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Deflating China's Nominal GDP Growth: 2004-2018

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Abstract

In this paper, we use both the expenditure approach and the value added approach with double deflation to deflate China's nominal GDP over a fifteen year period (2004-2018). The resulting estimates of China's real GDP growth during the period show significantly more fluctuation than the official figures indicate, and inflation as measured by the official implicit GDP deflator is generally overestimated during the booming years but underestimated during the down years. In particular, we show that the extent of China's growth slowdown in recent years may have been more severe than the official figures suggest.

Key Words: Chinese statistics; GDP growth; GDP deflator

JEL Classification: E01, O53, P24

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1. Introduction

China's economic growth has fallen sharply in recent years, with its official GDP growth rate dropping from 10.6% in 2010 to 6.1% in 2019, the lowest rate since 1990. The average annual GDP growth during 2012-2019 fell to 7.0% from 10.8% during 2003-2011. In spite of the slowdown, a 6-7% annual GDP growth is one of the fastest in the world. This still relatively fast growth is incongruous with stagnant growth at the sectoral or micro levels. For example, in 2015, the year when there was a heated debate about the accuracy of China's GDP figures (see below), the official GDP growth rate was 6.9%, barely missing the 7% target. In the meantime, electricity generation grew only 0.3%, freight transportation grew 0.2%, while both export growth and import growth were negative at -0.8% and -1.8% respectively.[4] Moreover, China's GDP growth rate in recent years has been incredibly stable to become suspicious (Kerola, 2019).

The discrepancies between the headline GDP growth figures and the micro level data have led many economists and general public to question the accuracy of China's official GDP statistics. Some twenty years ago, Professor Thomas Rawski (2001) wrote a famous article questioning the credibility of China's GDP data for 1998, the year of the Asian financial crisis, pointing out that the official GDP growth rate of 7.8% did not match electricity usage and other relevant data. The article sparked great media interest and debate. In fact, China's current Premier Li Keqiang did not trust the official GDP

[4] All figures cited here are from China Statistical Yearbook, 2016.

data very much when he was the party secretary in Liaoning Province, opting instead to trust the figures on power generation, railway freight, and bank loans. *The Economist* even created a "Keqiang Index" using these three indicators to measure the health of China's macroeconomy (*The Economist,* 2010).

GDP growth has always been a key performance measure in China for local government officials, who may have a strong incentive to exaggerate GDP figures, especially when their local economies are not doing well (Young, 2003). In a well publicized article, Chen, Chen, Hsieh and Song (2019) show that China's local statistics increasingly misrepresented the true GDP numbers after 2008, but there was no corresponding adjustment made by the National Bureau of Statistics (NBS). These authors use data on value added taxes, which are more difficult to falsify, to re-estimate local and national GDP, finding that China's nominal GDP growth during 2010-2016 may have been overestimated by close to 2 percentage points on average.

Local over-reporting is only one reason for the inaccuracy of China's GDP growth figures. Economists familiar with Chinese statistics have long recognized that underestimating inflation is another important reason for the overestimation of Chinese GDP growth (Ren, 1995; Keidel, 2001; Wu, 2002; Young, 2003; Maddison, 2007; Maddison and Wu, 2008; Brandt and Zhu, 2010; Holz, 2014). Real GDP growth is equal to nominal GDP growth minus inflation. Thus, if inflation is underestimated, real GDP growth will be overestimated. In this paper, instead of trying to evaluate or correct the bias in local GDP figures, we follow the spirit of Young (2003) and try to quantify biases introduced by the NBS's statistical methods in the measurement of real GDP in more recent years.

Again, we use year 2015 as an example. Based on the official figures of nominal GDP for 2014 and 2015, we can calculate that year 2015's nominal GDP growth rate was exactly 7%, so the implicit GDP price deflator, a more comprehensive measure of inflation than the consumer price index (CPI), was -0.1% for 2015, a slight deflation. But that seems inconsonant with the rising prices for consumer goods and services (CPI up by 1.4% in 2015) and the more rapid rise in housing prices (up by 9.1%).

In June 2015, a *Financial Times* article (Johnson 2015), citing an analysis by Capital Economics, an economic research consultancy, reported that China overstated real GDP growth by 1 to 2 percentage points because inflation was understated. As a result, China's economy only grew by 5-6% in the 12 months to the first quarter of 2015, rather than the officially announced 7%. The Capital Economics analysts pointed to a technical error in how the NBS estimated the GDP deflator, rather than any deliberate misrepresentation, for the overestimation of GDP growth. Specifically, they argued that the NBS did not take the fast-falling import prices during 2014-15 into full account, leading to underestimation of the implicit price deflators for most sectors of the economy. Citing the same source, however, *The Economist* criticized that China has a history of "ironing out the ruffles" in its growth figures, which are too smooth to be true.

Partly in defense of NBS, Sang (2015) argued that falling import prices did not have as big an effect as 1 to 2 percentage points on China's real GDP growth rate in 2014 as claimed by Capital Economics but a mere 0.5 percentage point, a figure the author derived by using a rough back-of-envelop calculation. More importantly, Sang pointed out that the real problem was that China used the single-deflation method instead of the double-inflation method to derive its real GDP. When the input price index is lower than the output price index, the single-deflation method underestimates inflation and overestimates real growth (see Sections 4 & 5 for more details).

In response to these criticisms in the media, Dr. Xu Xianchun, then-deputy director of the NBS in charge of the national accounts division and also a widely respected expert, published an article defending the official GDP figures (both the deflator and the growth rates) and the NBS's methodology for deriving these figures (Xu, 2015). His basic argument is that the questioning of China's GDP statistics is due to misunderstandings or confusions by some researchers and lay people about the difference between GDP deflator and other inflation measures such as CPI and PPI and about the official method for deriving real GDP and the implicit deflator. Particularly, he rejected the suggestion that lower import prices and the method of single deflation had contributed to overstatement of real growth.

Although the issue was heatedly debated in the press, we have not since then seen any academic study that effectively responds to Xu Xianchun's defense of the official GDP figures and the official method. In this paper, we first use the expenditure approach as well as the value added approach to deflate China's nominal GDP and derive an estimate of the GDP deflator for the year of 2015. We make use of publically available official data and follow the official methodology as closely as possible, but also modify it when appropriate. In particular, we use double deflation in the value added approach instead of the single-deflation approach used by the NBS. Our result shows that in 2015, the GDP deflator was underestimated by 1.5 to 3 percentage points depending on which accounting approach we use, and real GDP growth was overestimated by the same extent. The main reasons were indeed falling import prices and the single deflation method, implying that Xu's defense of the official figures does not hold water.

We then perform the same estimations over a fifteen year period (2004-2018).[5] Our estimates of China's real GDP growth during the period show significantly more fluctuation than the official figures indicate, and inflation as measured by the official implicit GDP deflator is generally overestimated during the booming years but underestimated during the down years. In particular, we show that GDP growth has slowed down more significantly than the official figures have indicated after 2013. Although the average growth rate during the period has not been affected much by a smoothing GDP deflator, the extent of fluctuation in growth has been significantly downplayed. This tendency distorts the cyclical pattern of China's macroeconomic conditions, thus hampering countercyclical policy-making.

A recent paper by Kerola (2019) also attempts to estimate the extent of the overstatement of China's real GDP growth in recent years. The paper uses a regression approach to estimate GDP deflator. It regresses China's official implicit GDP deflator on sectoral price indices for the period before 2014 and then uses the estimated (i.e., fitted) deflator to construct an alternative real GDP growth rate. The author finds that

[5] We choose 2004 as our starting year for several reasons. First, China's first national economic census started in 2004, which significantly improved the quality of GDP accounting. Second, China started to use price indices to deflate nominal values-added and estimate real GDP after 2002. Third, the price index for services was missing during 2001-2003.

true real growth after 2014 was significantly lower and fluctuated more than the official figures. The underlying assumption of Kerola's regression approach is that the official implicit deflator had a stable relationship with sectoral price indices before recent years. Our results show that it is not necessarily the case. In fact, we show that the official implicit GDP deflator was mostly overestimated before 2012, and that it was underestimated from 2012, not 2014. Kerola's paper also implies that the NBS has manipulated the GDP deflator after but not before 2014. We do not assume that is the case.

Our study is a contribution to a small but important literature on China's GDP statistics (e.g., Wu, 2002; Young, 2003; Maddison and Wu, 2008; Holz, 2014; Zhang and Zhu, 2015; Chen et al., 2019). It complements nicely a recent important study by Chen, Chen, Hsieh and Song (2019) that tries to estimate the degree of overstatement of China's nominal GDP growth in recent years. Combining their results with ours yields a picture of a much more fluctuating GDP growth and a more severe economic downturn in recent years.

The rest of the paper is organized as follows. Section 2 briefly describes and comments on China's official method for estimating real GDP and consequently GDP deflator. In Sections 3 and 4, we use, respectively, the expenditure approach and the value added approach to re-estimate China's real GDP and the implicit deflator for the year of 2015, and in the meantime show the detailed procedure and data for our estimations. Section 5 then presents our estimations for the whole period of 2004-2018. We also combine our estimations with those from Chen et al. (2019) and show that the two studies help to make better sense of each other's results. Section 6 concludes the paper with some remarks on how to improve China's GDP accounting.

2. Methodological Issues in Measuring Real GDP in China

In theory, China's national income and production accounting system is very similar to the ones adopted by many developed economies, but in practice, it is quite different. Before economic reform, China adopted the Soviet-style "Material Product System" (MPS). In 1985, China started to experiment with the Western-style System of National Accounts (SNA), and in 1993, China abandoned the MPS and fully adopted the SNA (Xu, 2009). In the SNA, there are three approaches to measuring both nominal and real GDP: the production approach, the income approach, and the expenditure approach. All three approaches, when used independently to estimate GDP, lead to similar, albeit not identical results due to measurement errors.

Most developed countries use all three approaches to independently estimate GDP, but primarily rely on the expenditure approach. In China, however, the annual and quarterly GDP figures officially released to the press by the NBS are obtained by a combination of the production approach and the income approach (Xu, 2009; NBS, 2010). The primary sector (agriculture, forestry, husbandry, and fishery) relies on the production approach, whereas the secondary sector (mining, manufacturing, utilities, and construction) and tertiary sector (service) rely on the income approach. China also publishes expenditure approach-based GDP figures annually, which, according to Liu, Zhang and Zhu (2016), are not exactly estimated independently in practice. In sum, China employs essentially just one production-cum-income approach to measuring its GDP, which, for convenience, we will call the *value added approach* in this paper.

Compared to many developed countries, China relies a lot more on data drawn directly from enterprise reports and administrative sources, and less on independent surveys. It is a legacy from the old MPS system. This practice was also reflected in the way China measured its real GDP before 2002. As Young (2003) pointed out, most developed countries estimated real GDP by deflating nominal GDP using separate, independently constructed, price indices, but China was different. For the primary and secondary sectors, China used to rely on industrial enterprises and rural units to report both the nominal value of output in current prices and the *real* value of output in constant prices. Constant prices for all products were compiled and published by statistical authorities at national and local levels for a base year, and all reporting units were required to use these prices to calculate a constant-price output value. Dividing the current price ("nominal") output by the constant price ("real") output yielded an implicit deflator. In the case of the secondary sector, this output deflator was then used to deflate the nominal *value added* to derive the real value added. It is called single deflation because it uses a single output price index to deflate value added. In contrast, double deflation was used for the primary sector, for which an implicit price deflator was also calculated for the intermediate input. In the case of the tertiary sector, a combination of single deflation, double deflation and volume extrapolation was used to obtain real value added.

The shortcomings of the above constant price approach to measuring real GDP are obvious. There is an embedded bias towards underestimating inflation and overestimating real growth (Wu, 2000 and 2002; Young, 2003).[6] Compiling thousands of constant prices accurately is no small task, and the NBS only did it twice for 1980 and 1990 during the reform era. Biases can easily arise with regard to which prices to use and how to weigh them in calculating an average constant price for a particular product. Many enterprises, especially new entrants, did not have sufficient expertise or incentives to calculate and report correctly the constant price output values. For new products, which were many for a fast growing economy, current prices had to be used as constant prices, and doing so naturally underestimated inflation.

A number of economists have tried different ways in their attempt to correct these biases. For example, Wu (2002) attempted to use physical quantity and price data of major industrial products to estimate real growth of industrial value added, and found that during the first two decades of reform (1978-1997), the compound annual growth of industrial value added was 8.7%, 3.3 percentage points lower than the official figure. Ren (1995) and Young (2003) followed the internationally standard practice and used relevant price indices to deflate nominal valued added of each economic sector and arrived at alternative estimates of real GDP growth rates. Young found that due to underestimation of inflation, the annual growth in China's non-agricultural economy during 1978-1998 was overstated by 2.5 percentage points, largely in line with Wu's

[6] This approach also tends to exaggerate real GDP growth due to the substitution bias that arises when we use the base year prices to calculate the aggregate constant price value of all products whose weights in the economy may have changed substantially since the base year (Wu, 2000). In particular, the real value of a manufactured product whose relative price has been falling and quantity rising fast will be over-estimated, while the real value of a service product whose relative price has been rising but quantity having changed little will be underestimated. As a result, real growth of the economy as a whole is exaggerated.

finding above.

From 2002, the NBS also began to use the price index method to deflate nominal GDP (Xu, 2009). So during the period 2004-2018 covered by this study, the price-index method was the main method used to obtain China's real GDP. In the case of value added approach to measuring real GDP, single deflation is used for the primary and secondary sectors, and a mixture of methods is used for the tertiary sector. In China's national income and product accounts, the economy is first divided into three broad sectors (primary, secondary and tertiary) as in every other country, and they are the first level industries in the Chinese industry classification system; these are further divided into 17 second level industries, 58 third level industries and 94 fourth level industries (NBS, 2010). The NBS first estimates the nominal value added of each third or fourth level industry, and then aggregates these values into the nominal GDP. Independently constructed output price indices (previous year = 100) are used to deflate the values added of all primary and secondary industries and some tertiary industries to derive the real (constant price) values added of these industries. For some tertiary industries, double deflation and quantity extrapolation are used to obtain real values added. With both nominal and real value added for each industry and for the whole economy, we can compute the implicit price deflator for each industry and for the whole economy, though NBS does not publish these implicit deflators.

Single deflation is a biased estimation of real GDP when the change in output price index is different from that of input price index. Real growth is overestimated when input price rises less than output price and underestimated otherwise. Single deflation has the advantage of requiring much less data, and the sacrifice in precision may be insignificant when input price change can be quickly transmitted to output prices so that the movement of two price series is very similar. However, when the two price series have significant divergence, single deflation can be very misleading. In this paper, we apply the method of double deflation to all three first level industries and re-estimate China's real GDP and the implicit deflator. We make use of the official input-output tables to estimate the values of inputs for each industry and use relevant price indices to deflate these input values. We show that the results are sometimes significantly different from the official figures based primarily on single deflation.

The NBS also uses the expenditure approach to measure both nominal and real GDP. For this purpose, GDP is divided into three first level expenditure components (final consumption, gross capital formation and net exports), which are further divided into 6 second level and 32 third level expenditure components. Price indices (e.g., CPI and fixed-asset investment price index) are constructed for each of these second- and third level components and are then used as deflators to convert nominal expenditures into real (constant price) expenditures. Thus in principle, China should have expenditure approach-based nominal and real GDP figures, but curiously, the NBS only releases the nominal figures. Therefore, we cannot readily compute the expenditure approach-based GDP deflator. Some twenty years ago, Keidel (2001) strongly suspected that China's expenditure figure was adjusted to bring it roughly in line with the official value added figure. The study of Liu, Zhang and Zhu (2016) supported this suspicion. Indeed, it still seems to be the case today. Ever since China started compiling the expenditure accounts in the early 1990s, the difference between the two GDP figures have been within 1% of each other (mostly less than 0.5%). This is maybe why China does not publish GDP growth figure based on expenditure accounts. There is no point of doing so when the expenditure-based GDP is set to be more or less the same as the value added figure.

However, if we suppose the official value added approach-based GDP is reliable, then the expenditure approach-based GDP should also be reliable. What we are not sure about is the composition of the expenditure components. According to Zhang and Zhu (2015), China's household consumption may be underestimated by an amount around 10% of GDP while fixed capital formation overestimated by the same amount. In this paper, we first assume the official nominal expenditure composition is correct, and use the relevant official price indices to deflate all expenditure components, yielding the real GDP by expenditure and the implicit GDP deflator. We then repeat the same procedure using the alternative expenditure composition of GDP proposed by Zhang and Zhu (2015), and we find that the results in the two scenarios are not much different.

3. The Expenditure Approach: The Case of 2015

In this and next section, we use year 2015 as an example to demonstrate the detailed procedure of our re-estimation of China's real GDP and the implicit deflator. We begin with the expenditure approach, which is relatively more straightforward, and then introduce the value added approach with double deflation.

The expenditure approach is internationally more standard. Although in principle, the NBS has a complete manual of methods, procedures and data sources on how to estimate both nominal and real GDP by expenditure, but it releases few details about all three levels of expenditure components and their price indices. Therefore, in our estimation of the real GDP by expenditure, we only work with data at a very aggregate level as shown in Table 1. We follow closely the procedure laid out in the official statistical manual (NBS, 2010), but we also modify the official method when appropriate as we will explain below.

Table 1. Re-estimation of China's Real GDP and Implicit Deflator in 2015: Expenditure Approach

Expenditure components	**Nominal value (bln yuan)**	**Name of price index (deflator)**	**Value of price index (Y2014=100)**	**Real value (bln yuan)**
	a		b	c = a/b*100
Household consumption	265,980	Consumer price index (official)	101.4	262,308
Government consumption				
Compensation of gov't employees	48,216	Wage index for urban non-private sector (constructed by authors)	114.0	42,309
Government purchases	40,495	Consumer price index (official)	101.4	39,936
Fixed asset depreciation	7,576	Price index for fixed asset investment	98.2	7,714
Gross capital formation				
Change of inventories	11,333	Producer price index for industrial products (official)	94.8	11,955
Fixed capital formation				
Construction and installation: residential buildings	43,051	Price index for residential buildings (constructed by authors)	109.1	39,460
Construction and installation: non-residential	165,191	Price index of construction and installation (official)	97.3	169,775
Purchase of equipment and instruments	59,609	Price index of purchase of equipment and instruments	99.3	60,029
Other investment expenses	33,651	Price index for other investment expenses (official)	100.7	33,418
Net exports of goods				
Exports of goods	141,167	Price index of exports of goods (official)	99.0	142,593
Imports of goods	-104,336	Price index of imports of goods (official)	88.4	-118,027
Expenditure-based GDP (excl. net exports of services)	**711,933**	**GDP deflator**	**103.0**	**691,468**

First, we have omitted net exports of services in Table 1. This is because the NBS has no official price index for either exports or imports of services. There is an official consumer price index for service items (publicly available in most years), but the services that are exported or imported are not the same as those consumed domestically. A less important reason for omitting the net exports of services is that the effect of its exclusion on real GDP growth and the implicit deflator would be less than 0.2 percentage point for any reasonable range of price indices, given the fact that the (absolute) value of China's net exports of services has been less than 2% of GDP.

Second, before the 3rd national economic census in 2013, government consumption was divided into only two categories, fixed asset depreciation and the rest, that were deflated by the price index for fixed asset investment and CPI respectively to yield real, constant price values (NBS, 2010). After 2013, according to Xu (2015), the NBS started to divide government consumption into three categories as recommended in the SNA and practiced by developed countries such as the US: compensation of government employees, government fixed asset depreciation (i.e., consumption of fixed capital), and government purchases. The first two categories constitute the value added of the government sector, and the third the intermediate goods and services needed to produce the gross output of the government sector. The flow of funds table compiled by the NBS has data on the government's value added and the compensation of employees. Government purchases equal government consumption minus government's value added, and government fixed asset depreciation equals government value added minus compensation of government employees. We use the growth of the average wage rate of the unban non-private sector to construct a wage index to deflate government employee compensation. As can be seen clearly from Table 1, this wage index is much higher than CPI. In other words, by using a much lower CPI index implicitly to deflate government employee compensation (as part of government consumption other than depreciation), the pre-2013 approach significantly overstated real government consumption expenditures, hence overstating real GDP and its growth and understating implicit GDP deflator. Using CPI to deflate government employee compensation amounts to assuming that the real wage increase is completely due to increase in employee productivity, which is implausible and contrary to the SNA recommendation that no imputation of productivity growth should be made in the non-market sector.[7] This is a criticism raised by Maddison (2007), who argued that China's government sector productivity growth was unusually high due to inadequate deflation. He adjusted China's real growth in the value added of the non-market sector by using the employment data and assuming no productivity growth in the sector.[8] In our estimation, we have also assumed no productivity growth in the government sector, and using the wage index to deflate government employee compensation is similar to using the employment data to calculate real growth.

Third, in the official manual, gross fixed capital formation (GFCF) is divided into seven categories: residential buildings, non-residential buildings, machinery and equipment, land improvement expenditures, mineral exploration fees, computer software, and other investments. However, the NBS has released few details about these investment categories. Therefore, we cannot use them for our estimation of real GFCF. But the NBS publishes investment statistics known as the "total investment in fixed

[7] This is based on the well known fact that wage increase in traditional service sectors is primarily due to the increase in the general wage level resulting from productivity increase in other (especially manufacturing) sectors.
[8] The US Bureau of Economic Analysis (BEA) also uses extrapolation of employment data to estimate real growth of government employee compensations (BEA, 2019, 9-15).

assets (TIFA) in the whole country". TIFA and GFCF are closely related measures of investment, but are conceptually different. According to the NBS (2010), GFCF is estimated primarily from TIFA, but is adjusted by adding and subtracting a few items. However, Liu, Zhang and Zhu (2016) show that these two data series should be very similar based on the official method for estimating GFCF.[9] The NBS divides TIFA into three categories: construction and installation, purchase of equipment and instruments, and other expenses. We also break down GFCF into the same three categories as in TIFA, and we make a simplified but reasonable assumption that the shares of these categories of investment in GFCF are the same as in TIFA, given the fact that GFCF is more or less derived from TIFA. We then use these shares to calculate the nominal values of these three categories of investment in GFCF. There are also corresponding official price indices that can be used as deflators.

Because the NBS also publishes data on total investment in residential buildings, we can further divide construction and installation into two subcategories: residential buildings and the rest (non-residential constructions and structures). In general, China's statistics on investments in both residential and nonresidential buildings and structures are based on costs, not on market prices. The official deflator for construction and installation is also cost-based. This practice may be justifiable in the case of non-residential buildings and structures, most of which are custom built and not transacted on the market, but it is indefensible in the case of residential buildings. Therefore, we

[9] But officially published TIFA and GFCF figures have diverged significantly since 2004. Based on this observation, Liu, Zhang and Zhu (2016) conclude that the official GFCF figures are not really estimated independently according to the published method, but treated more or less as a balancing term to align the expenditure-based GDP and the value added GDP.

construct a price index for residential buildings based on the national average selling prices (per square meter) of new residential buildings as an alternative deflator. This price index is generally (but not always) higher than the official price index of construction and installation during 2004-2018.[10] In 2015, the difference was significant (109.1 versus 97.3).

The last row of Table 1 shows that the implicit GDP deflator for 2015 is 103.0 by our estimation, which is 2.9% higher than the official GDP deflator (100.1) for the year. If our estimation is correct, this means that official GDP growth in 2015 was overestimated by 2.9 percentage points. In other words, the real GDP growth rate may have been only 4% that year rather than the official 6.9%

If we think of the implicit GDP deflator as a measure of inflation for the broad economy, then in 2015, according to the above estimation, China had an inflation rate of 3%, not the official 0.1%. At first glance, this result does not seem to make much sense. In 2015, CPI went up 1.4%, while the price index for fixed asset investment went down 1.8%. That year, final consumption accounted for 52% of GDP and investment (i.e., gross capital formation) 45% of GDP. A simple weighted average would seem to suggest an overall inflation rate below or close to zero. But a weighted average of price indices for consumption and investment only reflect the price level of *gross domestic purchases*, not gross domestic product. The gross domestic purchases price index measures the inflation in the prices of goods and services *purchased* by a country's

[10] For lack of data, we still use the cost-based total investment figure as the expenditure item for residential buildings in GFCF. This figure is in theory smaller than the true expenditure on residential buildings, and using this figure generally overestimates real GFCF (hence GDP growth) as we use the alternative higher-valued price index as the deflator for a smaller figure. This bias actually strengthens our argument that GDP growth has been overestimated in recent years.

residents, hence including imports but excluding exports. On the other hand, the GDP price index, which is essentially the same as GDP deflator, measures the inflation in the prices of final goods and services *produced* in a country, hence including exports but excluding imports.

In other words, to derive the GDP price index (i.e., GDP deflator), we need to add in the effect of exports but subtract the effect of imports from gross domestic purchases price index. Therefore, when the price index of imports is much lower than that of exports as in 2015 (88.5 versus 99.2), the gross domestic purchases price index will be significantly lower than the GDP price index or implicit deflator. In our estimation, the former would be 101.2 whereas the latter was 103.0, a 1.8 percentage point difference, accounting for about two thirds of the difference between our estimated GDP deflator and the official figure. In general, even if the net exports account for just a small fraction of GDP, its impact on the GDP deflator cannot be ignored when the changes in the price levels of exports and imports diverge significantly.[11] Therefore, the critics may be right that the NBS indeed did not take the impact of a sharp import price decline into sufficient account in its estimation of real GDP and implicit deflator for 2015.

4. The Value added Approach: The Case of 2015

The NBS can argue that China's real GDP and implicit deflator are estimated from

[11] The same effect can also be seen in the US economy. In 2015, the US gross domestic purchase price index, a featured inflation by BEA, was 100.3, but GDP deflator was 101, the reason being that import prices went down more than export prices (-7.7% versus -4.9%).

the value added approach, not the expenditure approach, and one should not use the estimation by one approach to prove the estimation by the other approach wrong. However, in principle, the results from both approaches should be broadly similar, and a 2.9 percentage point in real growth is too big a discrepancy to brush away. Perhaps the official approach itself is subject to question. So in this section, we use the value added approach to re-estimate China's real GDP and implicit deflator in 2015. Instead of using the official single deflation method, which uses an output price index to deflate the *value added* of an industry, we use the double deflation method that deflates both output and input of an industry with separate price indices to obtain the real value added. The two methods are equivalent when input and output prices move in perfect sync, but when the input price index is significantly lower than the output price index, as was the case in 2015, single deflation would underestimate inflation and overestimate GDP growth, and vice versa.

Double deflation is theoretically the correct method, but it requires a lot more data than single deflation, demanding also information on the values and prices of all the inputs. Therefore, when data availability is an issue and when the output prices move more or less in line with the input prices, single deflation is the preferred method. But when we look at the Chinese data, the difference between input and output price indices for both industrial and service sectors can be substantial in some years. In particular, service is an important input in industrial production, and industrial products are also important inputs for the service sector, while the price index for industrial products and that for services are significantly different in most years we cover in this study. As for data on inputs, the NBS has compiled the national input-output table every 2-3 years in the past 30 years, and the price indices for inputs in agriculture and industry are also available. What is lacking is a price index for services as an input in the production of goods and services, but the consumer price index for services may be used as a substitute. Hopefully, the discrepancy between the two is quite small.

According to the official manual, the NBS estimates both nominal and real value added of every fourth level industry (more than 90 in total -- see Section 2), but they do not release complete data on their nominal values added and price indices used for deflation. As in the case of the expenditure approach in Section 3, we only work with data at the four sector level as shown in Table 2. We use both single deflation and double deflation to estimate the real GDP and implicit deflator in 2015. The left panel of Table 2 uses each sector's output price index to deflate the nominal value added (i.e., single deflation). In the case of the service sector, there is no official price index for the whole sector. In its place, we use the implicit price deflator of the sector (derived from dividing the nominal index by the real index of value added) as the substitute. The resulting real GDP is 69,053 billion yuan (see the last row in column d), almost identical to the official nominal GDP of 69,025 billion yuan, implying a GDP deflator of 100.0, which is very close to the official GDP deflator of 100.1. This suggests that we can use data at the aggregate four-sector level and the corresponding output price indices in Table 2 to obtain single deflation-based real GDP and the implicit deflator that are consistent with the official figures based on much more detailed data on 90 some finely classified industries.

Table 2. Re-estimation of China's Real GDP and Implicit Deflator in 2015: Value added Approach

Sector	Nominal value added (bln yuan)	Name of output price index (deflator)	Price index (Y2014=100) for single deflation	Real value added - single deflation	Gross out and intermediate input (bln yuan)	Nominal value of output or input (bln yuan)	Name of output or input price index (deflator)	Price index (Y2014=100) for double deflation	Real value of output or input (bln yuan)	Real value added with double deflation (bln yuan)
	a		b	c=a/b*100		d		e	f = d/e*100	g = real output - real inputs
Agriculture	5,777	Producer price index for farm products	101.7	5,681	Gross output	9,833	Producer price index for farm products	101.7	9,668	5,629
					Intermediate input-all	4,055	Price index for means of agricultural production	100.4	4,039	
Industry	23,497	Producer price index for industrial products	94.8	24,786	Gross output	115,442	Producer price index for industrial products	94.8	121,774	25,137
					Intermediate input-agriculture, industry & construction	76,802	Purchasing price index for industrial producers	93.9	81,792	
					Intermediate input-services	15,142	CPI for services	102.0	14,845	
Construction	4,776	Price index of construction and installation	97.3	4,909	Gross output	20,722	Price index of construction and installation	97.3	21,297	4,940
					Intermediate input-agriculture	189	Price index for means of agricultural production	100.4	189	
					Intermediate input-industry	11,058	Producer price index for industrial products	95.9	11,531	
					Intermediate input-construction	665	Price index of construction and installation	97.3	683	
					Intermediate input-services	4,033	CPI for services	102.0	3,954	
Services	34,974	Implicit price deflator for service sector	103.9	33,678	Gross output	65,840	Implicit price deflator for service sector	103.9	63,399	32,248
					Intermediate input-agriculture	638	Producer price index for farm products	101.7	628	
					Intermediate input-industry	416	Price index of construction and installation	97.3	428	
					Intermediate input-construction	11,676	Producer price index for industrial products	94.8	12,316	
					Intermediate input-services	18,135	CPI for services	102.0	17,779	
GDP	**69,025**	**GDP deflator**	**100.0**	**69,053**			**GDP deflator**	**101.6**		**67,954**

In the right panel of Table 2, we employ the double deflation method, using an output price index to deflate each sector's gross output and the relevant input price indices to deflate the values of intermediate inputs from the four sectors, which are obtained by using the official input-output tables that are updated by the NBS every 2 to 3 years. Note, however, that for the agricultural sector, to which we also include forestry, husbandry and fishery, the intermediate inputs from all four sectors are lumped into one. This is because the "price index for means of agricultural production" is a comprehensive index that covers all intermediate inputs. Similarly, in the case of the industrial sector, we lump inputs from the three sectors of agriculture, industry and construction into one because the "purchasing price index for industrial producers" is also a comprehensive index that covers all intermediate inputs except for services. As mentioned above, there are no official price indices for deflating both the value of services as output and the value of services as input. But the official CPI has a component index for services, which is publicly available for most but not all years. In this paper, we use this CPI for services as the price index to deflate the value of service inputs in each sector except for agriculture. We believe it to be a more appropriate choice than the implicit price deflator for the whole service sector because the latter also covers non-market services, especially those from the public sector, that are not counted as intermediate inputs in the production of goods and services.

The results from the double deflation method are clearly different from those derived under single deflation. The real GDP under double deflation is 67,954 billion yuan (see column g in the last row of Table 2), implying a GDP deflator of 101.6 that is 1.6% higher than the GDP deflator under single deflation and 1.5% higher than the official figure. In other words, the single deflation method may have understated GDP inflation and overstated real growth by about 1.5 percentage points. Comparing column c and column g, we can see that single deflation slightly understates real value added in the industrial and construction sectors, but significantly overstates real value added in the service sector. The source of the overstatement is that the price indices of inputs (especially industrial products) for the service sector are significantly lower than the output price index. In fact, were the producer price index for industrial products the same as the output price index we use for the service sector (i.e., 103.9), the difference in estimated real GDP and implicit deflator between double deflation and single deflation would completely disappear.

To summarize, we have found that in 2015, the GDP deflator may have been underestimated and real growth overestimated by 1.5 to 3 percentage points depending on which accounting approach we use. A discrepancy of this magnitude may not be very noteworthy when the economy is growing at a double digit rate, but is consequential when growth is close to a low single-digit rate. A 1.5 to 3 percentage point error in real growth rate distorts our perception of the macroeconomic condition significantly and may lead to inadequate or even wrongheaded policies.

5. Re-estimated GDP Deflator and Growth over 2004-2018

We use the same methods as in Sections 3 and 4 to estimate China's GDP deflator for the 15 year period from 2004 to 2018. Table 3 presents our estimates of GDP deflator by both the expenditure approach and the value added approach together with the official figures for comparison. All price indices we use for our estimation that are not drawn directly from *China Statistical Yearbooks* are put in Table A1 in the Appendix. The four-sector input-output ratios we use to compute values of intermediate inputs for all years from 2004 to 2018 are assembled in Table A2 in the Appendix.

Table 3. Estimated vs Official GDP Deflator: 2004-18

Year	Estimate of GDP deflator by expenditure approach	Alternative estimate of GDP deflator by expenditure approach	Estimate of GDP deflator by value added approach	Official GDP deflator
	A	B	C	D
2004	104.3	104.5	103.8	107.0
2005	103.2	103.1	99.4	103.9
2006	102.4	102.4	100.6	103.9
2007	105.5	105.5		107.8
2008	104.4	104.7		107.8
2009	102.4	102.0	104.1	99.9
2010	101.9	102.2	103.8	107.0
2011	105.4	105.4	106.7	108.2
2012	103.4	103.2	104.7	102.4
2013	102.5	102.4	104.4	102.2
2014	102.1	102.0	102.9	100.8
2015	103.0	102.5	101.6	100.1
2016	101.9	101.9	102.0	101.1
2017	103.3	103.3	102.8	104.1
2018	103.9	103.9	102.5	102.1

Note: All original data for 2004-2017 are drawn from *China Statistical Yearbook 2018*. The data for 2018 are drawn from *China Statistical Yearbook 2019*.

In Table 3, we list two series of estimates of GDP deflator by the expenditure approach in columns A and B. In column A, we use the official GDP composition by expenditures. In column B, we use an alternative composition of GDP as proposed by Zhang and Zhu (2015) by adding 10% of GDP to household consumption expenditures and also subtracting the same percentage from fixed capital formation. The resulting two series of estimates of GDP deflator are very similar, and therefore we will use the estimates in column A for the rest of the paper.

Figure 1. Estimated vs Official GDP Deflator: 2004-18

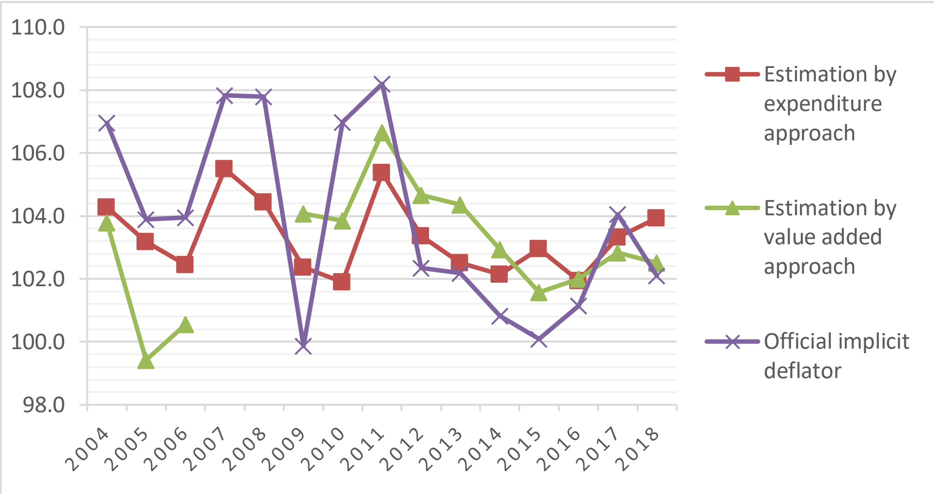
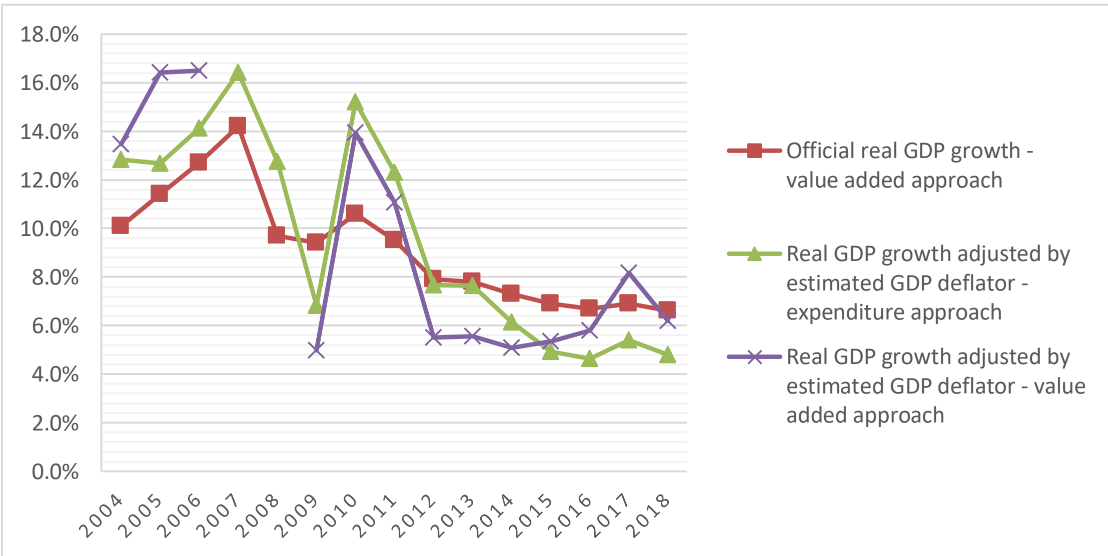


Figure 2. Real GDP Growth during 2004-18: Adjusted vs Official



We plot the numbers from columns A, C and D in Table 3 in a line graph in Figure 1. Note that there is no value added approach-based estimate for the years of 2007 and

2008 because no data is available on CPI for services for those two years. It is quite clear that before 2012, the official GDP deflator was higher than our estimations by both approaches except for 2009, but since 2012, it has been mostly higher than our estimations except for 2017. If so, then real GDP growth was generally underestimated before 2012, but has been overstated in most years since 2012.

Table 4. Real GDP Growth: Adjusted versus Official

Year	Official nominal GDP growth- expenditure approach	Official nominal GDP growth - value added approach	Official real GDP growth - value added approach	Real GDP growth adjusted by estimated GDP deflator - expenditure approach	Real GDP growth adjusted by estimated GDP deflator - value added approach
2004	17.7%	17.8%	10.1%	12.8%	13.5%
2005	16.3%	15.7%	11.4%	12.7%	16.4%
2006	16.9%	17.1%	12.7%	14.1%	16.5%
2007	22.8%	23.1%	14.2%	16.4%	
2008	17.8%	18.2%	9.7%	12.8%	
2009	9.4%	9.3%	9.4%	6.8%	5.0%
2010	17.4%	18.3%	10.6%	15.2%	13.9%
2011	18.3%	18.5%	9.5%	12.3%	11.1%
2012	11.3%	10.4%	7.9%	7.7%	5.5%
2013	10.3%	10.2%	7.8%	7.6%	5.6%
2014	8.4%	8.2%	7.3%	6.1%	5.1%
2015	8.0%	7.0%	6.9%	4.9%	5.3%
2016	6.7%	7.9%	6.7%	4.6%	5.8%
2017	8.9%	11.2%	6.9%	5.4%	8.2%
2018	8.9%	8.8%	6.6%	4.8%	6.2%
Average 04-18	13.3%	13.5%	9.2%	9.6%	9.1%
Average 12-18	8.9%	9.1%	7.2%	5.9%	6.0%

We use our estimated GDP deflators to deflate the growth of official nominal GDP by both the expenditure and value added approaches, and then compare them with the official real GDP growth, which is based on the value added approach. The results are presented in Table 4 and plotted in Figure 2. The pattern seems clear. The adjusted real GDP growth fluctuates a lot more than the official rate. When the economy is booming (2004-08 and 2010-11), real growth seems to be underestimated, and when it is slowing (2009 and 2012-18), real growth tends to be overestimated. Although on average, official real GDP growth during the entire 15 year period of 2004-2018 is very similar to the average of our estimates, it is overestimated during 2012-2018 by about 1.2 or 1.3 percentage points depending on whether we use the value added approach or the expenditure approach. But the overestimation of growth can be as high as more than 2 percentage points in a year. The reason for this as we have just identified is that the NBS relies on single deflation in its value added approach to measure real GDP. When the economy is booming, the prices of commodities and raw materials may go up faster than prices of final products. When the economy slows down, the opposite may happen as commodity prices go down faster than those of final products. There is likely to be more price rigidity in final goods than in commodities. As a result, single deflation overestimates real growth when the economy is weak and underestimates growth when it is strong. There may be an inherent incentive for government statisticians to favor this approach over double deflation. This issue would disappear if the expenditure approach is used to measure real GDP.

One problem with our adjustment is that the adjusted real GDP growth rate seems too high to be credible during 2004-2007 and in 2011 (above 15%). This may be because our adjustment of the real GDP growth is based on the assumption that nominal

GDP growth is accurate. But as we mentioned in the introduction, many economists question the accuracy of China's nominal GDP figures. The most recent systematic study on the problem is by Chen et al. (2019). They use value added tax data to correct for possible over-reporting of GDP figures by local governments. Their main findings are presented in Figure 3 and in Table 5. These authors adjusted only the nominal GDP growth rates during 2009-2016, but we can infer their implied real GDP growth rates by using the official GDP deflator, the result of which is also plotted in the figure. We can see that their implied real GDP growth rates for 2010 and 2011, two booming years after the famous 4 trillion yuan stimulus, were significantly lower than in 2009, the year during the global financial crisis. This is very counterintuitive and apparently wrong. Also, 2012 was a down year for the Chinese economy, and it was the first time in 20 years that China's GDP growth went below 8%, but the implied real growth in Chen et al. (2019) for the year was higher than that of the booming 2010 and 2011. This is again a peculiar result.

Figure 3. Real GDP Growth after Combined Adjustment to Nominal GDP Growth and GDP Deflator

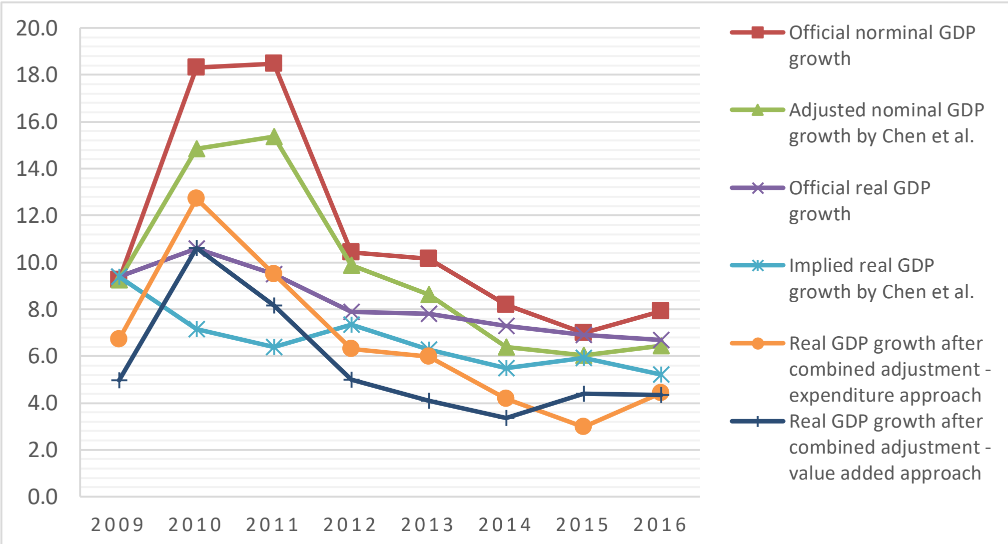


Table 5. Real GDP Growth after Combined Adjustment to Nominal GDP Growth and GDP Deflator

Year	Official nominal GDP growth	Adjusted nominal GDP growth by Chen et al.	Official real GDP growth	Implied real GDP growth by Chen et al.	Real GDP growth after combined adjustment - expenditure approach	Real GDP growth after combined adjustment - value added approach
2009	9.3	9.3	9.4	9.4	6.7	5.0
2010	18.3	14.9	10.6	7.1	12.7	10.6
2011	18.5	15.4	9.5	6.4	9.5	8.2
2012	10.4	9.9	7.9	7.3	6.3	5.0
2013	10.2	8.6	7.8	6.3	6.0	4.1
2014	8.2	6.4	7.3	5.5	4.2	3.3
2015	7.0	6.0	6.9	5.9	3.0	4.4
2016	7.9	6.4	6.7	5.2	4.4	4.3
Average 09-16	11.2	9.6	8.3	6.6	6.6	5.6
Average 12-16	8.7	7.5	7.3	6.1	4.8	4.2

However, if instead of the official GDP deflator, we use the alternative GDP deflators estimated in this paper to deflate the adjusted nominal GDPs in Chen et al. (2019), their otherwise baffling results then begin to make perfect sense. In Figure 3, we plot two lines of real GDP growth after the combined adjustment to both official nominal GDP growth as in Chen et al. and official GDP deflator as in this study, one from the expenditure approach and the other from the value added approach. In both cases, we can see that real growth in the two booming years of 2010 and 2011 is now higher than that of both 2009 and 2012. If the combined adjustment to China's real GDP growth in Table 5 and Figure 3 is close to the truth, then the official figure may have overstated growth during the downturn period of 2012-16 by, on average, 2.5 to 3.1 percentage points. So the true growth rate in the past few years may be about 4 to 5% rather than the official 6 to 7%.

6. Concluding Remarks

In this paper, we have shown that the official method used by the NBS to deflate nominal GDP tends to overstate real GDP during economic downturn but understate real GDP during the upturn. We have used both the expenditure approach and the value added approach with double deflation that have reached similar conclusions, giving extra credence to our results. Our new estimates of China's GDP deflator lend support to an important recent study of China's national accounts by Chen et al. (2019) by helping to reconcile their reasonable adjustment to China's nominal GDP growth during 2009-2016 with the implied real GDP growth rates that are implausible in some years.

On the other hand, their study also helps to make better sense of our estimates, especially during the booming years before 2012.

Although the official real GDP growth during the period of our study is on average very similar to our estimates by both the expenditure and value added approaches, its fluctuation is too low to be credible. Apparently, the official approach has artificially smoothened GDP growth in the recent decade. But for macroeconomic policies to be responsive to current economic conditions, accurate growth figures are very important. Therefore, we would like to argue for a reevaluation of the official method for measuring both the nominal and real GDP in China. If the NBS wants to continue to rely primarily on the value added approach, they should adopt the double deflation approach and collect better data on intermediate inputs and prices of services. To us, a better choice is to switch to the expenditure approach as the primary national accounting method and to rely more on direct surveys than overall reporting. The NBS needs to address the key issues with the expenditure accounts, especially the underestimation of household consumption and the overestimation of investment. Many developed countries are experienced with the expenditure approach, and there is no reason why China can't develop a statistical system that can quickly improve the quality of its expenditure accounts.

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Appendix

Table A1. Selected Price Indices Not in *China Statistical Yearbooks*
(Previous year = 100)

Year	Wage index for urban non-private sector	Price index for residential buildings	Price index of exports of goods	Price index of imports of goods	CPI for services	Implicit Price Deflator for Service Sector
2004	114.5	118.7	106.6	113.3	102.2	104.8
2005	115.4	112.6	101.9	102.4	103.3	103.4
2006	114.4	106.2	99.9	100.4	101.8	103.9
2007	120.2	116.9	100.6	101.7	NA	108.7
2008	116.0	98.1	99.2	105.8	NA	106.9
2009	112.7	124.7	92.3	85.9	98.9	103.2
2010	112.4	106.0	102.0	112.6	102.0	107.2
2011	113.4	105.7	105.0	108.7	103.5	108.4
2012	111.2	108.8	99.7	97.1	102.0	104.9
2013	108.9	107.7	97.3	95.8	102.9	104.8
2014	108.8	101.4	99.3	96.6	102.5	102.8
2015	114.0	109.1	99.0	88.4	102.0	103.8
2016	111.1	111.3	98.0	97.6	102.2	102.8
2017	111.8	105.7	103.9	109.4	103.0	103.1
2018	110.3	112.2	103.3	106.1	102.6	102.2

Note: (1) The wage index is constructed by the authors based on the annual growth of the "average wage of employed persons in unban non-private units".

(2) The price index for residential buildings is constructed by the authors based on the national "average selling prices [per square meter] of [new] residential buildings".

(3) Official price index of exports of goods and price index of imports of goods were based on prices in USD before 2014 and in RMB from 2014. We made adjustment to the official indices before 2014 by taking into account the yearly changes in average USD to RMB exchange rates between 2004 and 2013.

(4) CPI for services is not published in *China Statistical Yearbooks*, but is available in the CEIC database.

(5) The implicit price index for service sector is not officially published but is derived by the authors from the official nominal value added and the official real growth rate of the service sector.

Table A2. Input-Output Ratios by Sectors: 2004-2018

Output Sector	Agriculture	Industry		Construction				Service			
Input Sector	Intermediate inputs from all sectors	Intermediate inputs from agriculture, industry and construction	Intermediate input from service	Intermediate input from agriculture	Intermediate input from industry	Intermediate input from construction	Intermediate input from service	Intermediate input from agriculture	Intermediate input from industry	Intermediate input from construction	Intermediate input from service
2004	0.4181	0.5789	0.1225	0.0813	0.5133	0.0012	0.1699	0.0163	0.2315	0.0176	0.2030
2005	0.4135	0.6297	0.1188	0.0712	0.5213	0.0014	0.1505	0.0169	0.2668	0.0213	0.2051
2006	0.4135	0.6297	0.1188	0.0712	0.5213	0.0014	0.1505	0.0169	0.2668	0.0213	0.2051
2007	0.4138	0.6816	0.0854	0.0041	0.6047	0.0095	0.1503	0.0133	0.2442	0.0064	0.2013
2008	0.4138	0.6816	0.0854	0.0041	0.6047	0.0095	0.1503	0.0133	0.2442	0.0064	0.2013
2009	0.4138	0.6816	0.0854	0.0041	0.6047	0.0095	0.1503	0.0133	0.2442	0.0064	0.2013
2010	0.4153	0.6878	0.0956	0.0044	0.5529	0.0106	0.1716	0.0138	0.2283	0.0069	0.2002
2011	0.4153	0.6878	0.0956	0.0044	0.5529	0.0106	0.1716	0.0138	0.2283	0.0069	0.2002
2012	0.4145	0.6691	0.1070	0.0079	0.5552	0.0269	0.1444	0.0107	0.1966	0.0081	0.2659
2013	0.4145	0.6691	0.1070	0.0079	0.5552	0.0269	0.1444	0.0107	0.1966	0.0081	0.2659
2014	0.4145	0.6691	0.1070	0.0079	0.5552	0.0269	0.1444	0.0107	0.1966	0.0081	0.2659
2015	0.4124	0.6653	0.1312	0.0091	0.5337	0.0321	0.1946	0.0097	0.1773	0.0063	0.2754
2016	0.4124	0.6653	0.1312	0.0091	0.5337	0.0321	0.1946	0.0097	0.1773	0.0063	0.2754
2017	0.4056	0.6273	0.1264	0.0083	0.4895	0.0319	0.2285	0.0072	0.1585	0.0033	0.2944
2018	0.4056	0.6273	0.1264	0.0083	0.4895	0.0319	0.2285	0.0072	0.1585	0.0033	0.2944

Note: This table is derived from the official input-output tables for 2002, 2005, 2007, 2010, 2012, 2015 and 2017, published in *China Statistical Yearbook* in various years.