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Deflating China's nominal GDP: 2004–2018☆

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ABSTRACT

This paper is a preliminary attempt to use both the value added approach with double deflation and the expenditure approach to deflate China's nominal GDP over 15 years (2004–2018). The results show that China's real GDP growth during the period has significantly more fluctuations than the official statistics indicate. Additionally, inflation, as measured by the official implicit GDP deflator, is generally overestimated during boom years but underestimated during downturn years. In particular, it is shown that China's growth slowdown in recent years before the COVID-19 pandemic may have been more severe than official figures suggest.

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 (just before the COVID-19 pandemic), which was the lowest rate since 1990. During 2012–2019, the average annual GDP growth fell to 7.0% from 10.8% during 2003–2011. However, despite the slowdown, an annual GDP growth of 6–7% is among the fastest in the world. Nevertheless, in some years, China's relatively fast GDP growth is in contrast with stagnant growth at the sectoral or micro-level. For example, in 2015, China's official GDP growth rate was 6.9% (barely missing the 7% target); however, in the same year, electricity generation grew by only 0.3%, freight transportation grew by 0.2%, while both export growth and import growth were negative at −0.8% and − 1.8%, respectively.[1] The discrepancies between the headline GDP growth figures and the micro-level data lead many economists and the press to question the accuracy of China's official GDP statistics.[2] Moreover, in recent years, China's official GDP growth rate has been extremely smooth, which some economists find suspicious (Clark, Dawson, & Pinkovskiy, 2020; Fernald, Hsu, & Spiegel, 2021; Kerola, 2019).

As GDP growth has long been a key performance measure for local government officials in China, these officials may have strong

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[1] All figures cited here are from the *China Statistical Yearbook 2016*.

[2] See The Economist (2015) and Johnson (2015). In an influential article, Rawski (2001) questioned 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 micro-level data. The article sparked great media interest and debate at the time. Additionally, China's current premier, Li Keqiang, expressed doubt over the official GDP data 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 (2010) even created a "Keqiang Index" using these three indicators to measure the health of China's economy.

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incentives to manage GDP figures, especially when their local economies are not performing well. In a recent article, Chen, Chen, Hsieh, and Song (2019) show that after 2008, China's local statistics increasingly misrepresented the true GDP figures but no corresponding adjustment was 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 almost 2 percentage points on average.

However, local over-reporting is only one source of the inaccuracy of China's GDP growth figures. Economists have long recognized that underestimated inflation may have contributed to the overestimation of China's economic growth in some years (Brandt & Zhu, 2010; Keidel, 2001; Maddison, 2007; Maddison & Wu, 2008; Ren, 1995; Wu, 2002; Young, 2003). Especially influential is an article by Young (2003), which suggests that China's GDP growth in the first two decades of reform was not as spectacular as the official statistics indicate.

Real GDP growth is equal to nominal GDP growth minus inflation. Thus, if inflation is underestimated, real GDP growth will be overestimated. For example, for 2015, the official implicit GDP deflator is −0.1% (a slight deflation), which is inconsistent with the rise in the prices of consumer goods and services (the CPI increased by 1.4%) and the rapid increase in housing prices (which increased by 9.1%) in that year.[3] The economic research consultancy Capital Economics claims that China overstated its real GDP growth by 1 to 2 percentage points in the 12 months to the first quarter of 2015 because inflation was understated. This implies that China's economy only grew by 5–6% during this period rather than the officially announced 7%.[4]

In this paper, instead of trying to evaluate or correct the possible biases in China's official nominal GDP figures as in Chen et al. (2019), we follow the approach of Young (2003) to assess possible biases in the measurement of China's real GDP from 2004 to 2018. We use both the value added approach and the expenditure approach to deflate China's nominal GDP and estimate its real GDP growth.[5] We use publicly available official data and follow the official methodology as closely as possible, but also modify this methodology when appropriate. We use double deflation in the value added approach instead of the single deflation method used by the NBS. In our estimates, China's real GDP growth shows significantly more fluctuations than the official figures indicate, and inflation, as measured by the official implicit GDP deflator, is generally overestimated during the boom years but is generally underestimated during the down years. Although the average growth rate over the study period is not affected much by smoothed GDP deflators, the extent of the fluctuation in growth is significantly downplayed in the official statistics. Particularly, the findings indicate that China's GDP growth after 2012 may have slowed more than the official statistics suggest.

Our study contributes to a small but important literature on China's GDP statistics. Our finding of the countercyclical underestimation of China's GDP deflator is consistent with the findings of Nakamura, Steinsson, and Liu (2016) for China's CPI during 1996–2011. It is also consistent with the findings of Clark, Pinkovskiy, and Sala-i-Martin (2020), who use two sets of alternative indicators of economic activities to show that China's growth rates have been more volatile than portrayed in the official figures. Our results complement nicely the study of Chen et al. (2019), which estimates the degree of overstatement of China's nominal GDP growth in recent years. Combining their results with ours gives a picture of much more fluctuating GDP growth and a more severe economic downturn after 2012.

The rest of the paper is organized as follows. Section 2 introduces China's official methods for measuring its nominal and real GDP and briefly reviews the relevant literature. In Sections 3 and 4, we use, respectively, the value added approach and the expenditure approach to re-estimate China's real GDP and implicit GDP deflator for 2015, and by doing so demonstrate the procedures and data used for our estimations. In Section 5, we present our estimations for the entire study period (2004–2018) and combine our results with those of Chen et al. (2019), showing that the two studies help to make better sense of each other's results. Section 6 concludes the paper with remarks on possible improvements to China's GDP accounting.

2. Measuring nominal and real GDP in China: a brief literature review

The reliability of China's official GDP statistics has long been questioned in the literature (Adams & Chen, 1996; Chen et al., 2019; Fernald et al., 2021; He, 2010; Holz, 2014; Maddison, 1998; Nakamura et al., 2016; Perkins & Rawski, 2008; Rawski, 2001; Wu, 2000, 2007; Young, 2003; Zhu, 2021). Studies commonly identify possible overstatement of China's real GDP growth by the country's statistical authority. Indeed, the latest release of the widely used Penn World Table (PWT; version 10.0) adjusts China's real GDP growth rate downward by almost 3 percentage points per annum between 1979 and 2019 (Feenstra, Inklaar, & Timmer, 2015).

In theory, China's national income and production accounting system is very similar to those adopted by developed economies; however, in practice, it is quite different. Before its 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 lead to similar results (albeit non-identical due to measurement errors) when used independently to estimate GDP.

[3] These figures are based on data from the *China Statistical Yearbook 2016*.

[4] See Johnson (2015). The Capital Economics analysts blame the methodology used by the NBS to estimate the GDP deflator, rather than any deliberate misrepresentation, for the overestimation of China's real GDP growth. See Xu (2015) for a defense of the official methodology.

[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 in measuring real GDP after 2002. Third, the price index for services is missing during 2001–2003.

Many developed countries use all three approaches to independently estimate GDP but primarily rely on the expenditure approach. However, in China, the annual and quarterly GDP figures officially released to the press are obtained by a combination of the production approach and the income approach (Xu, 2009; NBS (National Bureau of Statistics), 2010).[6] China also publishes GDP figures annually based on the expenditure approach, which, according to Liu, Zhang, and Zhu (2016), are not estimated independently in practice. Thus, China employs essentially a single production-cum-income approach to measure its GDP—for convenience, we call this the "value added approach" in this paper.

Compared with many developed countries, China relies much more on data drawn directly from enterprise reports and administrative sources and relies less on independent surveys. This approach is a legacy from the old MPS system. This practice was also reflected in the way China measured its real GDP before 2003. As Young (2003) notes, most developed countries estimate real GDP by deflating nominal GDP using separate, independently constructed price indices; however, prior to 2003, China followed a different practice. For the primary and secondary sectors, China relied 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 the 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 current price ("nominal") output by constant price ("real") output yielded an implicit deflator. In the case of the secondary sector, this output deflator was then used to deflate nominal value added to derive real value added. This approach 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. For the tertiary sector, a combination of single deflation, double deflation, and volume extrapolation was used to obtain real value added.

The above constant price method for measuring real GDP has major shortcomings (Wu, 2000, 2002; Young, 2003). Accurately compiling thousands of constant prices is challenging, and the NBS only did this twice (in 1980 and 1990) during the reform era. Biases can easily arise regarding which prices to use and how to weight them when calculating an average constant price for a particular product. Many enterprises (especially new entrants) did not have sufficient expertise or incentives to correctly calculate and report the constant-price output values. For new products, current prices had to be used as constant prices, which led to the underestimation of inflation.

A number of economists have tried different ways in their attempt to correct these biases. For example, Wu (2002) uses physical quantity and price data of major industrial products to estimate the real growth of industrial value added and finds 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) follow the internationally standard practice and use relevant price indices to deflate the nominal values added of each of the three economic sectors (primary, secondary, and tertiary) and arrive at alternative estimates of real GDP growth rates. Young (2003) finds that due to the underestimation of inflation by the official method, the annual growth of China's non-agricultural economy during 1978–1998 was overstated by 2.5 percentage points, which is in line with the findings of Wu (2002).

In 2004, the NBS started using the price index method to deflate nominal GDP. In the case of the value added approach, single deflation is used for the primary and secondary sectors, and a mixture of methods is used for the tertiary sector (Xu, 2009; Zhu et al., 2012). However, single deflation obtains a biased estimate of real GDP when the change in the output price index is different from that of the input price index. Real growth is overestimated when the input price rises by a percentage that is less than the rise in the output price and is underestimated otherwise. When changes in the two price series diverge significantly, single deflation produces very misleading estimates. Nevertheless, single deflation has the advantage of requiring much fewer data, and the sacrifice in precision may be insignificant when the change in input prices can be quickly transmitted to output prices so that the movement of the two price series is very similar.

Double deflation, on the other hand, is not without its own problem. David (1962) notes that double deflation may in theory lead to negative real value added, which is difficult to interpret. Negative real values added may arise when there are great changes in relative prices or input proportions due to technological change or substitution (Cassing, 1996; Sato, 1976). Furthermore, David (1966) justifies the use of single deflation under certain conditions. In contrast, Sims (1969) identifies conditions under which double deflation makes theoretical sense and shows that negative real values added occur only when these conditions are violated and measurement errors are large. Sato (1976) provides further justification for double deflation. In practice, negative real values added at the industry level are rarely observed with the double deflation method (Oulton, Rincon-Aznar, Samek, & Srinivasan, 2018). Despite these theoretical issues, most major developed countries have adopted the double deflation method, which is recommended by the *System of National Accounts* 2008 (Alexander, Dziobek, Marini, Metreau, & Stanger, 2017). Therefore, we use double deflation in this paper.

According to the official manual, the NBS also uses the expenditure approach to measure both nominal and real GDP but only publishes nominal figures. Therefore, the GDP deflator based on the expenditure approach cannot be readily computed. Keidel (2001) strongly suspected that China's expenditure figure was adjusted to bring it roughly in line with the official value-added figure. Liu et al. (2016) support this suspicion. Nevertheless, the relevant official price indices can be used to deflate all expenditure components of nominal GDP to obtain real GDP based on expenditure and thereby obtain the implicit GDP deflator; we use this method in this paper.

The approach we use in this paper to re-estimate China's real GDP growth may be called the direct adjustment method (Clark, Dawson, & Pinkovskiy, 2020). It differs from the statistical regression method that has been increasingly used in recent years. Due to concerns about the reliability of China's official GDP-related statistics, some researchers have used the regression method based on

[6] The primary sector (agriculture, forestry, husbandry, and fishery) relies on the production approach, whereas the secondary sector (mining, manufacturing, utilities, and construction) and the tertiary sector (service) rely on the income approach.

alternative non-GDP indicators to assess the level of China's economic growth as well as the change in the growth rate over time under the assumption that these indicators may have regular relationships with real GDP growth. Of particular interest is the use of satellite observations of nighttime lights (NTL) as an independent indicator of economic activities. Based on NTL data, Clark, Pinkovskiy, and Sala-i-Martin (2020) find that China's GDP growth around 2015 may have been higher than officially reported. Additionally, in a related paper, Clark, Dawson, and Pinkovskiy (2020) combine NTL data with data on production, trade, investment, and credit to construct alternative measures of China's economic growth and show that it has been more volatile in recent years than portrayed in the official GDP statistics. Furthermore, using NTL data, Hu and Yao (2019) conclude that in the 1990s and 2000s, China's annual real GDP growth was significantly lower on average than the official figures, and that after 2008, China's official GDP growth has been smoother than their alternative estimates.

Moreover, using alternative measures based on Engel curves, Nakamura et al. (2016) find that between 1995 and 2011, China's official GDP growth and inflation are smoother than their alternative estimates but the official average GDP growth rate is about the same. Using data on exports to China from its trading partners during 2000–2019, Fernald et al. (2021) find that official Chinese statistics have broadly become more reliable over time but the official GDP figure has been excessively smooth since 2013.

More closely related to our study is that of Kerola (2019), who uses regression to estimate the extent of the overstatement of China's real GDP growth during 2014–2018 due to the underestimation of inflation. The paper 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 alternative real GDP growth rates for 2041–2018, which are significantly lower and fluctuate 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 prior to recent years. However, our results show that this is not necessarily the case; we show that the official implicit GDP deflator was mostly overestimated before 2012 and was mostly underestimated after 2012 rather than after 2014. Kerola's paper also implies that the NBS has manipulated the GDP deflator after 2014 but not before; however, we do not assume that this is the case.

Overall, the findings from our direct adjustment method complement those from the regression method reviewed above. These two methods require simplifications and assumptions regarding data quality and the appropriateness of proxies. The two methods are generally complementary. For example, in addition to their direct adjustment method using value added tax revenue data, Chen et al. (2019) conduct regressions based on a set of harder-to-manipulate economic indicators including NTL, national tax revenue, exports and imports, electricity consumption, railway cargo volume, and new bank loans. They find similar results using both methods.

3. The value added approach: the case of 2015

In Sections 3 and 4, we use 2015 as a case study to demonstrate the procedure used for our re-estimation of China's real GDP and implicit deflator. We begin with the value added approach in this section, followed by the expenditure approach in Section 4. In both approaches, price indices are used to deflate the components of nominal GDP.

As mentioned earlier, the NBS uses the single deflation method, which applies an output price index to deflate the value added of an industry. We use a double deflation method that deflates both the output and input of an industry with separate price indices to obtain the real value added. Under double deflation, the Laspeyres quantity index (*QI*) of an industry, which measures the growth of real value added, can be expressed as follows:

$$QI = \left(p^0y^1 - q^0x^1\right)/\left(p^0y^0 - q^0x^0\right) \tag{1}$$

where p is the price vector of outputs, y is the quantity vector of outputs, q is the price vector of intermediate inputs, and x is the quantity vector of inputs. The superscripts 1 and 0 denote, respectively, the current year and the previous year or base year. With these notations, the nominal value-added index (*VI*) can be expressed as follows:

$$VI = \left(p^1y^1 - q^1x^1\right)/\left(p^0y^0 - q^0x^0\right) \tag{2}$$

Therefore, the price index (*PI*) (i.e., the implicit deflator) of the value added of the industry can be derived as follows:

$$PI = VI/QI = \left(p^1y^1 - q^1x^1\right)/\left(p^0y^1 - q^0x^1\right) \tag{3}$$

which is a Paasche index. This price index can be further decomposed into two parts as follows:

$$\begin{aligned} PI &= VI/QI = \left(p^1y^1 - q^1x^1\right)/\left(p^0y^1 - q^0x^1\right) \\ &= \left(p^0y^1/\left(p^0y^1 - q^0x^1\right)\right)\left(p^1y^1/p^0y^1\right) - \left(q^0x^1/\left(p^0y^1 - q^0x^1\right)\right)\left(q^1x^1/q^0x^1\right) \end{aligned} \tag{4}$$

We call p^1y^1/p^0y^1 and q^1x^1/q^0x^1 the output price index and input price index, respectively. The price index of value added can thus be viewed as a "weighted difference" between the output price index and the input price index. If the output and input price indices are the same, then they are equal to the price index of value added; the single deflation method effectively assumes this to be the case in its use of the output price index to deflate the nominal values of both output and input.

However, when the output price index and the input price index differ, single deflation will be biased. Even a relatively small difference between the output and input price indices can lead to a significant difference in the price index of value added under double deflation. When the output price index is higher than the input price index, single deflation, by implicitly assuming that the latter is equal to the former, underestimates the price index of value added (i.e., inflation) and hence overestimates its real growth, and vice versa.

Although double deflation is preferable in theory and is practiced in most major developed economies, it requires detailed price information on intermediate inputs and accurate input–output tables. Consequently, single deflation is still practiced in many countries, including China. When data availability is low and output prices move more or less in line with input prices, single deflation is the preferred method. However, for China, the difference between the input and output price indices for both the industrial and service sectors are substantial in some years during the study period. Service is an important input to industrial production, and industrial products are also important inputs to the service sector. However, the price index for industrial products differs significantly from that for services in most of the years covered in this study. Therefore, we try the double deflation method to assess whether and to what extent the resulting real growth rates differ from the official figures (which are based on single deflation).

Note from Eq. (3) that $QI = VI/PI$, where QI is a Laspeyres quantity index, and PI a Paasche price index. That is, to obtain the Laspeyres quantity index, one should use the Paasche price index as the deflator of the nominal value. However, in practice, the NBS mainly uses the Laspeyres method to construct various price indices using base-year quantities as fixed weights (Zhu et al., 2012). The base year is adjusted every five years, and hence these weights are only updated every five years. The Laspeyres price index is easier to construct as it avoids the tedious work of adjusting weights every year, although it suffers from a well-known substitution bias that leads to the overstatement of inflation (Boskin, Dulberger, Griliches, Gordon, & Jorgensen, 1996; Braithwait, 1980). The main reason is that when the relative prices of goods and services change, people tend to substitute cheaper goods and services for more expensive ones. As a result, the quantity ratios in the current year may deviate significantly from those in the base year. For example, the relative prices of information and communication technology (ICT) products and services have declined substantially over the years, and, consequently, their relative quantities have increased significantly. Using the relatively low base-year quantities as weights for price changes understates the effect of the relative price decline of ICT products and services and hence overstates overall inflation and understates the real growth of the economy.

On the other hand, the same substitution bias tends to cause the Laspeyres quantity index to overstate real growth (Landefeld & Parker, 1997). This is because the Laspeyres quantity index uses the base-year prices as fixed weights to compute the real (i.e., constant-price) value of goods and services in an industry or economy whose relative prices may have changed substantially from those of the base year. Using ICT products and services as an example, the real value of these products and services whose relative prices have been falling and whose quantities have been rising rapidly will be overestimated by the Laspeyres method using the relatively much higher base-year prices. As a result, the real growth of the economy is overstated.

To mitigate these biases, some developed countries such as the US have adopted chain-type Fisher indices to replace the Laspeyres and Paasche indices. However, doing so is computationally more complex and requires much more work for data collection and quality control. It is beyond our means and the scope of this paper to correct the biases inherent in the Laspeyres method used by the NBS. Furthermore, while substitution biases cause Laspeyres price indices to overestimate inflation, they also lead Laspeyres quantity indices to overestimate real growth, and these two effects partially offset each other. Moreover, based on a study of the US economy, the effect of substitution biases on real GDP growth is likely to be relatively small (Landefeld & Parker, 1997). Therefore, we take the official price indices as given and assess whether double deflation gives different results for real GDP growth compared with single deflation.

In China's national income and product accounts (as in every other country), the economy is first divided into three broad sectors (primary, secondary, and tertiary); these are the first-level industries in the Chinese industry classification system. These sectors are then divided into 17 second-level industries, 58 third-level industries, and 94 fourth-level industries (NBS (National Bureau of Statistics), 2010).[7] The NBS estimates both the nominal and real values added of all 94 fourth-level industries but does not release complete data on these industries' nominal values added or the relevant price indices used for deflation. Consequently, we can only work with data at the four-sector level (i.e., agriculture, industry, construction, and services), as shown in Table 1. We use both single deflation and double deflation to estimate the real GDP and implicit deflator in 2015 and then compare the results with each other.

The left panel of Table 1 presents the results for single deflation, which uses each sector's output price index to deflate nominal value added. 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, i.e., the ratio of the nominal index to the real index of the sector's value added, which are derived from official figures. The resulting real GDP is 69,053 billion yuan (see the bottom row of column C)—which is 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. As the official figures are based on much more detailed data from 94 industries, their similarity to our results justifies our use of data at the aggregate four-sector level and the corresponding output price indices shown in Table 1 to obtain the single deflation-based real GDP and implicit deflator.

In the right panel of Table 1, we apply 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 using data from the official input–output tables. The NBS has published a 17-industry national input–output table every 2–3 years for the past 30 years. As we do not have price and output data for these industries, we aggregate the 17 × 17 input–output tables into four-sector ones and use the derived 4 × 4 tables to obtain the values of the intermediate inputs of the four sectors. However, this aggregation makes the price indices for intermediate inputs much less accurate. Thus, our study should be viewed as a preliminary attempt to assess the difference between the single deflation and double deflation methods.

The official price indices of intermediate inputs are available for the agricultural and industrial sectors. For the agricultural

[7] A fourth-level industry is similar to a 2-digit industry ("division") in the International Standard Industrial Classification (ISIC; U.N. Department of Economic and Social Affairs, 2008).

Table 1
Re-estimation of China's real GDP and implicit deflator in 2015: the 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 output 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	5777	Producer price index for farm products	101.7	5681	Gross output	9833	Producer price index for farm products	101.7	9668	5629
					Intermediate input-all	4055	Price index for means of agricultural production	100.4	4039	
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	4776	Price index of construction and installation	97.3	4909	Gross output	20,722	Price index of construction and installation	97.3	21,297	4940
					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	4033	CPI for services	102.0	3954	
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

Note: In this table, the agriculture sector also includes forestry, husbandry and fishery.

sector—in which we also include forestry, husbandry, and fishery—the intermediate inputs from all four sectors are lumped into one, because the official “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 the inputs from the agricultural, industrial, and construction sectors into one because the official “purchasing price index for industrial producers” is a comprehensive index that covers all intermediate inputs except for services. There is no official price index for deflating the nominal value of services as an intermediate input; however, the official CPI has a component index for services, which is publicly available for most years. We use this component index 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 service sector, which we use to deflate the gross output of the sector, because the latter also covers non-market services, including those from the public sector, that are not counted as intermediate inputs in the production of goods and services.

The results of the double deflation method differ from those of the single deflation method. Real GDP under double deflation is 67,954 billion yuan (see the bottom row of column G in Table 1); this implies a GDP deflator of 101.6, which is 1.6% higher than the GDP deflator under single deflation and 1.5% higher than the official figure. This suggests that the single deflation method understates GDP inflation and overstates real growth. By comparing columns C and G, it can be seen that single deflation slightly understates the real value added of the industrial and construction sectors but significantly overstates the real value added of the service sector. The reason for this overstatement is that the price indices of intermediate inputs (especially industrial products) for the service sector are significantly lower than the output price index. If the producer price index for industrial products were the same as the output price index we use for the service sector (i.e., 103.9), the difference in the estimated real GDP and implicit deflator between double deflation and single deflation would disappear completely.

4. The expenditure approach: the case of 2015

China has a complete manual of methods, procedures, and data sources for the estimation of both nominal and real GDP by the expenditure approach, which divides GDP into three first-level expenditure components (final consumption, gross capital formation, and net exports) that are further divided into 6 second-level and 32 third-level expenditure components. According to the NBS manual (NBS (National Bureau of Statistics), 2010), price indices (e.g., the CPI and the fixed asset investment price index) are constructed for almost all third-level components, and these indices are then used as deflators to convert nominal expenditures into real (constant-price) expenditures. However, the NBS releases few details on all three levels of expenditure components and their price indices. Therefore, in our estimation of real GDP by expenditure, we can only work with data at a much more aggregated level, as shown in Table 2. We largely follow the procedure laid out in the official statistical manual but also modify the official method when appropriate, as explained below.

We omit net exports of services in Table 2 because the NBS has no official price index for either exports or imports of services. There is an official CPI for service items (publicly available in most years); however, the services that are exported or imported are not the same as those that are consumed domestically. Another reason for omitting the net exports of services is that the effect of their exclusion on real GDP growth and the implicit deflator is extremely small ($\leq \sim 0.1$ percentage points for reasonable values of price indices). This is because the values of China’s exports and imports of services have been relatively small (each no greater than 4% of GDP), the net exports of services have generally not been greater than 2% of GDP, and the difference in price indices for services between China and its major trading partners has been quite small (generally less than 2 percentage points) due to the overall low inflation rate around the world in the past two decades.[8]

Furthermore, before the 3rd national economic census in 2013, government consumption was divided into only two categories—fixed asset depreciation and the rest—which were deflated by the price index for fixed asset investment and the CPI, respectively, to yield real, constant price values (NBS (National Bureau of Statistics), 2010). However, 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 constitutes the intermediate goods and services needed to produce the gross output of the government sector. The official flow of funds tables compiled by the NBS contain data on the government’s value added and the compensation of its employees. Government purchases equal government consumption minus the government’s value added, and government fixed asset depreciation equals the government’s value added minus the compensation of government employees. Instead of using the CPI to deflate government employee compensation as stated in the official NBS manual, we construct a new price index to do so; this new index is a simple average of the CPI and the growth rate of the average wage rate in the urban non-private sector (see Table A1 in the appendix). As shown in Table 2, this index is much higher than the CPI. This indicates that by using a much lower CPI to deflate government employee compensation (as part of government consumption other than depreciation), the pre-2013 approach significantly overstates real government consumption expenditures and hence overstates real GDP and its growth and understates the implicit GDP deflator. Using the CPI to

[8] In its official manual (NBS, 2010), the NBS instructs that the CPI service index can be used as a proxy for the price index of China’s service exports and that the average of the price indices for service exports by China’s major trading partners can be used as a proxy for the price index of China’s service imports. Based on this instruction, we use China’s CPI service index and the US price index for services as proxies for the price indices of service exports and imports, finding that including net exports of services in our calculation increases the estimated GDP deflator by 0.1 percentage points in 2015; for all other years from 2004 to 2018, the effect of including net exports of services is less than 0.1 percentage points.

Table 2
Re-estimation of China's real GDP and implicit deflator in 2015: the expenditure approach.

Expenditure component	Nominal value (bln yuan)	Name of price index (deflator)	Value of price index (Y2014 = 100)	Real value (bln yuan)	Contribution to GDP deflator (percentage points)
	A		B	C = A/B*100	D
Household consumption	265,980	Consumer price index (official)	101.4	262,308	0.5
Government consumption					
Compensation of gov't employees	48,216	Index for gov't employee compensation (constructed by authors)	107.7	44,776	0.5
Government purchases	40,495	Consumer price index (official)	101.4	39,936	0.1
Fixed asset depreciation	7576	Price index for fixed asset investment (official)	98.2	7714	0.0
Gross capital formation					0.0
Change of inventories	11,333	Producer price index for industrial products (official)	94.8	11,955	−0.1
Fixed capital formation					0.0
Construction and installation: residential buildings	43,051	Price index for residential buildings (constructed by authors)	109.1	39,460	0.5
Construction and installation: non-residential buildings	165,191	Price index of construction and installation (official)	97.3	169,775	−0.7
Purchase of equipment and instruments	59,609	Price index of purchase of equipment and instruments	99.3	60,029	−0.1
Other investment expenses	33,651	Price index for other investment expenses (official)	100.7	33,418	0.0
Net exports of goods					0.0
Exports of goods	141,167	Price index of exports of goods (official)	99.0	142,593	−0.2
Imports of goods	−104,336	Price index of imports of goods (official)	88.4	−118,027	2.0
Expenditure-based GDP (excl. Net exports of services)	711,933	GDP deflator	102.6	693,936	2.6

deflate government employee compensation effectively assumes that the real wage increase is completely due to the 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.[9] This is a criticism raised by Maddison (2007), who argues that the productivity growth of China's government sector was unusually high due to inadequate deflation. He adjusts China's real growth in the value added of the non-market sector by using employment data and assuming no productivity growth in the sector.[10] In constructing our index, we assume that half of the increase in government employee compensation is due to inflation and the other half is due to productivity growth in the government sector. We believe this is a more balanced approach than assuming that there is zero productivity growth in the public sector or assuming that any wage increase is due to productivity growth.

Moreover, in the official NBS 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 releases few details on these investment categories, and therefore we cannot use them for our estimation of real GFCF. Nevertheless, the NBS publishes investment statistics known as the "total investment in fixed assets (TIFA) in the whole country." The TIFA and GFCF are closely related measures of investment but are conceptually different. According to the NBS (NBS (National Bureau of Statistics), 2010), GFCF is primarily estimated from the TIFA but is adjusted by adding and subtracting a few items. Liu et al. (2016) show that these two quantities should be very similar based on the official method for estimating GFCF.[11] The NBS divides the TIFA into three categories: construction and installation, purchase of equipment and instruments, and other expenses. We also divide GFCF into the same three categories, and we additionally make the simplified but reasonable assumption that the percentage shares of these investment categories in GFCF are the same as for the TIFA as GFCF is largely derived from the TIFA. We then use these shares to calculate the nominal values of these three investment categories in GFCF and use the corresponding official price indices as deflators to calculate the real values.

Because the NBS also publishes data on total investment in residential buildings, we further divide construction and installation

[9] This is based on the fact that the wage increase in traditional service sectors is primarily due to the increase in the general wage level resulting from higher productivity in other sectors (especially manufacturing).

[10] The U.S. Bureau of Economic Analysis (BEA) also uses the extrapolation of employment data to estimate the real growth of government employee compensation (Bureau of Economic Analysis, 2017, 9–15).

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

into two subcategories: residential buildings and the rest (non-residential buildings and structures). China's statistics on investments in both residential and non-residential buildings and structures are generally based on costs, not 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; however, it is indefensible in the case of residential buildings. Therefore, as an alternative deflator, we construct a price index for residential buildings based on the national average selling price (per square meter) of new residential buildings. This price index is generally higher than the official price index of construction and installation during 2004–2018.[12] In 2015, the difference is significant (109.1 versus 97.3).

As shown in the bottom row of Table 2, our estimate of the implicit GDP deflator for 2015 is 102.6, which is 2.5 percentage points higher than the official GDP deflator (100.1) for that year. If our estimate is correct, China's official GDP growth in 2015 overestimated the actual figure by 2.5 percentage points; that is, the real GDP growth rate may have been 4.4% rather than the official 6.9%.

If we think of the implicit GDP deflator as a measure of inflation for the broad economy, then according to the above estimate, in 2015, China had an inflation rate of 2.6%, not the official rate of 0.1%. At first glance, this result does not seem to make sense. In 2015, the CPI increased by 1.4%, while the price index for fixed asset investment decreased by 1.8%. That year, final consumption accounted for 52% of GDP, and investment (i.e., gross capital formation) accounted for 45% of GDP. A simple weighted average would suggest an overall inflation rate below or close to 0. However, a weighted average of price indices for consumption and investment only reflects the price level of gross domestic purchases, not GDP. The gross domestic purchases price index measures the price inflation of goods and services purchased by a country's residents and hence includes imports but not exports. Meanwhile, the GDP price index, which is essentially the same as the GDP deflator, measures the price inflation of final goods and services produced in a country and hence includes exports but not imports.

Therefore, to derive the GDP price index (i.e., GDP deflator), it is necessary to add the effect of exports to, and subtract the effect of imports from, the 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. In our estimation, the former is 100.8 and the latter is 102.6; this 1.8 percentage point difference accounts for two thirds of the difference between our estimated GDP deflator and the official figure. This can be seen in column D of Table 2, which shows that exports contribute −0.2 percentage points and imports 2.0 percentage points to the GDP deflator. In general, even if net exports account for a small fraction of GDP, their impact on the GDP deflator cannot be ignored when the changes in the price levels of exports and imports diverge significantly.[13]

To summarize, both the value added approach with double deflation and the expenditure approach show that in 2015, the GDP deflator may have been underestimated and real growth overestimated by 1.5 to 2.5 percentage points, depending on the approach we use. A discrepancy of this magnitude may not be consequential when the economy is growing at a double-digit rate; however, when growth is close to a low single-digit rate, an error of 1.5 to 2.5 percentage points in the real growth rate significantly distorts the perception of macroeconomic conditions and may lead to inadequate policies.

5. Re-estimated GDP deflator and real growth during 2004–2018

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

Zhang and Zhu (2015) find that in the official figures, China's household consumption may be underestimated by around 10% of GDP and its fixed capital formation may be overestimated by the same amount. In this section, we first assume that the official nominal expenditure composition is correct and use the relevant official price indices to deflate all expenditure components, yielding 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 find that the real GDP figures in the two scenarios do not differ much. In columns A and B of Table 3, we list two series of estimates of the GDP deflator using the expenditure approach: in column A, we use the official GDP composition by expenditure, and in column B, we use an alternative composition of GDP proposed by Zhang and Zhu (2015) by adding 10% of GDP to household consumption expenditures and subtracting 10% of GDP from fixed capital formation. The resulting two series of estimates of the GDP deflator are very similar; therefore, we use the estimates in column A throughout the rest of this paper.

In Fig. 1, we plot the GDP deflators from columns A, C, and D of Table 3 in a line graph. (Note that there is no estimate based on the value added approach for 2007 and 2008 because no data are available on the CPI for services for these two years.) Before 2012, the official GDP deflator is higher than our estimates using both approaches, except for 2009; however, after 2012, it is higher than our estimates, except for 2017.

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

[13] The same effect is seen in the US economy. In 2015, the US gross domestic purchases price index (a featured inflation by the BEA) was 100.3, while the GDP deflator was 101, because import prices decreased more than export prices (growth of −7.7% and − 4.9%, respectively).

Table 3
A comparison of the estimated and official GDP deflators: 2004–2018.

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	103.9	104.2	103.8	107.0
2005	102.7	102.7	99.4	103.9
2006	102.0	102.0	100.6	103.9
2007	105.0	105.0		107.8
2008	104.1	104.4		107.8
2009	101.9	101.6	104.1	99.9
2010	101.6	101.9	103.8	107.0
2011	105.1	105.2	106.7	108.2
2012	103.1	103.0	104.7	102.4
2013	102.3	102.3	104.4	102.2
2014	101.9	101.8	102.9	100.8
2015	102.6	102.2	101.6	100.1
2016	101.7	101.6	102.0	101.1
2017	103.0	103.1	102.8	104.1
2018	103.6	103.7	102.5	102.1

Note: All official data used in our estimations for 2004–2017 are drawn from the *China Statistical Yearbook 2018*, and those for 2018 are drawn from the *China Statistical Yearbook 2019*.

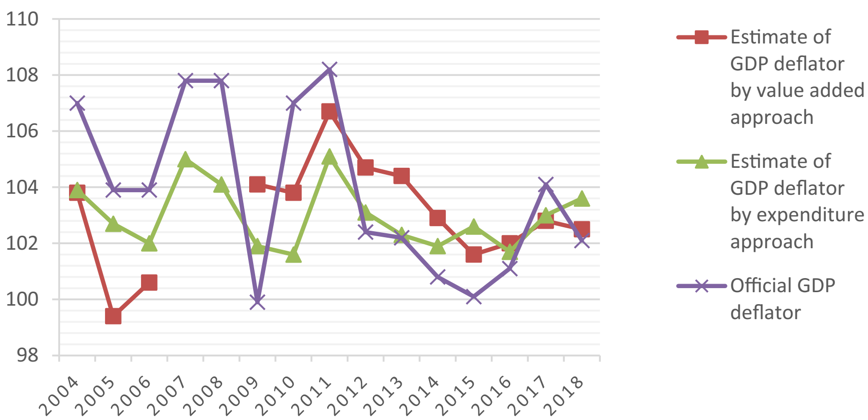

Fig. 1. Estimated and official GDP deflators: 2004–2018.

We then use our estimated GDP deflators to deflate official nominal GDP growth rates to obtain real GDP growth rates during 2004–2018 and compare them with the official figures. The results are presented in Table 4 and plotted in Fig. 2. The adjusted value for real GDP growth fluctuates much more than the official value. Furthermore, when the economy is booming (2004–2008 and 2010–2011), real growth is generally underestimated, and when it slows (2009 and 2012–18), real growth tends to be overestimated. Although the average official real GDP growth during 2004–2018 is very similar to the average of our estimates, the average official real GDP growth during 2012–2018 is overestimated by about 1.0 or 1.2 percentage points depending on whether we use the value added approach or the expenditure approach; however, the overestimation of growth can be more than 2 percentage points in a year. This is probably due to the fact 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 increase faster than the prices of final products. However, when the economy slows down, the opposite may occur as commodity prices decrease faster than the prices 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 real growth when it is strong.

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 to real GDP growth is based on the assumption that nominal GDP growth is accurate. However, as mentioned in the introduction, many economists question the accuracy of China's nominal GDP figures. The most recent systematic study of the issue is by Chen et al. (2019), who use value added tax data to correct for possible over-reporting of GDP figures by local governments. Their main findings are presented in panel A of Fig. 3 and in Table 5. These authors adjust only the nominal GDP growth rates during 2009–2016; however, it is possible to infer the real GDP growth rates from their figures by using the official GDP deflator; these inferred values are also plotted in Fig. 3. From the figure, it can be seen that the inferred real GDP growth rates for 2010 and 2011—which were two boom years following China's 4 trillion yuan stimulus—were significantly lower than that in 2009 during the global financial crisis. This is very counterintuitive and likely wrong. Additionally, 2012 was the first year in the

Table 4
Adjusted and official real GDP growth.

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%	13.2%	13.5%
2005	16.3%	15.7%	11.4%	13.2%	16.4%
2006	16.9%	17.1%	12.7%	14.6%	16.5%
2007	22.8%	23.1%	14.2%	17.0%	
2008	17.8%	18.2%	9.7%	13.1%	
2009	9.4%	9.3%	9.4%	7.3%	5.0%
2010	17.4%	18.3%	10.6%	15.5%	13.9%
2011	18.3%	18.5%	9.5%	12.6%	11.1%
2012	11.3%	10.4%	7.9%	7.9%	5.5%
2013	10.3%	10.2%	7.8%	7.8%	5.6%
2014	8.4%	8.2%	7.3%	6.3%	5.1%
2015	8.0%	7.0%	6.9%	5.3%	5.3%
2016	6.7%	7.9%	6.7%	4.9%	5.8%
2017	8.9%	11.2%	6.9%	5.8%	8.2%
2018	8.9%	8.8%	6.6%	5.1%	6.2%
Average 2004–2018	13.3%	13.5%	9.2%	10.0%	9.1%
Average 2012–2018	8.9%	9.1%	7.2%	6.2%	6.0%

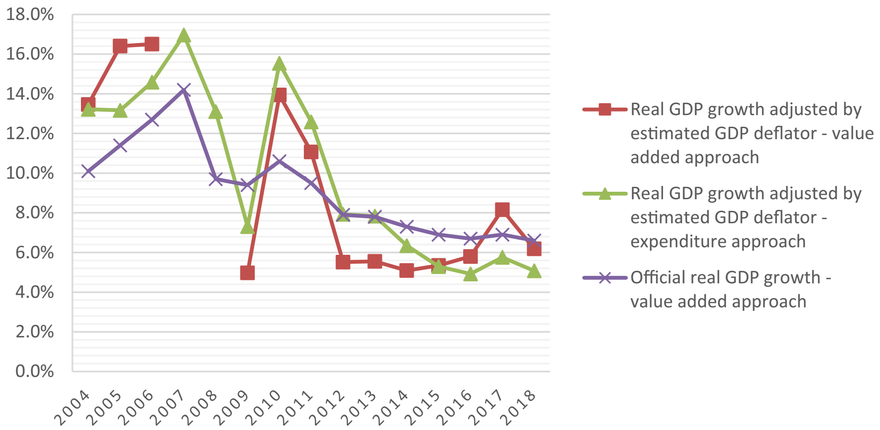

Fig. 2. Adjusted and official real GDP growth during 2004–2018.

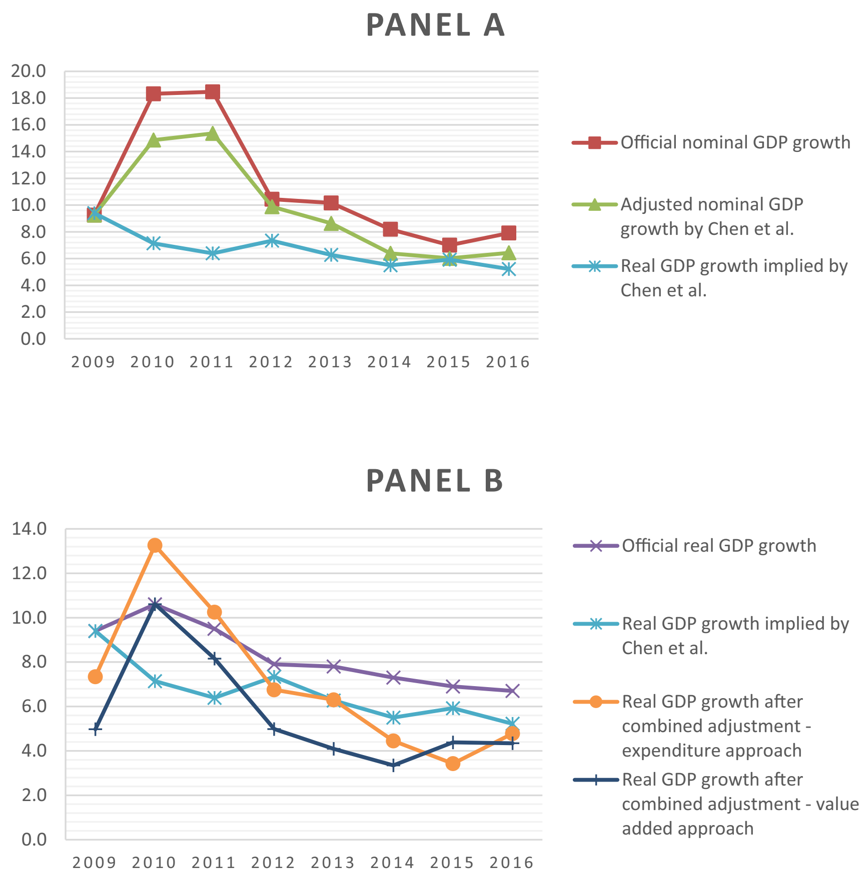

Fig. 3. Real GDP growth after combined adjustment to nominal GDP growth and the GDP deflator.

previous 20 years in which China's GDP growth fell below 8%; however, the real growth for this year implied by Chen et al. (2019) is higher than the implied values of real growth for 2010 and 2011 (boom years). This is again a peculiar result.

However, if instead of the official GDP deflator, we use the alternative GDP deflators estimated in this paper to deflate the adjusted nominal GDP values in Chen et al. (2019), their otherwise baffling results then begin to make perfect sense. In panel B of Fig. 3, we also plot two time series of real GDP growth after the combined adjustment to both the official nominal GDP growth rate as in Chen et al. and the official GDP deflator as in this study, one using the expenditure approach and the other using the value added approach. In

Table 5
Real GDP growth after combined adjustment to nominal GDP growth and the GDP deflator.

Year	Official nominal GDP growth	Adjusted nominal GDP growth by Chen et al.	Official real GDP growth	Real GDP growth implied 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	7.3	5.0
2010	18.3	14.9	10.6	7.1	13.3	10.6
2011	18.5	15.4	9.5	6.4	10.2	8.2
2012	10.4	9.9	7.9	7.3	6.7	5.0
2013	10.2	8.6	7.8	6.3	6.3	4.1
2014	8.2	6.4	7.3	5.5	4.4	3.3
2015	7.0	6.0	6.9	5.9	3.4	4.4
2016	7.9	6.4	6.7	5.2	4.8	4.3
Average 2009–2016	11.2	9.6	8.3	6.6	7.1	5.6
Average 2012–2016	8.7	7.5	7.3	6.1	5.1	4.2

both cases, real GDP growth in the boom years of 2010 and 2011 is now higher than that in 2009 and 2012. If the combined adjustment to China's real GDP growth is closer to the true value, this suggests that the official figure overstates growth during the downturn period of 2012–2016 by an average of 2.2 to 3.1 percentage points; that is, the true growth rate in these years may have been about 4–5% rather than the official 6–8%.

6. Concluding remarks

In this paper, we show that the official method used by the NBS to deflate nominal GDP tends to overstate real GDP during economic downturns and understate real GDP during upturns. We use both the value added approach with double deflation and the expenditure approach, which generate similar results, thus giving more credibility to our findings. Our new estimates of China's GDP deflator support the 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 boom years before 2012.

Although the official real GDP growth rate during our study period is on average very similar to our estimates obtained with both the expenditure and value added approaches, its fluctuation is much lower than that of our estimates. It seems possible, as suggested by some authors (Kerola, 2019; Nakamura et al., 2016), that the official approach may have artificially smoothed GDP growth in the recent decade. For macroeconomic policies to be responsive to current economic conditions, accurate growth figures are very important. Therefore, we would like to argue for a re-evaluation of the official method for measuring both nominal and real GDP in China. If the NBS wishes to continue to rely primarily on the value added approach, it should adopt the double deflation approach and collect better data on intermediate inputs and prices of services. We consider that a preferable choice is to switch to the expenditure approach as the primary national accounting method and rely more on direct surveys than bottom-up reporting. The NBS needs to address the key issues with expenditure accounts, especially the underestimation of household consumption and the overestimation of investment. Many developed countries have rich experience 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.

Acknowledgements

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Appendix A. 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 urban 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) The official price index of exports of goods and the official price index of imports of goods are based on prices in USD before 2014 and in RMB from 2014. We adjust the official indices before 2014 by accounting for the yearly changes in the average USD-to-RMB exchange rates between 2004 and 2013.
(4) The CPI for services is not published in *China Statistical Yearbooks* but is available in the CEIC database.
(5) The implicit price index for the 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 in four 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 Yearbooks*.

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