195	0.176	0.166	0.141
9	Rubber	0.077	0.042		0.064	0.069
10	Minerals	0.012	0.035	0.019	0.017	0.013
11	Metals	0.101	0.096	0.100	0.072	0.061
12	Metal Products	0.072	0.099	0.111	0.040	0.033
13	Machinery	0.185	0.211	0.200	0.173	0.141
14	Transport	0.087	0.100	0.096	0.092	0.100
15	Electrical	0.142	0.247	0.208	0.145	0.104
16	ICT	0.337	0.410	0.507	0.451	0.353
17	Office	0.233	0.887	1.065	0.705	0.594
18	Others	0.045	0.039	0.167	0.150	0.222
M	Manufacturing	0.107	0.156	0.182	0.130	0.109

Notes: The maximum numbers of sectoral divisions available to the manufacturing industries are 71, 71, 17, 80, and 39 from I-O tables of 1997, 2002, 2005, 2007 and 2010, respectively. Because of the limited information from the data, there is a lack of sectoral divisions in food/tobacco and chemicals/rubber industries in 2005.

We now use the input–output tables to compute the import penetration ratio in each industry, which is the ratio of imports to domestic expenditure (defined as sectoral output plus imports and net of exports). Table 5 reports these ratios for 5 years, 1997, 2002, 2005, 2007 and 2010 and includes the main industries as well as manufacturing sub-industries. Focusing on the benchmark year (2002), for manufacturing sub-industries the import penetration ratios range from 0.012 to 0.887. While industries such as office, ICT, electrical, machinery and chemicals feature relatively high import penetration ratios (greater than 0.18), those including food, tobacco, rubber, minerals and others have low ratios (below 0.05) From 1997 to 2007, import penetration ratios rose sharply by at least 50% in office and others industries. Over the same period, import ratios in tobacco and textiles fell significantly (at least 50%).

Table 6. Gains from Trade (Change in Real Income) Relative to the Autarky Level

Changes in real income (%)		*Gains*			*Dynamic Gains*	
Scode	*Industry*	*1997*	*2002*	*2007*	*Δ(97 to 02)*	*Δ(97 to 07)*
A	Primary	0.179	0.263	0.516	0.084	0.337
Q	Mining	0.830	1.148	2.259	0.318	1.429
1	Food	1.437	1.580	1.614	0.143	0.177
2	Tobacco	0.563	0.450	0.130	−0.113	−0.433
3	Textile	1.340	2.138	0.579	0.798	−0.761
4	Garment	0.993	1.291	0.590	0.298	−0.403
5	Wood	0.513	0.491	0.270	−0.022	−0.243
6	Paper	0.692	0.522	0.383	−0.170	−0.309
7	Petroleum	0.195	0.105	0.106	−0.090	−0.089
8	Chemicals	5.126	6.713	5.641	1.587	0.515
9	Rubber	4.676	2.554	3.897	−2.122	−0.779
10	Minerals	0.514	1.486	0.725	0.972	0.211
11	Metals	3.203	3.041	2.243	−0.162	−0.960
12	Metal products	1.060	1.477	0.578	0.417	−0.482
13	Machinery	13.16	15.11	12.25	1.950	−0.910
14	Transport	4.828	5.587	5.101	0.759	0.273
15	Electrical	1.182	2.168	1.202	0.986	0.020
16	ICT	9.87	12.51	14.10	2.640	4.230
17	Office	2.052	15.66	9.110	13.608	7.058
18	Others	1.144	0.985	4.013	−0.159	2.869

Notes: As shown in Table 4, the estimate of trade elasticity in the transport industry is between 0.39 and 1.84. The first estimate is to the industry of motor vehicles and trailers only, whereas the second is to the industry of rest of transport equipment. Here, the gains are measured by using the value 1.84 to the aggregate transport industry. Moreover, dynamic gains are computed from 1997 to 2002 (column 6) and from 1997 to 2007 (column 7).

With the information about trade elasticities and import penetration ratios, we are ready to compute welfare gains from trade (measured by percentage changes in real income) in 1997, 2002 and 2007. The results are reported in Table 6. Comparing the benchmark year (2002) with autarky, one can see that gains from trade vary greatly across industries, from a modest gain of 0.105% to a sizeable gain of 15.66%. The range in China is wide, which is mainly due to the large variation in the pre-WTO level of import penetration in China and the changes since China's accession to the WTO. Among manufacturing industries in 2002, office, ICT and machinery enjoyed the largest gains from trade exceeding 10%, while tobacco, wood, paper, petroleum and others had gains below 1%. Comparing the benchmark year (2002) with the pre-WTO regime (1997), 11 industries incurred gains while seven industries suffered losses. Office, ICT, machinery and chemicals gained more than 1.5%, whereas rubber lost more than 1.5%.

We finally turn to export and import intensities and report the figures in 1997, 2002 and 2007 in Table 7. Owing to limited data availability, the long-term changes can be presented in Figure 5 for reference. Notice that the results derived from both of the input–output tables and OECD–CEIC databases suggest that the dynamics of export and import intensities may have different effects on the changes of gains from trade.

Table 7. Export and import intensities by I-O tables

		Export intensities			*Import intensities*		
Scode	*Industry*	*1997*	*2002*	*2007*	*1997*	*2002*	*2007*
A	Primary	0.017	0.017	0.014	0.016	0.024	0.048
Q	Mining	0.057	0.043	0.022	0.113	0.162	0.354
1	Food	0.056	0.068	0.050	0.037	0.040	0.041
2	Tobacco	0.032	0.017	0.005	0.014	0.012	0.003
3	Textile	0.184	0.302	0.326	0.094	0.134	0.032
4	Garment	0.354	0.419	0.314	0.054	0.065	0.034
5	Wood	0.131	0.169	0.221	0.053	0.048	0.025
6	Paper	0.154	0.140	0.152	0.103	0.078	0.055
7	Petroleum	0.057	0.043	0.036	0.127	0.068	0.069
8	Chemicals	0.077	0.083	0.097	0.165	0.223	0.180
9	Rubber	0.157	0.139	0.169	0.070	0.038	0.057
10	Minerals	0.034	0.072	0.065	0.012	0.034	0.017
11	Metals	0.062	0.030	0.084	0.106	0.103	0.071
12	Metal products	0.131	0.178	0.201	0.067	0.090	0.033
13	Machinery	0.059	0.101	0.145	0.214	0.241	0.178
14	Transport	0.058	0.068	0.100	0.090	0.104	0.091
15	Electrical	0.225	0.285	0.251	0.129	0.234	0.127
16	ICT	0.306	0.383	0.519	0.352	0.429	0.396
17	Office	0.266	0.878	0.663	0.223	0.954	0.805
18	Others	0.143	0.146	0.127	0.040	0.034	0.155

Note: See note to Table 3.

In particular, the substantial drops of import intensities in chemicals and machinery industries come along with the continuous growth of export intensities. As a result, the moderate losses of the two industries suggest that import intensities may play an essential role under the post-WTO regime.

4. Quantitative Results

Table 6 reports the dynamic patterns of gains from trade. In column 3–5, we report the gains from trade in 1997, 2002 and 2007 compared with the hypothetical state of autarky. The results indicate that three of the import industries, chemicals, machinery and ICT, incurred the largest gains throughout, amounting to 5.1–15.1% real income increase compared with the corresponding autarky levels. While the initial gain of another importing industry (Office) in 1997 was not as large (2.1), the gains rose substantially since China's accession to the WTO in 2002 (to 15.6 and 9.1). There are seven industries whose gains from trade have never reached 1.5, including four exporting industries (garment, wood, paper and metal products) and three autarky industries (tobacco, petroleum and minerals) where their gains from trade are by definition small. In summary, we have:

RESULT 1: (*Gains from Trade Compared to Autarky*)—*Most of China's importing industries incurred large gains from trade compared with autarky, whereas most of its exporting industries had modest gains*.

The results are readily understood from equation (1). On the one hand, all importing industries have sizable import penetration ratios, with the office industry facing the highest rate of import penetration. On the other hand, all but the office industry have relatively inelastic domestic demands. These together explain why importing industries incurred large gains from trade compared with autarky.

The next question is how China's accession to the WTO affected its gains from trade. We further report in columns (6) and (7) of Table 6 the gains from trade in 2002 and 2007 compared with the pre-WTO regime in 1997. We find that four import industries (chemicals, machinery, ICT and office) posted the largest trade gains from the pre-WTO regime in 1997 to the post-WTO regime in 2002. Such gains range from 1.5% to 13.6% in real income. In contrast, three exporting industries (wood, paper and rubber) posted welfare losses from trade owing to the requirements for openness by the WTO. While the relatively closed industries (tobacco and petroleum) incurred small losses, only one import industry posted negative but modest losses. We can thus conclude:

RESULT 2: (*Gains from Trade Before and After the Accession to the WTO*)—*Most of China's importing industries incurred large trade gains from the pre- to the post-WTO regime, whereas several of its exporting and relatively closed industries suffered losses*.

Intuitively, tariff reduction induced by WTO accession led to cheaper imported consumables and cheaper imported intermediate inputs, both yielding large trade gains to importing industries. While cheaper imported intermediate inputs can also result in trade gains to exporting industries, it is apparent that such gains are not as large quantitatively. After examining dynamic gains from trade and export intensities, we shall return to this latter issue by further studying input usage based on input–output tables.

We further compare the trade gains from the pre-WTO regime in 1997 with the post-WTO regime in 2002 vs the post-WTO regime in 2007. To do this consider the last two columns of Table 6. We see, for example, that the ICT industry gained 2.6 from 1997 to 2002 and 4.2 from 1997 to 2007. This tells us that the ICT industry gained significantly in the early period of liberalization and these gains continued through the post-accession period. Examination of Table 6 shows that this pattern is relatively rare. Most industries achieved most of their gains from trade in the early (1997–2002) period and that these gains slowed down or were even reversed in some cases. If we look at chemicals, for example, we see that in the early period they gained 1.6 and their total gains (1997–2007) were smaller, 0.5. This tells us that in the later period gains from trade were much smaller and perhaps even negative. That is, the sizable gains from trade liberalization in China seem relatively short-lived, excluding the two relatively modern ICT and office industries (posting large gains of 4.2% and 7.1%, respectively).

This is not surprising because tariffs had been reduced sharply at the early stage years before 2002. By grouping all importing industries into the importing sector and all exporting industries into the exporting sector, we obtain an average trade gain of 1.0% and 0.03%, respectively, over the period from 1997 to 2002. Over a longer term from 1997 to 2007, the gains from trade in the exporting sector remained at 0.03% but those in the import sector dropped to 0.67%. Thus, we have:

RESULT 3: (*Dynamic Gains from Trade*)—*Most of China's gains from trade liberalization were incurred at the early stage from 1997 to 2002 when tariffs were reduced sharply*.

We now look at how China's export intensities changed over time since its accession to the WTO. Focusing on the import industries, we find that all of their export intensities were rising. Turning to the exporting industries, we find that, such patterns were mixed, possibly rising (textile, wood and metal products), flat (rubber and electrical), falling (others) or eventually falling (garment). The above findings imply:

RESULT 4: (*Export Intensities*)—*After its accession to the WTO, China's export intensities in most import industries were rising but those in exporting industries experienced mixed patterns*.

Using what we have learned from Results 2, 3 and 4, we examine trade and industrial transformation in several key import industries. We find that all four import industries experienced rising export intensities compared with the pre-WTO regime. Only the ICT and office industries enjoyed sizable gains from trade, while the other two import industries either faced small gains from trade (chemicals) or losses (machinery). This is because of their different dynamic patterns of imports: both chemicals and machinery incurred drops in import intensities shortly after China's accession to the WTO (see equations (1) and (2)). We thus have:

RESULT 5: (*Pattern of Trade vs Gains from Trade*)—(1) *During the period from 1997 to 2007 when changing from the pre- to the post-WTO regime, among import industries;* (2) *The ICT and office industries enjoyed sizable gains from trade throughout and expanded exports over time;* (3) *Despite their expanded exports, chemicals and machinery had large reductions in import intensities and experienced short-lived gains from trade*.

To better understand the findings above, let us further examine the extent to which the role of intermediate goods is played. In Table 8, we report the input–output table of all sub-industries, where the figures indicate the percentages of row industries used by column industries. For illustrative purposes, let us focus on the input–output coefficients exceeding 5%. Two observations follow immediately. First, putting aside primary inputs and services (tertiary), intermediate inputs are largely within each industry. That is, a majority of intermediate inputs used by firms in an industry is coming from other firms in the same industry. Second, among all 18 manufacturing industries, only chemicals and metals have been used at the 5% level or greater by three or more industries (including own industries).

Interestingly, focusing on the import-competing sectors, the ICT sector used 45.3% intermediate inputs from ICT and 3.5% from the other three import-competing sectors; the office sector used 6.1% intermediate inputs from office and 28.4% from other import-competing sectors; the chemical sector used 29.6% intermediate inputs from chemical and 2.0% other import-competing sectors; the machinery sector used 18.1% intermediate inputs from machinery and 4.0% other import-competing sectors. That is, all four import-competing sectors have used intermediate inputs from import-competing sectors more heavily than other sectors. As a result of tariff reduction, these import-competing sectors have benefited from cheaper intermediate goods inputs, thereby yielding higher welfare gains. Such gains via the intermediate goods channel are even higher in the ICT and the office sectors, owing to even larger usage of intermediate goods from import-competing sectors (48.8% in ICT and 34.5% in office, vs 31.6% in chemical and 22.1% in machinery).[4]

Table 8. Direct input coefficient of the input-output table

		Output																			
	Input	*A*	*Q*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*
A	Agriculture	0.162	0.004	0.376	0.039	0.133	0.045	0.107	0.026	0.000	0.021	0.050	0.001	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.064
Q	Mining	0.003	0.034	0.004	0.001	0.005	0.001	0.007	0.005	0.597	0.065	0.003	0.097	0.120	0.024	0.010	0.005	0.008	0.001	0.002	0.008
1	Food	0.055	0.000	0.140	0.000	0.000	0.037	0.000	0.000	0.000	0.011	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004
2	Tobacco	0.000	0.000	0.000	0.095	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	Textiles	0.001	0.001	0.001	0.000	0.339	0.286	0.011	0.017	0.000	0.002	0.006	0.005	0.000	0.003	0.005	0.002	0.001	0.002	0.002	0.060
4	Garments	0.000	0.004	0.001	0.000	0.003	0.127	0.015	0.007	0.001	0.002	0.006	0.003	0.002	0.002	0.002	0.003	0.002	0.001	0.002	0.002
5	Wood	0.003	0.004	0.001	0.000	0.001	0.002	0.238	0.015	0.000	0.002	0.003	0.006	0.001	0.013	0.003	0.002	0.003	0.001	0.002	0.012
6	Paper	0.002	0.002	0.021	0.025	0.006	0.015	0.014	0.235	0.001	0.014	0.011	0.030	0.001	0.008	0.006	0.003	0.025	0.008	0.011	0.035
7	Petroleum	0.010	0.025	0.002	0.000	0.003	0.003	0.009	0.005	0.042	0.046	0.007	0.029	0.035	0.009	0.007	0.004	0.006	0.002	0.002	0.008
8	Chemicals	0.060	0.021	0.015	0.017	0.099	0.038	0.072	0.074	0.016	0.296	0.288	0.050	0.012	0.022	0.016	0.020	0.043	0.020	0.062	0.033
9	Rubber	0.007	0.014	0.020	0.002	0.006	0.026	0.014	0.034	0.002	0.031	0.187	0.016	0.003	0.011	0.036	0.041	0.077	0.037	0.054	0.021
10	Minerals	0.003	0.007	0.006	0.000	0.002	0.002	0.006	0.003	0.002	0.006	0.004	0.081	0.018	0.010	0.005	0.006	0.013	0.025	0.024	0.011
11	Metals	0.001	0.026	0.002	0.000	0.001	0.002	0.018	0.010	0.006	0.007	0.011	0.026	0.302	0.339	0.175	0.106	0.198	0.018	0.064	0.044
12	Metal products	0.003	0.014	0.008	0.001	0.002	0.004	0.020	0.013	0.003	0.007	0.009	0.026	0.009	0.115	0.036	0.017	0.042	0.020	0.038	0.032
13	Machinery	0.008	0.035	0.004	0.002	0.016	0.004	0.010	0.012	0.012	0.013	0.010	0.035	0.026	0.017	0.181	0.086	0.045	0.013	0.030	0.005
14	Transport	0.004	0.012	0.003	0.001	0.002	0.001	0.005	0.007	0.003	0.002	0.004	0.003	0.007	0.004	0.012	0.286	0.005	0.003	0.005	0.002
15	Electrical	0.001	0.015	0.001	0.001	0.003	0.002	0.004	0.005	0.006	0.004	0.004	0.006	0.006	0.006	0.041	0.022	0.097	0.067	0.055	0.005
16	ICT	0.000	0.003	0.001	0.000	0.002	0.002	0.002	0.010	0.003	0.003	0.004	0.004	0.001	0.002	0.020	0.006	0.033	0.453	0.192	0.003
17	Office	0.000	0.006	0.001	0.000	0.001	0.002	0.002	0.002	0.002	0.004	0.002	0.003	0.002	0.002	0.004	0.005	0.005	0.002	0.061	0.002
18	Others	0.001	0.004	0.002	0.001	0.003	0.003	0.004	0.022	0.001	0.002	0.005	0.008	0.041	0.005	0.008	0.003	0.006	0.003	0.004	0.043
U	Utility	0.012	0.065	0.013	0.002	0.023	0.008	0.024	0.023	0.025	0.059	0.026	0.063	0.055	0.040	0.024	0.014	0.015	0.010	0.011	0.013
N	Construction	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.001	0.001	0.000	0.001	0.001	0.000	0.000	0.000	0.002
S	Tertiary	0.079	0.124	0.128	0.049	0.102	0.146	0.146	0.138	0.105	0.126	0.103	0.179	0.113	0.132	0.127	0.107	0.136	0.105	0.119	0.099
Value added (in total)		0.582	0.582	0.578	0.250	0.763	0.248	0.246	0.273	0.337	0.172	0.275	0.257	0.329	0.244	0.237	0.281	0.262	0.241	0.210	0.257
Total output		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Notes: The input coefficient table is constructed based on China's I-O table of 2002. A number in the matrix, say a_{ij}, represents the amount of inputs from sector j to be used in order to produce one unit of output in sector i. In particular, a number in the diagonal is the share of the intermediate inputs in an industry required by the same industry to produce final goods.

Table 9. Counterfactual on Gains from Trade by Fixing Export and Import Intensities to the 1997 Level

		Counterfactual		
		fixing x_i	*fixing* m_i	*Benchmark*
Scode	*Industry*	Δ*(97–02)*	Δ*(97–02)*	Δ*(97–02)*
A	Primary	0.083	0.000	0.084
Q	Mining	0.333	−0.012	0.318
1	Food	0.124	0.018	0.143
2	Tobacco	−0.106	−0.009	−0.113
3	Textile	0.513	0.210	0.798
4	Garment	0.176	0.106	0.298
5	Wood	−0.043	0.022	−0.022
6	Paper	−0.162	−0.010	−0.170
7	Petroleum	−0.089	−0.003	−0.090
8	Chemicals	1.552	0.028	1.587
9	Rubber	−2.070	−0.094	−2.122
10	Minerals	0.915	0.021	0.972
11	Metals	−0.065	−0.100	−0.162
12	Metal products	0.342	0.059	0.417
13	Machinery	1.398	0.518	1.950
14	Transport	0.706	0.046	0.759
15	Electrical	0.839	0.090	0.986
16	ICT	1.598	0.932	2.640
17	Office	4.252	5.749	13.608
18	Others	−0.162	0.004	−0.159

Note: The benchmark values are derived from column (6) of Table 6.

We next turn to determining whether the gains from trade liberalization experienced by the importing industries can be attributed to increased importing or exporting. To do this we decompose the welfare gains from the pre-WTO regime of 1997 to the post-WTO regime of 2002 using counterfactual analysis. That is, we compute the gains from trade with either the export intensities or the import intensities fixed at the pre-WTO regime figure in 1997 (see columns (3) and (4) of Table 9). A larger gain with fixed export intensities indicates that enhanced importing is a more important driver of welfare gains resulting from trade liberalization. If gains are larger given fixed import intensities, then export expansion is more crucial. Examination of Table 9 reveals that across all manufacturing industries, enhanced importing is relatively more important for explaining the resulting gains from trade. Looking at the four import industries, three industries (chemicals, machinery and ICT) had gains from trade primarily driven by enhanced importing with only the office industry having export expansion play a significant role.

We thus arrive at the following conclusion:

RESULT 6. (*Counterfactual Analysis*)—*From 1997 to 2007 when changing from the pre- to the post-WTO regime, among importing industries, the gains from trade in all but one (office) industry were primarily driven by enhanced import activity rather than export expansion.*

This result lends further support to the argument that cheaper imported consumables and cheaper imported intermediate inputs heavily used by importing industries are the primary source of the larger trade gains from tariff reduction induced by China's WTO accession. Moreover, the negative consequences of tougher competition facing domestic import-competing firms are likely small or diminishing quickly over time, thus not harming importing sectors much after trade liberalization.

5. Concluding Remarks

In this paper, we have examined the gains from Chinese accession to the WTO in 2002.

We have provided a new quantitative measure by dividing the manufacturing sector into exporting and importing sub-sectors and decomposed the gains from trade measure into import and export expansion channels.

We find that, relative to autarky, most of China's import industries incurred large gains from trade, with most of its exporting industries seeing modest gains. While most of China's importing industries incurred large trade gains from the pre-WTO to the post-WTO regime, several of its exporting and relatively closed industries suffered losses. Moreover, we find that most of China's gains from trade were incurred at the early stage from 1997 to 2002 when tariffs were reduced sharply. Across the pre-WTO and the post-WTO regimes, two of the import industries (ICT and office industries) enjoyed sizable gains from trade throughout and expanded exports over time, while the other two (chemicals and machinery) had large reductions in import intensities and experienced short-lived gains from trade. We find that all of these import-competing sectors have large intermediate input shares from import-competing sectors whereas all but one (office) have relatively inelastic domestic demands. These explain why larger welfare gains are incurred. Furthermore, in these importing industries, counterfactual analysis suggests that the gains from trade in all but one (office) industry were primarily driven by expanded importing rather than export expansion. Thus, cheaper imported consumables and cheaper imported intermediate inputs heavily used by importing industries can be regarded as the primary source of the large trade gains incurred in China as a result of tariff reduction induced by its WTO accession.

Our results pose a challenging question for future research: What are the underlying forces leading to larger gains from tariff reduction in import industries? We can think of four possible channels. Three are the classical channels: relative factor abundance, intensity of factor shares and the relative prices of inputs and outputs. A fourth possibility, technology trade along a vertically integrated world production chain, seems to us to be an important channel to investigate. We plan to do this using a dynamic, calibrated trade model.

Data Appendix

This appendix describes the data sources and explains how we reach concordance of the data from different sources. Our main focus is on bilateral trade flows, outputs of manufacturing industries and tariff rates at the two-digit level. For this purpose, we select the data with detailed information at more than the two-digit level and make aggregation on a comparable basis.

First, the bilateral trade data are obtained from OECD-STAN bilateral trade database, in which the nominal values under current prices corresponding to each particular year are reported in thousands of US dollars. The sectors are defined in terms of

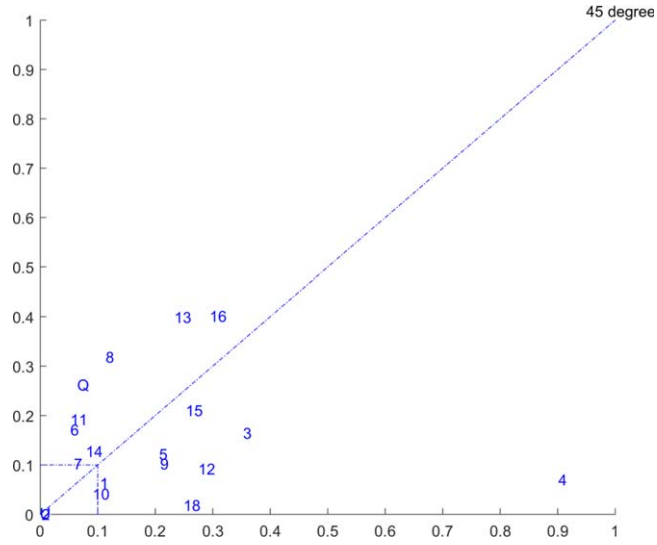

Figure A1. Export (X-axis) and Import (Y-axis) Intensities by Sectors

Notes: The figures are computed from the OECD database along with the CEIC database. Industries located above/below the 45° line mean that they have more/fewer imports than exports.

two-digit ISIC-Rev.3 industry code and total trade in goods for end use in each sector is considered. The available time-series spans from 1992 to 2014 but our analysis mainly focuses on the trade between China and the world during 1992–2008. In order to compute sectoral import penetration ratios, we still seek data from outer sources because OECD database does not provide the value of output at sub-industry level in China. Hence, we resort to gross value of output at a similar sub-industrial level from CEIC's China premium database. It is one of the well-accepted sources since its data are mainly derived from official publications of China; for example, CSY. However, there is a potential measurement problem when we are using the sectoral gross output as a substitute. The reason is that the industry survey only investigates enterprises above the designated size, which is RMB 5 million in annual revenue. As a result, the computed import penetration ratios by combining the two databases may overestimate the true ratios because of the data limitation.

An alternative to address this issue is using the input–output tables provided by the Chinese Input–Output Association. The tables were made every 3–5 years from 1987 and they are regularly published by National Bureau of Statistics of China. The data to be used are limited to the tables of 1997, 2002, 2005, 2007 and 2010 because the information about imports and exports is only available from tables after 1997. The division of manufacturing industries varies from year to year; for example, manufacturing is divided into 73, 72, 17, 81 and 39 sectors in the 5 years, respectively. Even though the information is incomplete, we proceed data concordance and aggregation according to Standard Industriral Classification (SIC) codes of the version 2002 by National Bureau of Statistics. The results summarized in Tables 2 may justify our concern. The values reported in columns (5) and (6) are in general larger than the values in columns (3) and (4). Although the numbers may not be accurate, the industrial ranking based on their import and export intensities are consistent with each other in most of the industry cases. In order to take the

measurement problem into account, we only present the computed import penetration ratios (Table 4) and gains from trade (Table 5) from using the input–output tables. In contrast, we include the long-term pattern of import and export intensities from using the OECD and CEIC databases in Figure 5 as a reference.
Finally, the data related to tariff at the two-digit ISIC-Rev.3 industry level are from the World Integrated Trade Solution (WITS) and the Trade Analysis and Information System (TRAINS) databases. The duty type that we select is the effectively applied rates evaluated by the *ad-valorem* equivalent. We take a simple average over a broad industry classification whenever it includes multiple industries. For example, the tariff rates of the primary sector shown in Figure 3 are derived from a simple average of the tariff rates of the agriculture, forestry and fishing industries.

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Notes

1. A possible reason is that the sectoral output reported by CEIC is derived from different versions of the China Statistical Yearbook (CSY), in which only firms of a large scale are surveyed. However, the trade flows provided by OECD-STAN database are constructed by China's customs and all imported commodities are included. The inconsistency may result in a bias of trade intensities.
2. In a study by Hsieh and Ossa (2015), it is found that China's productivity growth is biased toward import-competing sectors. This is consistent with our arguments that the detrimental effects are likely short-lived.
3. Note that there are other studies also reporting the estimate of sectoral trade elasticities; for example, Broda and Weinstein (2006) and Ossa (2015).
4. The only other industry with comparable large usage of intermediate inputs from import-competing industries is Rubber (30.4%).