Trade-Cost-Adjusted GDP: A Comparison between the US and China[1]

Yuning Gao[a] **Angang Hu**[a] **Zhaochen Li**[a] **Penglong Zhang**[a]

August 2021

Abstract: As emerging economies and developing countries are rapidly growing, accurately analyzing their real economic size is of strong interest. However, comparisons of GDP based on both exchange rate and purchasing power parity methods remain controversial. This paper proposes a new trade cost method to measure China's comparable real GDP. The trade cost between China and the US for each industry is calculated using the structural gravity model and world input-output tables. Industrial value added is adjusted by industrial trade cost and product quality. The aggregation of the adjusted industrial value added yields China's real GDP relative to the US, which we measure from 1995 to 2018. This new method does not need survey data of product prices but obtains consistent results with the PPP method. We find that China's real economic size surpassed that of the US in 2017. Furthermore, China's real GDP growth rate after 2012 has been underestimated, mainly because the service sector has been severely undervalued.

Keywords: trade cost, real GDP, international comparison, PPP.

JEL codes: C82 E01 F14.

[a] School of Public Policy and Management, Tsinghua University, Beijing 100084, China.
[1] Corresponding author: Penglong Zhang. E-mail address: zhangpenglong@tsinghua.edu.cn.

1. Introduction

Emerging markets and developing countries are growing rapidly. According to the World Bank (2020), China's GDP measured by the purchasing power parity (PPP) method was ranked the highest in the world, reaching $19.6 trillion in 2020, after overtaking the US by 0.5% in 2017.[2] It is important to correctly recognize the world economic situation by comparing and analyzing the relative economic size of China and the US.

Current calculation methodologies for estimating the real size of economies remain controversial. The exchange rate method is simple to calculate, and its meaning is straightforward. However, it fails to consider the difference in price levels among countries and can be affected by fluctuations in international trade and financial markets. The results between countries deviate when the foreign exchange rate is experiencing volatility. The assumption of the PPP method is that the items included in the basket are homogenous and representative, which is more applicable in countries that are similar in economic structure. However, severe errors may occur when comparing countries that diverge in economic development levels, especially when comparing among developing countries (World Bank, 2020). Besides these two methods, some studies estimate real GDP comparisons for the US and China using physical indicators, such as electricity usage and trade volume (Fernald et al., 2015; Chen et al., 2019). However, it is challenging for estimates using such statistic-based measurements, which are limited in terms of their economic significance and theoretical basis, to adapt to changes in the economic structure and external shocks. In summary, a certain degree of controversy remains concerning the methodology used and results generated in the existing literature. As a consequence, the real GDP relationship between the US and China remains open to further research.

This paper proposes the trade cost method to compare the economic size of the US and China. This method uses the trade cost to measure the price differences in products and services between the US and China and make adjustments to account for varying product quality between industries to obtain comparable GDP measures for the two countries. The key basis of the trade cost method is using the US's price level to measure the value of China's products and services. According to

[2] The World Bank. Purchasing Power Parities and the Size of World Economies — Results from the 2017 International Comparison Program. 2020.

the law of one price, if the trade cost of open economies is zero, then identical goods in different countries have the same price expressed in the same currency. When the trade cost is non-zero, the price difference in goods can be measured by the trade cost. The basis of the trade cost method is to measure the trade cost for identical products and services between the two countries. By estimating these price differences, measures of comparable economic size can be calculated.

This paper estimates trade costs for products and services among industries between the US and China based on world input-output data. In particular, we determine real economic sizes across industries by adjusting for the different quality of products. This study concludes that China's real GDP, which was 18.6% of that of the US in 1995, surpassed the US's GDP by 1.03 times in 2017. The industry analysis indicates that China's service industry was severely underestimated and that it accounted for 50% and above of China's GDP after 2009. The results of the trade cost method suggest that China's real GDP growth rate is overestimated for the period before 2011 but underestimated for the post-2012 period.

This paper is organized as follows. Section 2 summarizes existing methods of GDP international comparison. We discuss the theoretical model of trade cost adjustment in Section 3 and compute China's trade-cost-adjusted GDP in Section 4. The characteristics and properties of the GDP measure will be discussed in Section 5. Finally, we present conclusions in Section 6.

2. Literature Review

The existing literature comparing real GDP between the US and China can be summarized into three categories: studies using the exchange rate method, the PPP method, and the substitution method. The exchange rate method treats the exchange rate between the US and China as the currency conversion factor by translating China's GDP in the Chinese renminbi into US dollars. This methodology is simple to calculate, but the result deviates from the real GDP by a considerable amount when it does not account for volatility in the exchange rate and price levels.

The PPP method is a widely implemented methodology. The PPP method estimates the currency needed to purchase an identical basket of goods and services in different countries and treats the purchasing power as the conversion factor. The International Comparison Program (ICP), monitored by the World Bank, is the largest and most frequently used statistical project comparing

GDP internationally, incorporating 199 counties and regions. Kravis et al. (1982) provide sufficient data for comparison in the PPP method by adopting the statistical approach to estimating the ICP data to establish the Penn World Table (PWT). Furthermore, Feenstra et al. (2015) improve the PWT by using changes in the prices of consumption, investment, and government expenditure to deflate the nominal growth rate. In 1993, China joined the ICP program, and surveys were conducted in Shanghai and Shenzhen, covering 140 GDP expenditure categories. Later, additional cities were included (seven in 1999 and 11 in 2005), and Beijing's data were surveyed and refreshed in 2009. In 2011, the ICP survey covered the entire country and consisted of 155 GDP categories. The World Bank calculates China's GDP compared to that of the US using the PPP method; in 2014, for the first time, it considered that China's GDP exceeded that of the US (World Bank, 2016). Using the ICP statistics, other studies investigate China's real GDP compared to the US using PPP. The results suggested that China's real GDP would exceed that of the US during 2010–2020 (Feenstra et al., 2013).

The substitution method does not directly measure GDP but analyzes the relationship between external indicators and GDP. This method intentionally selects highly accurate and reliable variables as indicators of economic growth, such as power generation and freight volume. A few studies estimate real GDP between the two countries using statistical relationships among indicators and can be categorized under the substitution method. Fernald et al. (2015) use trade data between China and its partners to examine China's real GDP, building on physical evidence of electricity generation, railway freight volume, raw material supply, and retail volume. They conclude that China's official statistics do reflect China's real economic situation. Using satellite image data, Clark et al. (2018) find that China's real GDP is underestimated compared with the official figure. However, numerous studies argue that the opposite is the case; China's real GDP is lower than the official figures. Young (2003) combines the input-output tables with the price index, employment, capital investment, and other factors in a regression analysis, finding that China's economy is overestimated. Maddison and Wu (2008) propose the upward-bias hypothesis of China's real GDP, which is confirmed by Wu (2013) using the input-output table data. Xu et al. (2015) investigate satellite image data to measure China's real GDP and conclude that the actual value is 1.02% less than the official figure. Chen et al. (2019) show that China's GDP growth rate is overestimated by more than 1% after 2008 when they estimate China's real GDP using physical data indicating the degree to which there is a match between value added and value-added tax, electricity usage, railway freight volume, imports, and exports.

The PPP and substitution methods both have their limitations. The PPP method relies on statistical setting and sampling, and its effect varies between countries. Therefore, different calculation methods may result in significant deviations. The PPP method requires goods that are homogenous and representative. However, different countries vary in their economic development status, resulting in significant divergence in goods purchased (Maddison, 2009). The substitution method relies on a statistical relationship when constructing an index between indicators. Thus, the method is inadequate from the perspective of economic theory and economic significance. Moreover, relationships that depend on historical data are fragile when considering structural economic change and external shocks, especially for developing countries. When adopting methods such as the relationship between a structural equation model and real GDP, the measurement may be adversely affected by insufficient sample size and weak micro-foundations (Dell' Anno, 2007; Buehn et al., 2009).

This paper proposes the trade cost method, measuring products and services to determine the difference in price levels between the US and China and then adjusting to ensure comparable prices. Trade costs can be directly or indirectly calculated by including the costs outside the marginal cost of production under the process when delivering to users. Direct measurement involves collecting data to determine the observable cost and then using this to calculate a proxy variable of trade cost. Transaction and insurance costs are measured using ratios based on the cost, insurance, and freight price or the free onboard price (Hummels, 2007); the policy cost, incorporating tax and technical barriers (Head and Mayer, 2000; Chen, 2004); the information costs, when searching cost are higher in differentiated products trade (Rauch, 1999); and the time cost, when different products experience different requirements depending on timeliness, or when willingness to pay varies based on time (Hummels, 2013).

Trade cost is widely used in various applications, which can be divided into three broad categories, as follows. (1) Trade cost is used in studies where it is a significant part of the trade issue, affecting trading volume, trading structure, and trading categories. Baier and Bergstrand

(2001) conduct an empirical analysis of the influence of trade cost on international trade in 16 OECD countries. They find that there is a 25% increase in trade and an 8% decrease in transportation costs as a result of reduced tariffs. Thus, trade cost is part of comparative advantage and systematically influences the trading structure (Milner and McGowan, 2013). (2) At the micro level, trade cost affects firms' behavior and productivity. A decrease in trade cost would increase labor productivity, investment in innovation and encourage the use of more advanced technology in firms (Lileeva and Trefler, 2010). Bernard et al. (2006) examined a reduction in trade cost that would lead to a favorable increase in firms' productivity using US manufacturing data. The mechanism includes the price of intermediate goods, firms' entry and exit, and resource reallocation. Amiti and Konings (2007) conduct empirical research on manufacturing and find that a reduction in trade costs, such as a decrease in tariffs, would increase competence in importing products. Thus, domestic firms would prefer to learn, diversify, and improve the quality of their products. (3) At the macro level, trade cost affects economic development. Greenaway et al. (2002) use the dynamic panel approach and find that a decrease in trade cost benefits economic development. More specifically, it follows a J-curve, with an initial reduction followed by a rise. Jacks et al. (2011) use data from 130 countries between 1870 and 2000 and find that the trading boom before the First World War was due to a reduction in trade cost, while the trading boom after the Second World War was a result of an increase in production. The trade depression between the two world wars was the result of the increase in the trade cost.

When considering trade cost, the direct measurement method is difficult to use when solving problems involving unobservable factors. Therefore, the indirect measurement method is used to estimate trade cost by calculating the difference between the actual trade and the baseline model (Anderson and van Wincoop, 2003; Zhang, 2020). Jacks et al. (2008) construct a multi-country general equilibrium model of differentiated product trade using a gravity model and calculate the long-term change in trade cost. Chen and Novy (2011) extend the gravity model to a bilateral trade model, allowing for exogenous industry and providing a micro-level basis. They find that the main factors that influence trade cost are technical barriers to trade, transportation costs, and product weights. Novy (2013) proposes a modified gravity model, using the relationship between domestic and international trade as the trade cost. The study uses time-varying observable data to calculate trade costs comprehensively. Anderson and van Wincoop (2004) estimate trade cost in different categories and conclude that the average trade cost in industrialized countries is around 170%, including 21% for transportation cost, 44% for marginal cost due to trade barriers, and 55% for retail cost. Arvis et al. (2016) study the trade and production data of 167 countries from 1996 to 2010. They discover that the trade cost is significantly higher in low-income countries. The main influencing factors include regional trade agreements, connectivity of maritime transport, and trade facilitation. Indirect measurement has an advantage over direct measurement because the latter only accounts for a portion of the trade cost. In theory, the indirect method can calculate the entire trade cost, enabling more practical calculations of country and year level (Gervais, 2019).

3. Theoretical Model

The existing literature reaches different conclusions in comparing GDP between the US and China, with studies claiming both overestimation and underestimation. Problems with the existing studies include that they heavily rely on the accuracy of survey data that consists of micro-level prices, the models used are too complicated to apply accurately, the assumptions of the prediction methods are too strong, or the studies focus heavily on manufacturing while neglecting the importance of the service industry, for example.

This article proposes the trade cost method to adjust price levels according to the trade cost. It uses price levels among different US industries as the baseline to measure China's real GDP. Like the PPP production method, this method involves calculating price, output, and value in different industries and then measuring China's real GDP compared to the US. Comparable prices are not collected from surveys but from calculating trade costs between China and the US. The core of the trade cost method is to measure China's output across industries according to the US's price level.[3]

The central assumption of the trade cost method is the law of one price in the case of zero transaction fees and free trade. Thus, identical goods would be sold elsewhere for the same price

[3] Traditional international trade theory suggests that the economy is divided into tradable and non-tradeable sectors, with products generally considered tradeable, and services non-tradable. However, with the development of and progress in technology, nearly all service industries are involved in international trade. In general, therefore, any product and service are considered tradeable with differentiated trade costs.

expressed in the same currency. If price differences exist among countries, international trade will occur until the price difference is eliminated, while trade ceases when equilibrium is reached in the commodity market. Therefore, the key variable in the trade cost method is the measurement of the trade cost of identical products or services between the two countries.

An important prerequisite of the law of one price is that goods of identical quality are required; the corresponding goods and services must be comparable between the two countries. Thus, if China's product quality was commonly lower than that of the US, directly using the US's price would overestimate China's GDP. To correct this potential estimation bias, we use the product quality index from Feenstra and Romalis (2014) to adjust the trade cost. Therefore, a necessary correction in the trade cost method is the quality ratio when comparing amounts of identical products and services.

3.1 Trade Cost

According to the structural gravity model proposed by Anderson and van Wincoop (2003), this paper uses the domestic and bilateral trade of China and the US to calculate the trade cost of every industry in each year. This method estimates the price difference between the two economies and then adjusts China's value added and real GDP according to the US's price level.

Based on the gravity model, the total value of products among k industries from country i exports to country j is

$$x_{ij}^{k} = \frac{y_i^k e_j^k}{y^k}\left(\frac{t_{ij}^k}{P_j^k \Pi_i^k}\right)^{1-\sigma}, \quad (1)$$

and the total value of products among k industries importing to country i from country j is

$$x_{ji}^{k} = \frac{y_j^k e_i^k}{y^k}\left(\frac{t_{ji}^k}{P_i^k \Pi_j^k}\right)^{1-\sigma}. \quad (2)$$

In each industry k, y is total income, e is the total expenditure, and t is the bilateral trade cost. After multiplying the two equations, we obtain

$$x_{ij}^{k} x_{ji}^{k} = \frac{y_i^k y_j^k e_i^k e_j^k}{y^k y^k}\left(\frac{t_{ij}^k t_{ji}^k}{P_i^k P_j^k \Pi_i^k \Pi_j^k}\right)^{1-\sigma}. \qquad (3)$$

The domestic trade volume can also be expressed by the gravity model. For example, the domestic trade volume for country i industry k is

$$x_{ii}^k = \frac{y_i^k e_i^k}{y^k}\left(\frac{t_{ii}^k}{P_i^k \Pi_i^k}\right)^{1-\sigma}. \quad (4)$$

Within the equation, t is the trade cost in domestic trade for industry k. With a simple transformation, we obtain

$$\left(P_i^k \Pi_i^k\right)^{1-\sigma} = \frac{y_i^k e_i^k}{y^k x_{ii}^k}\left(t_{ii}^k\right)^{1-\sigma}. \quad (5)$$

Therefore, trading volumes between the two countries can be expressed as the product function of two domestic trading volumes and the geometric mean of average trade cost. The relationship depends on the elasticity of substitution across different products

$$x_{ij}^k x_{ji}^k = x_{ii}^k x_{jj}^k \left(\frac{t_{ij}^k t_{ji}^k}{t_{ii}^k t_{jj}^k}\right)^{1-\sigma}. \quad (6)$$

Based on Chen and Novy (2011), macro-level data are used to obtain the industry trade cost

$$\tau_{ij}^k = \left(\frac{t_{ij}^k t_{ji}^k}{t_{ii}^k t_{jj}^k}\right)^{1/2} = \left(\frac{x_{ii}^k x_{jj}^k}{x_{ij}^k x_{ji}^k}\right)^{\frac{1}{2(\sigma-1)}}. \quad (7)$$

The average trade cost in a particular industry among two countries can be measured by the ratio between bilateral trading volume in this industry and domestic trading volume. The trade cost measured by this method is an indirect measurement. It includes the observable trade cost (transportation cost and tariffs) and the magnitude of unobservable trading barriers (environmental standards and protectionism). Therefore, using the structural gravity model with the trade cost method, we can obtain data and a simple calculation method.

China's GDP measured by the US's price is

$$GDP = \sum_{k=1}^{K} p_{US}^k c^k = \sum_{k=1}^{K} \tau_{US}^k p_{CN}^k c^k, \quad (8)$$

where p is price, c is quantity, and all variables are specific variables in industry k. The product of price and quantity equals the total value in the industry and, therefore, we have

$$GDP = \sum_{k=1}^{K} \tau_{US}^k y^k. \quad (9)$$

Therefore, China's trade-cost-adjusted GDP equals the aggregate industrial value added adjusted by industrial trade cost.

3.2 Product Quality

Feenstra and Romalis (2014) measure product quality according to each unit's value, estimating the product quality index from 1984 of 185 countries. We use the same method to measure the product's quantity and adjust each industry's value added each year, excluding the price difference caused by product quality.[4] In this way, value added is successively adjusted by trade cost and product quality. China's GDP measured by the US's price level thus is

$$GDP = \sum_{k=1}^{K} \tau_{US}^{k} \, q_{US}^{k} y^{k}, \qquad (10)$$

where q is the relative quality of corresponding goods between China and the US. Therefore, the trade-cost-adjusted GDP of China equals the aggregate industrial value added adjusted by industrial trade cost, as well as the quality difference.

4. Construction of Trade-cost-adjusted GDP

4.1 Data

The World Input-Output Database (WIOD) is used to calculate China and the US's value added in each industry and each year.[5] It includes the agriculture sector, 15 industries in the manufacturing sector, and 19 industries in the service sector. The sample period ranges from 1995 to 2018, with 1995–2011 data from the 2013 version of WIOD, 2012–2018 data from the Asian Development Bank Multi Regional Input Output data. In the existing literature, WIOD is used to study the value structure of the product (Johnson, 2014), productivity (Schwörer, 2013), changes in industries (Foster-McGregor, 2013), the global value chain (Baldwin and Lopez-Gonzalez, 2015), and policy impacts (Ward et al., 2019).

Among the three sectors, the tertiary industries are the central pillar of the trade between China and the US. The gap between China's secondary and tertiary industries is narrow, whereas the tertiary sector dominates in the US. This indicates that the US has entered the postindustrial era, whereas China has just passed the industrialization phase. China's value added in manufacturing surpassed that of the US when the US experienced deindustrialization. The

[4] There is no quality index on the service industry among countries calculated in Feenstra and Romalis (2014). Thus, we use the average of the quality index from manufacturing industries for the service industry.

[5] The 2016 version includes data from 43 countries and 56 industries for 2000–2014. The 2013 version includes 40 countries and 35 industries for the period 1995–2011. This major focus of this study is the 2013 version.

difference in service value added between the two countries is significant. The US focuses on leasing and commercial services, real estate, wholesale, retail, and the financial industry, whereas China emphasizes the financial, wholesale, and retail industries.

4.2 Trade Cost

Figure 1 illustrates trade costs among manufacturing industries between the US and China calculated based on equation (7) with value added and trading data in 2011.[6] The average trade cost is 1.82; thus, the cost of products manufactured in the US is 82% higher than similar products from China. The trade cost generated from the gravity model is an indirect measurement. Therefore, the trade cost figure is inferred backward from the trading volume, including both the entire observable trade cost and unobservable trading barriers. Electronic products have the lowest trade cost, whereas petrochemical products rank the highest. Furthermore, Figure 1 indicates that the trade costs in the agriculture and mining industries are 2.03 and 2.48, respectively, higher than the trade cost in the manufacturing industry.

Figure 2 illustrates trade costs among different service industries. The average trading cost is 3.17. On average, the service cost in the US is 217% higher than in China. The airline industry has the lowest trade cost, and the retail industry has the highest.

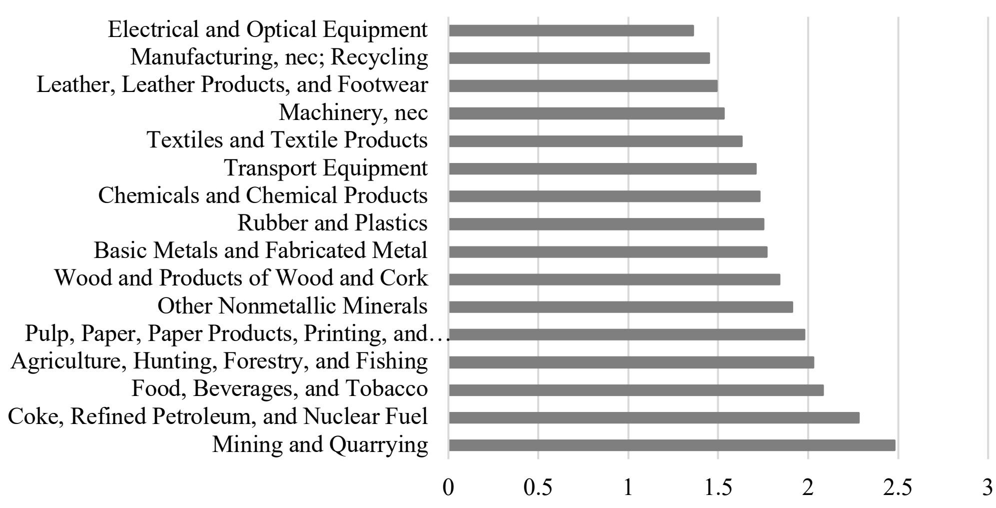

Figure 1. Trade Costs in the Manufacturing Industry

[6] The latest trading data finish after fiscal year 2014. Given the limitations in the trading data, the trade costs for 2015–2017 are based on the result for 2014.

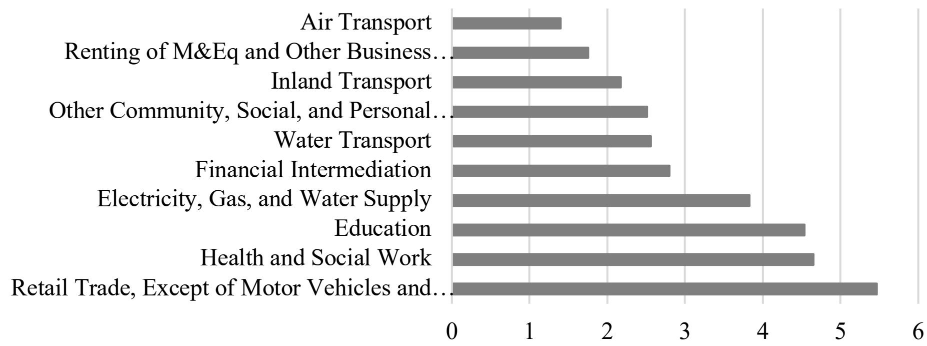

Figure 2. Trade Costs in the Service Industry

4.3 Product Quality

Figure 3 uses value added and trading data from 2011 to calculate the product quality ratio among different manufacturing industries between the US and China. The average is 0.64, which indicates that, on average, the quality of products is 64% that of the US's products. The unit price of products manufactured on average in China is 36% lower than that produced in the US. The relative quality index is less than 1, indicating that China's product quality is lower in all industries than in the US. Nonmetallic minerals products from China ranked the lowest in relative quality, only 36% of those products in the US. The quality of China's coke, refined petroleum and nuclear fuel product is closest to the US, higher than 90%. For agriculture, Figure 3 shows that the magnitude of relative quality is 64%.

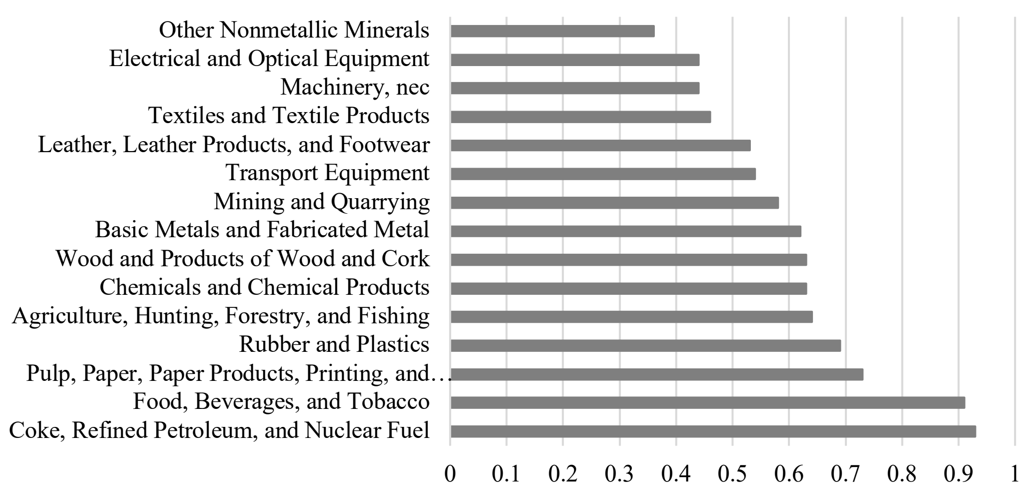

Figure 3. Relative Product Quality in the Manufacturing Industry

4.4 Real GDP

After measuring trade cost and product quality, we determine an adjustment factor with two variables. Then, China's real GDP is aggregated and made comparable to the US by measuring it using the US's price level.

Table 1 reports the main results of the trade cost method from 1995 to 2018. On average, the trade cost adjustment factor is 2.77. Thus, the price of similar products is 177% higher in the US than in China. The relative quality factor is 0.63, implying that the quality of products manufactured in China is 63% of the US's product quality. Therefore, combining the two factors, we can obtain an adjustment factor of 1.75 for value added. When comparing different years within the full analysis period, we find that the highest trade cost was 3.17 in 1997. After China entered the WTO, its trade cost continually decreased, reaching 2.51 in 2013.

As the value added varies among industries, we first need to adjust each industry to make them comparable. The fourth column provides the GDP calculated by the trade cost method. To ensure comparability with existing studies, we selected the most frequently used methods, the exchange rate and PPP methods, to calculate GDP in the same period. After conducting the comparison, the findings are as follows.

First, GDP calculated by the trade cost method is larger than the result given by the exchange rate method. The trade cost method is based on the exchange rate method, with adjustments for trade cost according to the GDP of each industry. As trade cost is greater than 1, the adjustment direction is positive. Furthermore, product quality is used in the adjustment. Hence, it can be seen that the GDP resulting from the trade cost method is larger than that from the exchange rate method.

Second, GDP calculated by the trade cost method is smaller than using the PPP method before 2014. Like the PPP method, the trade cost method measures price, output, and value using the US's price level and the output of the comparable real GDP. The comparable price level is not generated from surveys but from calculating the trade cost and adjusting the value added in each industry. This method eliminates the limitations of surveys on price samples under the PPP method and overcomes the low comparability of products and services among different countries. In most cases, the relative price calculated by the trade cost method is lower than the result generated by the PPP method.

In typical situations, the GDP calculated by the trade cost method falls between the GDP calculated by the exchange rate and PPP methods, avoiding the former underestimation and the latter. The outcomes of the trade cost method are in line with widespread expectations and intuition. The trade cost method has a comprehensive theoretical basis based on the structural gravity model and the law of one price. Moreover, its calculations are simple, and data are available, using common macroeconomic data such as industry value added and trade volume. Overall, based on the exchange rate and PPP methods, the trade cost method involves adjustments in relative price and product quality, which provide additional progress besides the existing methods for comparing real GDP.

Table 1. GDP Comparison of China and the US

	China-US		China's GDP by the method of			
Year	Trade Cost	Product Quality	Trade Cost (trillion US$)	Exchange Rate (trillion US$)	PPP (trillion US$)	US's GDP (trillion US$)
1995	3.100	0.656	1.36	0.73	2.24	7.33
1996	3.160	0.666	1.69	0.86	2.51	7.75
1997	3.168	0.646	1.84	0.95	2.79	8.24
1998	3.157	0.655	2.03	1.02	3.04	8.69
1999	3.104	0.634	2.05	1.08	3.32	9.24
2000	3.037	0.657	2.35	1.20	3.69	9.83
2001	2.960	0.652	2.55	1.32	4.08	10.17
2002	2.861	0.669	2.80	1.45	4.53	10.52
2003	2.797	0.655	2.97	1.64	5.07	11.01
2004	2.809	0.639	3.43	1.93	5.74	11.73
2005	2.829	0.635	4.14	2.26	6.59	12.50
2006	2.811	0.619	4.82	2.71	7.65	13.25
2007	2.755	0.623	6.07	3.50	8.98	13.91
2008	2.659	0.610	7.36	4.52	10.03	14.22
2009	2.612	0.624	8.41	4.98	11.06	13.97
2010	2.551	0.616	9.67	5.93	12.38	14.37
2011	2.542	0.616	11.85	7.30	13.84	14.93
2012	2.515	0.616	13.41	8.32	15.12	15.91
2013	2.512	0.616	15.19	9.38	16.19	16.41
2014	2.512	0.616	16.75	10.28	17.06	17.08
2015	2.512	0.616	18.11	11.06	17.72	18.22
2016	2.512	0.616	18.39	11.19	18.55	18.71
2017	2.512	0.616	20.15	12.29	19.62	19.49
2018	2.512	0.616	22.64	13.67	21.41	20.54

5. Discussion

5.1 Trend

Figure 4 shows GDP for the US and China calculated using the exchange rate and the trade cost methods. Table 2 summarizes the relative GDP for China and the US under the different calculation methods. We find that when measured by the trade cost method, China's GDP was 18.6% of the US's GDP in 1995. By 2017, China had surpassed the US as a factor of 1.03 times, which increased slightly to 1.1 times in 2018.

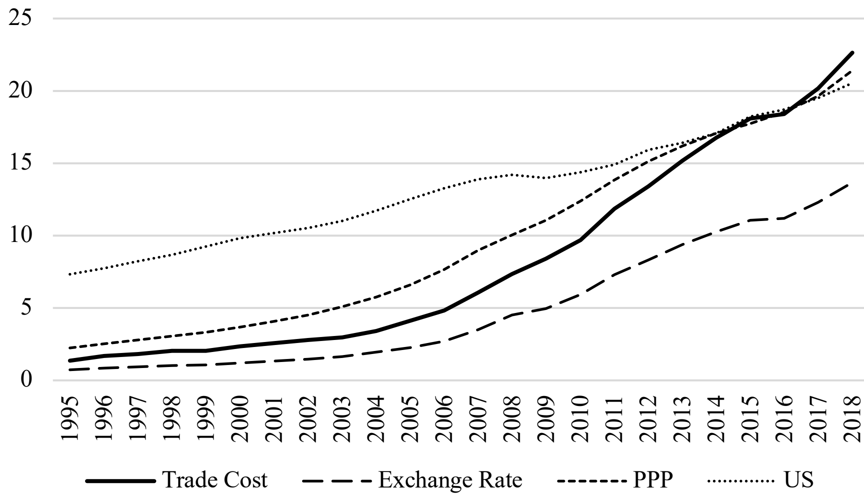

Figure 4. GDP of China and the US

Table 2. China's GDP Relative to the US

Year	Trade Cost	Exchange Rate	PPP
1995	18.6%	9.9%	29.4%
1996	21.9%	11.0%	31.1%
1997	22.3%	11.6%	32.5%
1998	23.4%	11.7%	33.6%
1999	22.1%	11.7%	34.5%
2000	23.9%	12.2%	36.0%
2001	25.1%	13.0%	38.6%
2002	26.6%	13.8%	41.4%
2003	26.9%	14.9%	44.3%
2004	29.2%	16.5%	47.0%
2005	33.1%	18.1%	50.5%

2006	36.4%	20.5%	55.4%
2007	43.6%	25.1%	62.1%
2008	51.8%	31.8%	68.2%
2009	60.2%	35.7%	76.5%
2010	67.2%	41.3%	82.6%
2011	79.4%	48.9%	89.1%
2012	84.3%	52.3%	93.4%
2013	92.6%	57.2%	96.4%
2014	98.1%	60.2%	97.4%
2015	99.4%	60.7%	97.3%
2016	98.3%	59.8%	99.2%
2017	103.4%	63.1%	100.7%
2018	110.2%	66.6%	104.2%

Based on the results of the trade cost method, we can separate the growth of China's GDP into four phases:

(1) Stage of falling behind: 1995–2000

Toward the end of the past century, China's GDP measured by the trade cost method was relatively low compared with the US, measuring only 18.6% of the US's GDP in 1995 and 23.9% in 2000. The exchange rate method provides even lower figures, of only 9.9% and 12.2%, respectively. Due to gaps and shortages in the stocks of capital, human capital, production technology, and other sectors, China's real GDP was far behind the US. Using the PPP method, GDP is 36% of the US's GDP, 1.5 times as the results given by the trade cost method (23.9%). The PPP method is much criticized because it overestimates the economic situation in developing countries, especially when China joined the WTO when global marketization was only moderate. The difference in products between the two countries was enormous, and, thus, the PPP method had limited applicability. In contrast, the result given by the trade cost method can reflect the real gaps in the economic level over the last century more objectively.

(2) Stage of increasing: 2001–2008

After China joined the WTO, it entered a period of rapid growth. This was also a period of favorable growth in the US period. Measured by the trade cost method, China's GDP increased from 25.1% of the US's GDP in 2001 to 51.8% in 2008. Notably, using the exchange rate method, China's GDP reached 31.8% of the US's GDP. With the high growth rate in trade and rapidly growing investment in infrastructure construction, China's economic development narrowed the gap between it and the US.

(3) Stage of catching up: 2009–2016

After the global financial crisis in 2008, the US economy and the major European economies experienced negative growth. Even after the crisis, those economies remain in an adverse situation, with growth rates stagnating. Conversely, China's economy continues to experience robust growth. In this environment, China's economic power has been rising swiftly compared with that of the US. Calculated by the trade cost method, China's GDP increased from 60.2% of the US's level in 2009 to 98.3% in 2016, almost identical to the US. Using the exchange rate method, China's GDP was only 59.8% of the US's level in 2016, but this method underestimates China's GDP significantly and overestimates the gap between the US and China.

(4) Stage of exceeding: 2017 onward

In 2017, China's GDP measured by the trade cost method reached $20.2 trillion, almost 1.03 times the US's level of $19.5 trillion. Thus, China's GDP in 2017 was 3% higher than the US's GDP. Measured by the PPP method, China's GDP exceeded the US's GDP in 2017 by 0.7%, reaching $19.62 trillion. The relative GDP measured by both methods exceeds 1, even though it experienced a different pattern in a different period. As a result, we show that the relationship between China's GDP and the US's GDP reversed in 2017, as China surpassed the US and became the largest economy.

Using the trade cost method, China's GDP reached 22.6 trillion in 2018, 1.1 times the US's level of 20.5 trillion. Thus, China's GDP was 10% higher than that of the US. We cannot calculate 2019 GDP for China using the trade cost method because value-added data for 2019 has not yet been published. However, we can estimate the magnitude of relative GDP between the two countries in 2019 using officially published economic growth data. In 2019, China's GDP growth rate was 6.1%, whereas that of the US was 2.3%. Given the relative magnitude of 1.1 in 2018, we can infer that China's GDP relative to the US was 1.14 in 2019. Thus, China's GDP was 14% higher than that of the US; not only has it surpassed the US, but the gap between them continues to grow.

5.2 Growth Rate

Table 3 reports China's real GDP growth rate between 1995 and 2018 using the trade cost method. Furthermore, we select the actual GDP growth data released by the National Bureau of Statistics to provide a comparison. Using the trade cost method, China's GDP growth rate converges with the rate measured by the exchange rate method between 1995 and 2005. As shown in Figure 5, from 2006 to 2011, China's GDP growth rate measured by the trade cost method is significantly lower than that calculated by the exchange rate method. For instance, in 2007, the amount calculated by the trade cost method is 11.88%, 2.35% lower than the 14.23% calculated using the exchange rate method. Conversely, after 2012, China's GDP growth rate measured by the trade cost method is significantly higher than that measured by the exchange rate method. For example, the calculated rates for 2015 are 9.16% using the trade cost method and 6.91% (2.24% less) using the exchange rate method. In 2017, the corresponding rates are 7.11% and 6.76%, respectively, with a 0.35% difference. Both methods yield a similar growth rate in 2018.

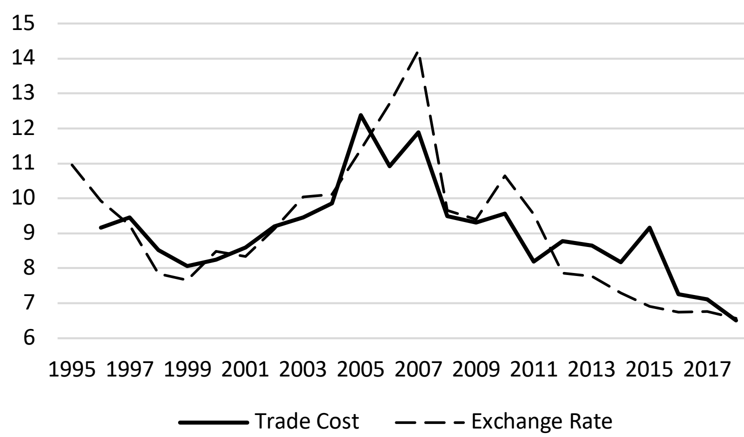

Figure 5. Growth of China's Real GDP

Table 3. Growth of China's Real GDP

Year	Trade Cost	Exchange Rate
1996	9.16	9.93
1997	9.45	9.23
1998	8.52	7.84
1999	8.07	7.67
2000	8.24	8.49
2001	8.60	8.34

2002	9.19	9.13
2003	9.45	10.04
2004	9.85	10.11
2005	12.38	11.40
2006	10.91	12.72
2007	11.88	14.23
2008	9.50	9.65
2009	9.31	9.40
2010	9.56	10.64
2011	8.20	9.55
2012	8.78	7.86
2013	8.65	7.77
2014	8.17	7.30
2015	9.16	6.91
2016	7.26	6.74
2017	7.11	6.76
2018	6.51	6.57

5.3 Industry Structure

Table 4 reports China's tertiary (service) sector as a percentage of GDP using the trade cost method from 1995 to 2018. To ensure comparability with other studies, we choose the most commonly used exchange rate method and calculate GDP for China's service industry in the same period. As shown in Figure 6, using the exchange rate method, China's service industry accounts for 35.1% of the total GDP. In 2015, it exceeded 50% for the first time (measured at 50.4%). Using the trade cost method, China's service industry accounted for 38.3% of total GDP in 1995, growing to 54.5% in 2015. GDP in the service industry exceeded 50% in 2009. Therefore, under the traditional calculation method, value added in the service industry is significantly underestimated due to relatively lower wages and price levels in China than in the US.

The tertiary sector is severely underestimated, and therefore it is necessary to further investigate each industry in the tertiary sector. Figure 7 illustrates the value added in each industry in 2014 and the adjusted results using the trade cost method. We find that GDP is greatly underestimated in high value-added industries, such as education, public service, and the financial industry.

It has long been a complex problem in GDP calculations that the statistical accuracy of data for the service industry lags behind that for the manufacturing industry. The National Bureau of

Statistics of China has made new attempts in this regard. In 2018, the new economy's value added (new forms of business, new technologies, and new business models) was measured at 12,957.8 billion CNY for 2017, accounting for 15.7% of total GDP. The 14.1% growth rate calculated under the current price level is 2.9% higher than the current GDP growth rate over the same period. The value-added service industry in the new economy is 7,668.9 billion CNY, accounting for 52.8% of GDP and reflecting the importance of the service industry.

Table 4. China's Service Industry as a Proportion of GDP

Year	Trade Cost	Exchange Rate
1995	38.3%	35.1%
1996	38.1%	34.8%
1997	40.0%	36.5%
1998	42.4%	38.7%
1999	44.4%	40.5%
2000	45.6%	41.7%
2001	47.3%	43.2%
2002	48.7%	44.4%
2003	48.7%	44.2%
2004	48.2%	44.0%
2005	49.7%	44.2%
2006	49.5%	43.8%
2007	49.6%	44.8%
2008	49.6%	44.7%
2009	50.9%	46.1%
2010	50.9%	46.0%
2011	50.7%	45.9%
2012	50.5%	46.3%
2013	51.6%	47.5%
2014	52.7%	48.6%
2015	54.5%	50.4%
2016	55.3%	51.1%
2017	55.4%	51.0%
2018	56.5%	52.3%

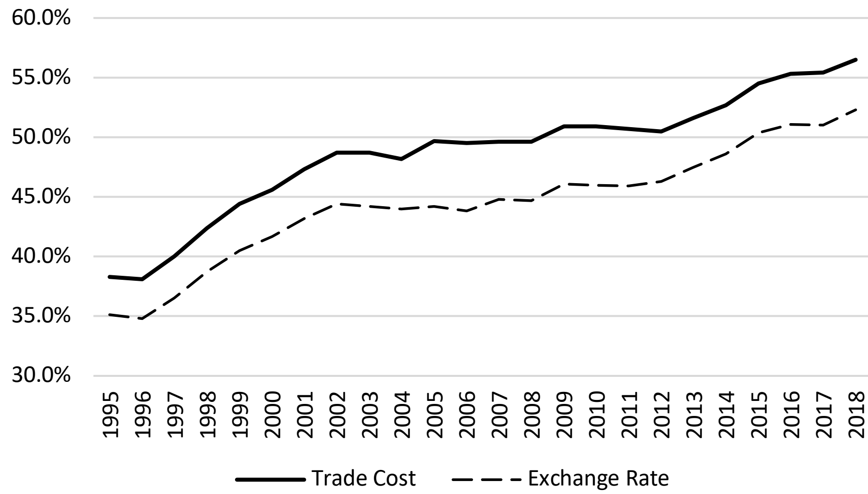

Figure 6. China's Service Industry as a Proportion of GDP

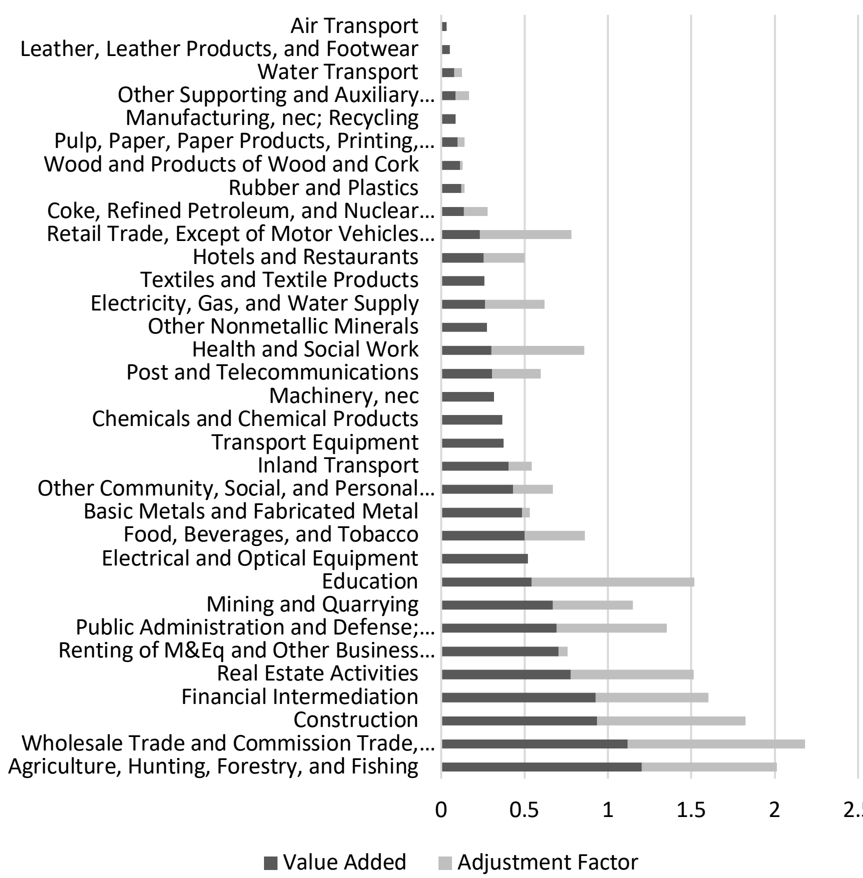

Figure 7. Value Added and Adjustment Factor of Each Industry (2014)

6. Conclusion

The trade cost method proposed in this study calculates the cost of trade among products and services in each industry between the US and China using input-output tables. On this basis, we provide measures of the comparable economic size of industries in the US and China adjusted for differences in product quality.

The trade cost method introduced in this article improves the existing measurement methods in terms of feasibility, robustness, and comprehensiveness. This approach, based on using macroeconomic data to calculate trade cost, is relatively simple to calculate. Trade cost calculated by the structural gravity model includes observable and unobservable costs. The method has theoretical foundations in the law of one price. We test its robustness by comparing the calculated results and find that they are similar to those using the PPP method in the ICP program. Moreover, the trade cost method is comprehensive because it allows measurement among different industries and historical periods. In the calculation results, we show that China has become the largest economy globally and discuss the meaning of the results in the context of changing trends, the growth rate, and the industrial structure.

This study provides a new direction for future research in comparing GDP internationally, especially comparing emerging economies and developed economies. The existing literature has not reached a consensus on GDP comparisons given the limitations of different methods. The trade cost method validates the existing methods by combining economic theory and realistic data for future development.

References

Amiti, M. & Konings, J., 2007, Trade Liberalization, Intermediate Inputs, and Productivity: Evidence from Indonesia, American Economic Review, 97(5), pp. 1611-1638.

Anderson, J. E. & Van Wincoop, E., 2003, Gravity with Gravitas: A Solution to the Border Puzzle, American Economic Review, 93(1), pp. 170-192.

Anderson, J. E. & Van Wincoop, E., 2004, Trade Costs, Journal of Economic Literature, 42(3), pp. 691-751.

Arvis, J. F., Duval, Y., Shepherd, B., Utoktham, C. & Raj, A., 2016, Trade Costs in the Developing World: 1996-2010, World Trade Review, 15(3), pp. 451-474.

Baier, S. L. & Bergstrand, J. H., 2001, The Growth of World Trade: Tariffs, Transport Costs, and Income Similarity, Journal of International Economics, 53(1), pp. 1-27.

Baldwin, R. & Lopez-Gonzalez, J., 2015, Supply-Chain Trade: A Portrait of Global Patterns and Several Testable Hypotheses, World Economy, 38(11), pp. 1682-1721.

Bernard, A. B., Jensen, J. B. & Schott, P. K., 2006, Trade Costs, Firms and Productivity, Journal of Monetary Economics, 53(5), pp. 917-937.

Buehn, A., Karmann, A. & Schneider, F., 2009, Shadow Economy, and Do-It-Yourself Activities: The German Case, Journal of Institutional and Theoretical Economics, 165(4), pp. 701-722.

Chen, N., 2004, Intra-National Versus International Trade in the European Union: Why Do National Borders Matter?, Journal of International Economics, 63(1), pp. 93-118.

Chen, N. & Novy, D., 2011, Gravity, Trade Integration, and Heterogeneity across Industries, Journal of International Economics, 85(2), pp. 206-221.

Chen, W., Chen, X., Hsieh, C. T. & Song, Z., 2019, A Forensic Examination of China's National Accounts, NBER Working Papers.

Clark, H. L., Pinkovskiy, M. & Salaimartin, X., 2018, China's GDP Growth May Be Understated, China Economic Review, 62, 101243.

Dell' Anno, R., 2007, The Shadow Economy in Portugal: An Analysis with the Mimic Approach, Journal of Applied Economics, 10(2), pp. 253-277.

Feenstra, R. C., Inklaar, R. & Timmer, M. P., 2015, The Next Generation of the Penn World Table, American Economic Review, 105(10), pp. 3150-3182.

Feenstra, R. C., Ma, H., Peter Neary, J. & Rao, D. S. P., 2013, Who Shrunk China? Puzzles in the Measurement of Real GDP, Economic Journal, 123(573), pp. 1100-1129.

Feenstra, R. C. & Romalis, J., 2014, International Prices and Endogenous Quality, Quarterly Journal of Economics, 129(2), pp. 477-527.

Fernald, J., Hsu, E., & Spiegel, M. M., 2015, Is China Fudging its Figures? Evidence from Trading Partner Data. BOFIT Discussion Papers.

Foster-Mcgregor, N., Stehrer, R. & De Vries, G. J., 2013, Offshoring and the Skill Structure of Labour Demand, Review of World Economics, 149(4), pp. 631-662.

Gervais, A., 2019, Indirect Measures of Trade Costs: Limitations and Caveats, Economics Letters, 176, pp. 96-102.

Greenaway, D., Morgan, W. & Wright, P., 2002, Trade Liberalisation and Growth in Developing Countries, Journal of Development Economics, 67(1), pp. 229-244.

Head, K. & Mayer, T., 2000, Non-Europe: The Magnitude and Causes of Market Fragmentation in the EU,-Review of World Economics, 136(2), pp. 284-314.

Hummels, D., 2007, Transportation Costs and International Trade in the Second Era of Globalization, Journal of Economic Perspectives, 21(3), pp. 131-154.

Hummels, D. L. & Schaur, G., 2013, time as a Trade Barrier, American Economic Review, 103(7), pp. 2935-2959.

Jacks, D. S., Meissner, C. A. & Novy, D., 2008, Trade Costs, 1870-2000, American Economic Review, 98(2), pp. 529-534.

Jacks, D. S., Meissner, C. M. & Novy, D., 2011, Trade Booms, Trade Busts, and Trade Costs, Journal of International Economics, 83(2), pp. 185-201.

Johnson, R. C., 2014, Five Facts About Value-Added Exports and Implications for Macroeconomics and Trade Research, Journal of Economic Perspectives, 28(2), pp. 119-142.

Kravis I B, Heston A, & Summers R., 1982, World Product and Income: International Comparisons of Real Gross Product. The World Bank.

Lileeva, A. & Trefler, D., 2010, Improved Access to Foreign Markets Raises Plant-Level Productivity. For Some Plants, Quarterly Journal of Economics, 125(3), pp. 1051-1099.

Maddison, A., 2009, Measuring the Economic Performance of Transition Economies: Some Lessons from Chinese Experience, Review of Income and Wealth, 55, pp. 423-441.

Maddison, A. & Wu, H. X., 2008, Measuring China's Economic Performance, World Economics, 9(2), pp. 13-44.

Milner, C. & Mcgowan, D., 2013, Trade Costs and Trade Composition, Economic Inquiry, 51(3), pp. 1886-1902.

Novy, D., 2013, Gravity Redux: Measuring International Trade Costs with Panel Data, Economic Inquiry, 51(1), pp. 101-121.

Rauch, J. E., 1999, Networks Versus Markets in International Trade, Journal of International Economics, 48(1), pp. 7-35.

Schwörer, T., 2013, Offshoring, Domestic Outsourcing, and Productivity: Evidence for a Number of European Countries, Review of World Economics, 149(1), pp. 131-149.

Ward, H., Steckel, J. C. & Jakob, M., 2019, How Global Climate Policy Could Affect Competitiveness, Energy Economics, 84: 104549.

World Bank, 2016, World Development Indicators 2016 [M]. Washington, DC: World Bank.

World Bank, 2020, Purchasing Power Parities and the Size of World Economies: Results from the 2017 International Comparison Program. https://www.worldbank.org/en/programs/icp#7.

Wu, H. X., 2013, How Fast has Chinese Industry Grown? – The upward Bias Hypothesis Revisited, China Economic Journal, 6(2-3), pp. 80-102.

Xu, K., Chen, F. & Liu, X., 2015, The Truth of China Economic Growth: Evidence from Global Night-Time Light Data, Economic Research Journal, (9), pp. 17-29.

Young, A., 2003, Gold into Base Metals: Productivity Growth in the People's Republic of China During the Reform Period, Journal of Political Economy, 111(6), pp. 1220-1261.

Zhang, P., 2020, Home-biased Gravity: The Role of Migrant Tastes in International Trade, World Development, 129, 104863.

Appendix

Table A1. List of Industries

ID	Industry
1	Agriculture
2	Mining and Quarrying
3	Food， Beverages and Tobacco
4	Textiles
5	Leather and Footwear
6	Wood
7	Paper， Printing and Publishing
8	Coke and Refined Petroleum
9	Chemicals
10	Rubber and Plastics
11	Other Nonmetallic Mineral
12	Basic Metals
13	Machinery
14	Electrical and Optical Equipment
15	Transport Equipment
16	Recycling
17	Electricity， Gas and Water Supply
18	Construction
20	Wholesale
21	Retail
22	Hotels and Restaurants
23	Inland Transport
24	Water Transport
25	Air Transport
26	Other Transport Activities
27	Post and Telecommunications
28	Financial Intermediation
29	Real Estate
30	Renting of MandEq
31	Public Admin and Defence
32	Education
33	Health and Social Work
34	Other Personal Services

Table A2. Trade Cost: Manufacturing Industry

year	tc1	tc2	tc3	tc4	tc5	tc6	tc7	tc8	tc9	tc10	tc11	tc12	tc13	tc14	tc15	tc16
1995	2.14	2.55	2.26	1.73	1.56	1.96	2.06	2.49	1.99	2	2.66	2.03	1.83	1.57	2.1	1.82
1996	2.27	2.27	2.29	1.77	1.61	2.03	2.09	2.48	1.95	2.03	2.64	2.06	1.83	1.61	2.08	1.77
1997	2.25	2.2	2.18	1.75	1.6	2.02	2.07	2.35	1.85	2.01	2.12	2.11	1.78	1.59	2.07	1.63
1998	2.35	2.29	2.21	1.76	1.61	2.09	2.1	2.42	1.87	2.04	2.15	2.09	1.81	1.59	2.04	1.62
1999	2.43	2.59	2.24	1.76	1.59	2.09	2.1	2.34	1.88	2.03	2.16	2.09	1.79	1.57	2.06	1.62
2000	2.35	2.55	2.24	1.73	1.56	2.1	2.08	2.39	1.89	1.99	2.11	2.04	1.75	1.54	2.02	1.56
2001	2.39	2.67	2.26	1.72	1.55	2.09	2.09	2.43	1.9	2	2.08	2.06	1.71	1.51	1.98	1.52
2002	2.37	2.63	2.24	1.69	1.51	2.01	2.05	2.42	1.87	1.99	2.14	2.04	1.68	1.48	2.02	1.46
2003	2.24	2.72	2.2	1.66	1.5	1.98	2.04	2.4	1.83	1.95	2.09	1.97	1.65	1.44	1.95	1.43
2004	2.17	2.52	2.2	1.61	1.46	1.94	2.03	2.36	1.79	1.87	2.04	1.93	1.57	1.37	1.89	1.37
2005	2.19	2.48	2.2	1.6	1.46	1.93	2.04	2.45	1.78	1.84	2.05	1.89	1.57	1.35	1.84	1.37
2006	2.16	2.61	2.15	1.6	1.46	1.9	2.02	2.47	1.79	1.81	2.04	1.85	1.57	1.35	1.78	1.41
2007	2.16	2.6	2.14	1.61	1.48	1.9	2.02	2.5	1.78	1.81	2.07	1.83	1.54	1.35	1.76	1.38
2008	2.1	2.88	2.13	1.63	1.48	1.93	2.01	2.36	1.75	1.81	2.04	1.81	1.55	1.37	1.76	1.39
2009	2.06	2.71	2.17	1.64	1.46	1.96	2.03	2.57	1.79	1.82	2.04	1.86	1.57	1.38	1.78	1.44
2010	2.04	2.59	2.16	1.62	1.48	1.88	1.99	2.4	1.75	1.77	1.96	1.82	1.54	1.35	1.74	1.42
2011	2.03	2.48	2.08	1.63	1.49	1.84	1.98	2.28	1.73	1.75	1.91	1.77	1.53	1.36	1.71	1.45
Mean	2.22	2.55	2.2	1.68	1.52	1.98	2.05	2.42	1.84	1.91	2.14	1.96	1.66	1.46	1.92	1.51
St.d.	0.12	0.17	0.05	0.06	0.05	0.08	0.04	0.07	0.07	0.1	0.2	0.11	0.11	0.1	0.14	0.14

Table A3. Trade Cost: Service Industry

year	tc17	tc21	tc23	tc24	tc25	tc28	tc30	tc32	tc33	tc34
1995	3.51	9.08	3.29	2.87	1.72	3.74	2.61	5.37	5.95	2.78
1996	3.87	9.08	3.7	2.9	1.75	3.93	2.75	5.37	6.96	2.94
1997	3.89	9.08	4.02	2.89	1.74	3.97	2.86	5.37	6.33	3.07
1998	3.86	7.7	3.89	2.86	1.75	4.03	2.39	5.37	5.92	2.9
1999	3.85	7.5	3.47	2.71	1.79	4.57	2.4	5.37	5.85	2.92
2000	3.97	7.13	3.45	2.69	1.73	3.91	2.33	5.37	5.87	2.67
2001	3.59	6.07	2.99	2.49	1.68	4.23	2.29	5.37	4.86	2.64
2002	3.52	5.54	2.71	2.4	1.63	3.5	2.18	5.37	5.74	2.53
2003	3.61	5.58	2.74	2.65	1.65	3.97	2.14	5.2	5.74	2.62
2004	3.65	6.17	2.7	2.65	1.58	3.93	2.25	6.64	5.74	2.67
2005	3.63	6.08	2.63	2.69	1.52	3.41	2.17	6.75	5.74	2.63
2006	3.66	6	2.55	2.64	1.48	3.62	1.97	5.11	5.74	2.65
2007	3.71	5.48	2.53	2.76	1.47	3.58	1.96	5.03	5.74	2.6
2008	3.72	5.5	2.48	2.81	1.45	3	1.81	4.05	4.34	2.49
2009	4.01	5.47	2.33	2.56	1.48	3.22	1.85	4.22	4.78	2.61
2010	3.87	5.47	2.17	2.56	1.4	2.81	1.76	4.42	4.6	2.51
2011	3.83	5.47	2.17	2.56	1.4	2.8	1.75	4.54	4.65	2.51

Mean	3.75	6.61	2.93	2.69	1.6	3.66	2.2	5.23	5.56	2.69
St.d.	0.15	1.34	0.58	0.14	0.13	0.48	0.32	0.69	0.67	0.17

Table A4. Product Quality

year	qa1	qa2	qa3	qa4	qa5	qa6	qa7	qa8	qa9	qa10	qa11	qa12	qa13	qa14	qa15
1995	0.69	0.47	0.43	0.64	0.6	0.87	0.9	0.74	0.55	0.81	0.41	0.7	0.59	0.67	0.76
1996	0.9	0.5	0.61	0.67	0.76	0.92	0.78	0.78	0.56	0.87	0.43	0.59	0.75	0.41	0.62
1997	0.59	0.44	0.57	0.82	0.51	0.9	0.67	0.6	0.59	0.84	0.36	0.57	0.4	0.32	0.92
1998	0.74	0.65	0.47	0.69	0.6	0.86	0.94	0.95	0.63	0.82	0.43	0.64	0.65	0.39	0.75
1999	0.5	0.5	0.49	0.51	0.6	0.94	0.92	0.87	0.63	0.86	0.39	0.5	0.5	0.46	0.54
2000	0.9	0.66	0.61	0.62	0.6	0.85	0.83	0.83	0.42	0.8	0.53	0.58	0.61	0.7	0.58
2001	0.69	0.69	0.73	0.68	0.68	0.72	0.83	0.81	0.43	0.81	0.72	0.54	0.44	0.64	0.61
2002	0.48	0.92	0.64	0.53	0.57	0.7	0.87	0.89	0.3	0.76	0.69	0.56	0.63	0.67	0.74
2003	0.48	0.49	0.63	0.74	0.65	0.68	0.79	0.85	0.41	0.73	0.66	0.57	0.66	0.57	0.59
2004	0.69	0.67	0.64	0.56	0.54	0.64	0.78	0.91	0.43	0.72	0.44	0.56	0.67	0.57	0.49
2005	0.97	0.6	0.62	0.52	0.62	0.71	0.73	0.78	0.43	0.71	0.42	0.54	0.68	0.74	0.66
2006	0.47	0.6	0.78	0.49	0.54	0.66	0.68	0.76	0.46	0.63	0.34	0.53	0.53	0.73	0.64
2007	0.7	0.61	0.74	0.52	0.55	0.73	0.66	0.71	0.49	0.68	0.35	0.65	0.55	0.68	0.85
2008	0.62	0.73	0.65	0.55	0.59	0.71	0.7	0.8	0.51	0.69	0.38	0.6	0.41	0.53	0.67
2009	1.01	0.84	0.89	0.5	0.54	0.64	0.7	0.88	0.38	0.64	0.36	0.6	0.45	0.56	0.49
2010	0.83	0.65	0.68	0.44	0.54	0.62	0.72	0.9	0.49	0.68	0.34	0.62	0.37	0.62	0.62
2011	0.64	0.58	0.91	0.46	0.53	0.63	0.73	0.93	0.63	0.69	0.36	0.62	0.44	0.44	0.54
Mean	0.7	0.62	0.65	0.58	0.59	0.75	0.78	0.82	0.49	0.75	0.45	0.59	0.55	0.57	0.65
St.d.	0.17	0.13	0.13	0.1	0.06	0.11	0.09	0.09	0.09	0.08	0.12	0.05	0.11	0.12	0.12

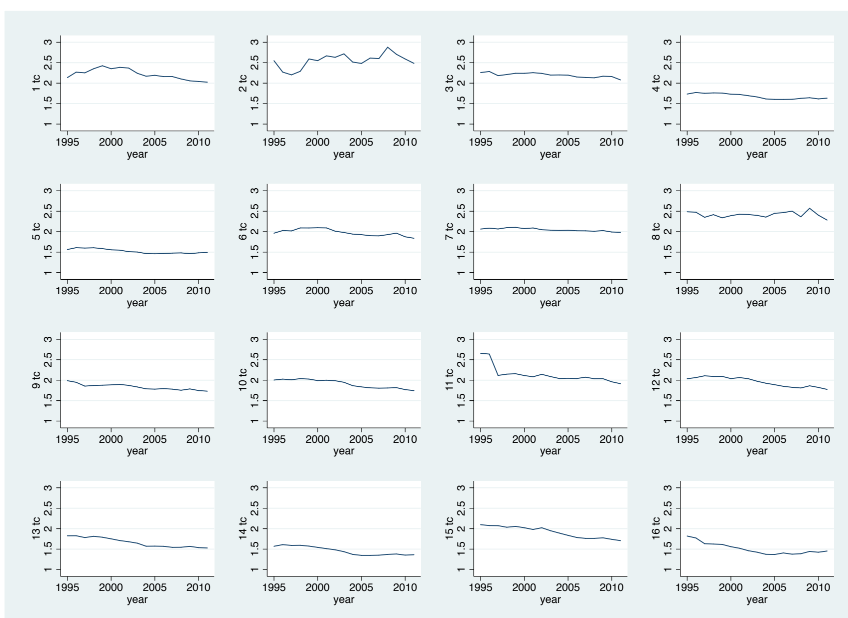

Figure A1. Trade Cost: Manufacturing Industry

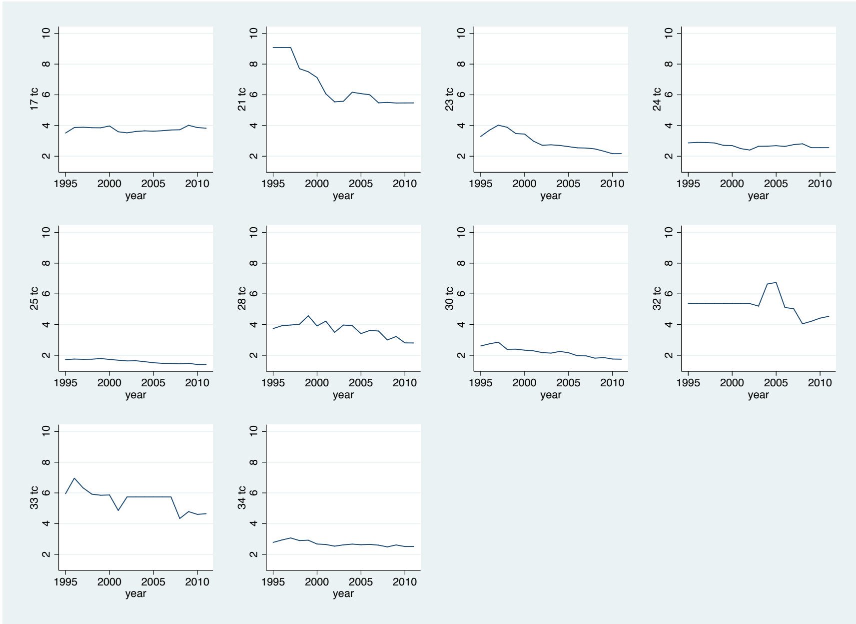

Figure A2. Trade Cost: Service Industry

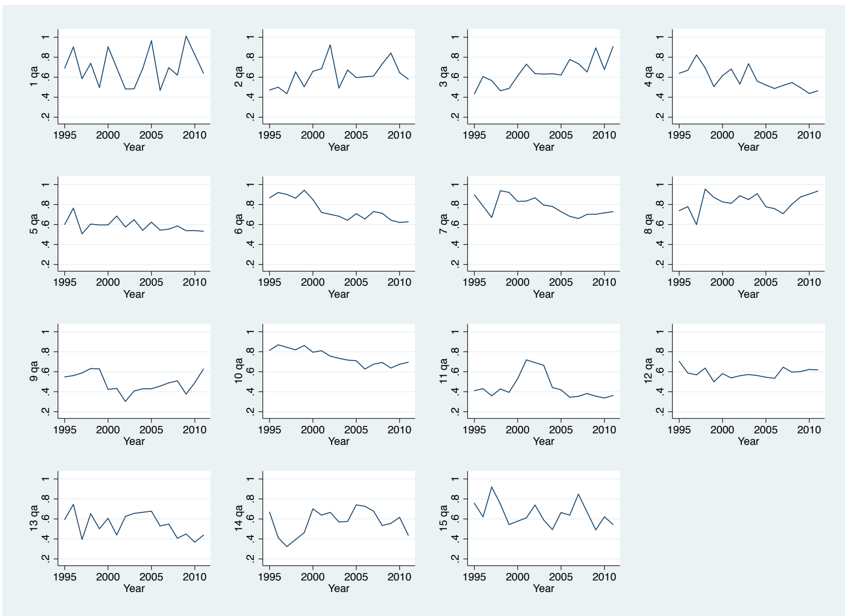

Figure A3. Product Quality