ANNALS OF ECONOMICS AND FINANCE **25-1**, 327–344 (2024)

Re-estimating the Growth Rate of the Chinese Economy from A Provincial Perspective by Correcting Two Biases

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This paper accepts the way adopted by the official statistics for constructing price indices at sectoral level across provinces and reconstructs provincial output data by reconciling the GDP totals reported in provincial statistical yearbooks and the industry structure in provincial input-output tables. The average annual growth rate of real GDP in the Chinese economy over 1992-2018 is 7.7% based on the preferable double and Tornqvist aggregation approach, which is 1.8 percentage points below the official claimed 9.5%. The alternative estimates show significant volatility of the growth, hence providing much more useful information than the remarkably smoothed official series.

Key Words: The Chinese Economy; Provincial Perspective; Double Deflation; Tornqvist Aggregation.

JEL Classification Numbers: O41, C82, C67, C43.

Disclosure Statement: The author declares that he has no financial and personal relationships with other people or organizations that can inappropriately influence the research work, there is no professional or other personal interest of any nature or kind in any product, service and/or company that could be construed as influencing the position presented in, or the review of this manuscript.

1. INTRODUCTION

Although the Chinese economy has achieved rapid growth over past four decades since 1978, the quality of the official GDP statistics has always been considered controversial. It is difficult to exaggerate the importance of reasonably measuring the growth rate of real GDP in the Chinese economy given that it has become the second largest economy in the world

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1529-7373/2024

in terms of nominal GDP. Correctly measuring China's real GDP growth performance can not only enable the Chinese policymakers to form a comprehensive understanding of the actual economic situation, but also provide references to other countries due to China has deeply integrated into the world economy and had a profound impact on the economic development of other countries.

The price deflator is an important factor that causes the official growth statistics to be questioned. Wu (2002) points out that the Chinese official statistics tend to underestimate actual price changes so as to overestimate the real GDP growth rate. The two strategies researchers have to bypass the price issue are either searching for alternative price deflators or adopting the physical indicator approach. Young (2003) uses farm and sideline products purchasing price index, retail price index, consumer price index, and so on, to replace the official implicit GDP deflators. Kerola (2019) adopts principal component analysis to derive an alternative GDP deflator by using a total of 70 different subindices from the consumer price index, the investment price index, the producer price index, and so on. On the other hand, the essence of the physical indicator approach is using the output in volume to measure the real output so as to avoid the deflation process. For example, Wu (1997) and Maddison (1998) measure the real output of industry and agriculture by using industrial products and farm products, respectively. Xu et al. (2015) uses the globe nighttime light data to gauge the growth rate of China's real GDP. The above studies, to a large extent, support the finding in the current literature that the official statistics tend to understate actual price changes and overstate the real GDP growth rate. By adjusting the nominal value added in the industrial and wholesale and retail trade sectors using value added tax data and that in construction using fixed-capital formation data, Chen et al. (2019) finds that the annual real GDP growth was overstated by about 2 percentage points between 2010 and 2016 in official statistics. However, it is hard to state that the alternative price deflators are better than the official ones due to the officials are responsible for collecting data and constructing GDP deflators. Moreover, the physical indicators do not fall into the scope of national accounting so that the results derived from the physical indicator approach are not comparable with official estimates.

The second factor that causes the official GDP statistics to be questioned lies in the deflation approach. According to Xu (2019), who is the former deputy director of the National Bureau of Statistics of China, the officials adopt single deflation to measure China's GDP at constant price. The key assumption underlying the single deflation is that the price change of intermediate input keeps the same pattern as that of output, which is hard to be considered as an appropriate prerequisite. With the further deepening of the division of labor, the linkage among industries has been strength-

ened. An industry usually consumes more than one type of intermediate inputs delivered from other industries in its production process. Thus, the final price change of intermediate input of an industry should be the comprehensive result of various types of intermediate inputs consumed in the production process, which hardly keeps the same pattern as that of output. In order to better measure price changes of both output and various intermediate inputs, the double deflation is recommended as the theoretically sound approach to derive real value added (United Nations, 2009; OECD, 2001; European Communities, 2008), in which the real value added is calculated as the residual between the gross output and intermediate inputs at constant price, both are deflated by their own price deflators, respectively.

The aggregation approach is the third factor that affects the results of the Chinese official GDP statistics. The official statistics adopt the constant-price value aggregation approach to measure the growth rate of China's real GDP, that is, first summing up the real value added across industries to derive the aggregate GDP and then calculating its growth rate. The Laspeyres price index or Paasche price index is the common way adopted to calculate the real value added of each industry, which uses quantities of a given base year and of a current year as fixed weights, respectively. The constant-price value aggregation approach tends to introduce the substitution bias due to the base year-fixed price index keeps the structure of goods in the basket over time fixed, ignoring that consumers substitute goods in response to price changes. Consequently, the Laspeyres price index tends to give a higher rate of volume growth in years close to current year and the Paasche price index tends to give a lower rate of growth at the years closer to the current year (United Nations, 2003). The Tornqvist aggregation approach that can avoid the substitution bias, in which the growth rate of real GDP of the whole economy is derived by aggregating the growth rates of value added of each industry with the nominal shares of value added of each industry in the whole economy as weights, should be applied to measure the growth rate of real GDP of the aggregate economy.

By correcting above three biases via reconstructing sectoral-specific price deflators and adopting double deflation and Tornqvist aggregation approach, Wu and Li (2021) make the effort to gauge the growth rate of China's real GDP from an industry perspective by following theory as much as possible. They find that the average annual growth rate is 8.3% during 1978-2018, which is 1.2 percentage points below the official 9.5%. Moreover, the annual change of the growth rates is much more volatile than official estimates for either the whole economy or sectors.

There still exists room to improve the work of Wu and Li (2021). Firstly, they measure the growth rate of real GDP of the whole economy from an industry perspective, which implies that the development of each industry is identical across provinces and thus overlooks the impact of the unbal-

anced provincial economic development on the development of the industry[1]. Although the Chinese economy has grown rapidly over past four decades, there exists obvious growth heterogeneity across provinces, especially between coastal and inland regions, eastern and western regions. Furthermore, under the regime of regionally decentralized authoritarian (Xu, 2011), the central government evaluates the ability of local officials based on the performance of provincial economic growth. To win the growth competition among their counterparts, local governors are inclined to adopt industry policy to stimulate the development of certain industries and further of the provincial economy. Given that resource endowment and industry structure are heterogeneous across provinces, the industry policy adopted by local governments is different among provinces, which brings about different influences on the development of the industry. Therefore, it is necessary to integrate provinces into the entire accounting framework to form a complete blueprint about the growth of the Chinese economy. Secondly, as mentioned earlier, it is difficult to argue that the reconstruction of price deflators of each industry by Wu and Li (2021) is better than the official given that the latter is in charge of data collection and should be considered as constructing price deflators by using as much data as possible. The discrepancy of the construction of price deflators between the official and Wu and Li (2021) is not conducive to provide a common ground for communication between each other.

In this paper, we accept the way adopted by the official statistics for constructing price indices of each industry by province, which could provide a common ground for productive communication with official statisticians. Meanwhile, we correct two biases in official statistics, i.e., adopting the theoretically sound double deflation and Tornqvist aggregation approach, to make the measurement follow the theory, and test the influences of two biases on the growth rate of China's real GDP. In addition, this paper measures the growth rate of real GDP of the whole economy from the perspective of provincial industry, that is, taking the impacts of unbalanced provincial development on the growth of the industry into account, which is not only beneficial to further master the growth details of the Chinese economy, but also to analyze the aggregate growth issues from the sub-aggregate level.

The rest of this paper is organized as follows. Section 2 first uses formulas to show the effects of two biases in official statistics on the growth rate of real GDP in the Chinese economy, and then introduces the procedures for constructing provincial accounts. Section 3 provides and analyzes the growth results. Section 4 concludes this paper.

[1]All 31 regions in Chinese Mainland are referred to as provinces.

2. METHODOLOGY AND DATA CONSTRUCTION

Following Wu and Li (2021), the nominal value added of industry i in province j is the residual of gross output and total intermediate input according to the accounting identity, that is,

$$P_{i,j}^{V} V_{i,j} = P_{i,j}^{Y} Y_{i,j} - P_{i,j}^{M} M_{i,j} \tag{1}$$

where $V_{i,j}, Y_{i,j}$, and $M_{i,j}$ are value added, gross output and intermediate input of industry i in province j. $P_{i,j}^{V}, P_{i,j}^{Y}$ and $P_{i,j}^{M}$ are the corresponding prices. Time subscripts are suppressed for convenience wherever possible.

In case of single deflation, the real value added is estimated by deflating the nominal value added with a price index, and the price index of gross output is usually adopted, that is,

$$V_{i,j} = \frac{P_{i,j}^{Y} Y_{i,j} - P_{i,j}^{M} M_{i,j}}{P_{i,j}^{Y} / P_{i,j}^{Y_0}} \tag{2}$$

where $P_{i,j}^{Y_0}$ represents the price of gross output at a base year.

Taking the differential of Equation (2), we can derive the growth rate of real value added as:

$$\Delta \ln V_{i,j}^{S} = \frac{P_{i,j}^{Y} Y_{i,j}}{P_{i,j}^{V} V_{i,j}} \Delta \ln Y_{i,j} - \frac{P_{i,j}^{M} M_{i,j}}{P_{i,j}^{V} V_{i,j}} \Delta \ln M_{i,j} - \frac{P_{i,j}^{M} M_{i,j}}{P_{i,j}^{V} V_{i,j}} (\Delta \ln P_{i,j}^{M} - \Delta \ln P_{i,j}^{Y}) \tag{3}$$

where $\Delta \ln V_{i,j}^{S}$ is the growth rate of industry value added based on single deflation and $P_{i,j}^{V}$ is equal to $P_{i,j}^{Y}$ in case of single deflation.

On the other hand, taking the differential of Equation (1), we can derive the growth rate of real value added by double deflation ($\Delta \ln V_{i}^{D}$) as:

$$\Delta \ln V_{i,j}^{D} = \frac{P_{i,j}^{Y} Y_{i,j}}{P_{i,j}^{V} V_{i,j}} \Delta \ln Y_{i,j} - \frac{P_{i,j}^{M} M_{i,j}}{P_{i,j}^{V} V_{i,j}} \Delta \ln M_{i,j} \tag{4}$$

Combining Equations (3) and (4), we can derive the difference of the growth rate of industry value added between double deflation and single deflation, that is,

$$\Delta \ln V_{i,j}^{D} - \Delta \ln V_{i,j}^{S} = \frac{P_{i,j}^{M} M_{i,j}}{P_{i,j}^{V} V_{i,j}} (\Delta \ln P_{i,j}^{M} - \Delta \ln P_{i,j}^{Y}) \tag{5}$$

which shows that the discrepancy of the growth rate of industry value added between double deflation and single deflation depends on the relative price changes of industry intermediate input and gross output. If the

price change of intermediate input is increasing (decreasing) faster than that of gross output, the growth rate of industry value added will be underestimated (overestimated) by adopting single deflation.

Thus far, real value added and its growth rate have been discussed at industry level, and the question arises as to how to aggregate them with a view to obtain an overall measure of the growth rate of the provincial economy and further of the whole economy. In aggregating, two choices can be made: one is the constant-price value aggregation and the other is the Tornqvist aggregation. As stated earlier, the constant-price value aggregation would introduce the substitution bias due to the base year-fixed price index ignores the substitution of goods corresponding to their price changes, while the Tornqvist aggregation takes the nominal share of individual components in the total as weights, which considers the structure change of each component and thus avoids the substitution bias. Furthermore, as shown in above formulas, the growth rate of each indicator is essentially calculated by following the Divisia index approach, i.e., calculated in continuous time. In practice, however, the economic data are not continuous over time but come in discrete-time units, and the Tornqvist index is the exact approximation of the Divisia index as long as the function is sufficiently smooth, which is the key assumption underlying the methodology in this paper.

Following the Tornqvist index approach, the growth rate of value added of province j is calculated as the weighted average of the growth rates of value added of industry i, that is,

$$\Delta \ln V_j = \sum_i \overline{w}_{i,j} \Delta \ln V_{i,j}^D \tag{6}$$

where $\overline{w}_{i,j}$ is the two-period average nominal value added share of industry i in province j, V_j is the real value added of province j.

Further, the growth rate of value added of the whole economy is calculated as the weighted average of the growth rates of value added of province j, that is,

$$\Delta \ln V = \sum_j \overline{w}_j \Delta \ln V_j \tag{7}$$

where $\overline{w}_j$ is the two-period average nominal value added share of province j in the whole economy, V is the real value added of the whole economy.

The nominal provincial accounts used in this paper are from Li (2021)[2]. The official provincial statistics do not report complete provincial income

[2]The main content of Li (2021) is to construct data at provincial level, which provides a powerful database for this study. The main steps of data construction are briefly mentioned in the text.

and production accounts and instead focus on the indicator of value added. However, the available value added data by sector in official statistics suffer from inconsistences in concept, coverage, and classification over time. Revealing the structure of intermediate inputs of every industry is the critical prerequisite for conducting theoretically sound double deflation. Therefore, provincial input-output tables are the ideal data tool to reconstruct provincial accounts. The provincial bureau of statistics had started conducting detailed input and output survey and publishing provincial input-output table every five years since 1987. The benchmark provincial input-output table covers detailed industries, the total number of industries is over 100, which is more than industries covered by official GDP statistics and thus helpful to disclose the input-output linkages among industries. Besides, the detailed industry classification in the provincial input-output tables is conducive to maintain the classification consistent over time via regrouping industries.

To match the GDP total in official statistics, Li (2021) first takes the value added of three broad industries, i.e., the primary, secondary, and tertiary industries, from provincial statistical yearbooks as control totals, and the industry structure from benchmark provincial input-output tables as control structures to construct totals of 37 industries in each province. Then, Li (2021) constructs time series of input-output tables of each province by using the time series of the industry structure constructed by interpolating the industry structure of benchmark provincial input-output tables and the control totals constructed earlier. The time span of the reconstructed provincial accounts covers 1992-2018. To get items at constant price, this paper follows the way adopted by the official statistics for constructing sectoral-specific producer price index (PPI) in each province, which is shown in Table 1. Adopting the same principle to construct price indices can exclude the important price factor that causes the incomparability between the results of this study and official figures, and test the impacts of calculation methods adopted by official statistics that do not conform to the theory on the results.

3. RESULTS

As mentioned above, with the continuous development of the Chinese economy, the economic growth performance and the industry structure among provinces have shown significant differences. Table 2 shows the heterogeneity among provinces from the perspectives of industry structure and growth rate. The classification of nine sectors is consistent with the classification in official statistics. In terms of the overall provincial economy, the share of Guangdong in Chinese economy is the biggest, i.e., 10.8% in 2018, while that of Tibet is the smallest, merely 0.2%, and provincial

TABLE 1.

Approaches Used in Constructing Provincial Sector-specific PPIs

Sector Code	Approach	Data Sources
Agriculture (1)	Aggregate PPI for all agricultural products	"Price Index", PSY
Mining (2-5)	Sector-specific PPIs, not adjusted	"Price Index", PSY
Manufacturing (6-24)	Sector-specific PPIs, geometric average of sub-sectors	"Price Index", PSY
Utilities (25)	Aggregate, geometric average of sub-sectors	"Price Index", PSY
Construction (26)	Investment price index of construction and installation	"Price Index", PSY
Wholesale and retail (27)	Retail price index	"Price Index", PSY
Hotels and catering (28)	Geometric average of residence and dining out in provincial consumer price index	"Price Index", PSY
Transportation and storage (29)	Geometric average of index of turnover volume of passenger and freight and price index of service items	"Transportation, Post and Telecommunication Service", "Price Index", PSY
Post and telecommunication (30)	Business volume index of post and telecommunication, communication service, wage index of urban staff	"Transportation, Post and Telecommunication Service", "Employment and Remuneration", PSY
Financial services (31)	Price index of money and financial service	"National Economic Accounts", "Price Index", PSY
Real estate services (32)	Index of floor space of buildings under construction, and price index of service items	"Real Estate", "Price Index", PSY
Leasing, business services (33)	As financial services (31)	"National Economic Accounts", "Price Index", PSY
Public management (34)	Provincial consumer price index	"Price Index", PSY
Education (35)	Tuition and childcare charges before 2000; educational service from 2001	"Price Index", PSY
Healthcare, social welfare (36)	Medical care service	"Price Index", PSY
Other services (37)	Geometric average of cosmetic beauty fees, culture and entertainment expense, repair and other service fees before 2000; geometric average of culture and entertainment expense, tourism from 2001 onwards	"Price Index", PSY

Note: PSY refers to provincial statistical yearbook.
Source: Author's construction with adjustments by following the approaches in Table 1 of Xu (2019) while taking into account the availability of data at the provincial level.

GDP share shows a certain degree of dispersion according to the standard deviation. The differences in value added shares of nine sectors among 31 provinces are also apparent. For example, the share of agriculture in Heilongjiang is 24.4% while it is 0.3% in Shanghai, the share of industry in Henan is 40.4% while it is 12.2% in Hainan, and so on. The differences in value added shares of each sector among 31 provinces reflect the comparative advantages of each province to some extent.

TABLE 2.

Descriptive Statistics on Growth Heterogeneity among Chinese Provinces

	Min	Max	Standard deviation
	Nominal value added share (%)		
Provincial GDP	0.2 (Tibet)	10.8 (Guangdong)	2.5
Agriculture	0.3 (Shanghai)	24.4 (Heilongjiang)	5.2
Industry	12.2 (Hainan)	40.4 (Henan)	7.6
Construction	2.0 (Shanghai)	12.1 (Chongqing)	2.6
Wholesale and retail trade	5.6 (Ningxia)	15.7 (Anhui)	2.5
Transport, storage and post	4.4 (Anhui)	14.9 (Beijing)	2.0
Hotel and catering services	1.0 (Shanghai)	3.7 (Hainan)	0.6
Finance	0.7 (Fujian)	15.7 (Shanghai)	2.8
Real estate	3.1 (Zhejiang)	13.9 (Hainan)	2.4
Others	13.9 (Hebei)	51.9 (Tibet)	6.8
	Real growth rate per annum (%)		
Provincial GDP	2.6 (Heilongjiang)	11.6 (Tianjin)	1.9
Agriculture	−11.6 (Shanghai)	6.0 (Xinjiang)	4.4
Industry	1.3 (Heilongjiang)	17.3 (Fujian)	3.1
Construction	−2.5 (Hainan)	13.4 (Chongqing)	4.0
Wholesale and retail trade	5.7 (Xinjiang)	16.3 (Shanghai)	2.7
Transport, storage and post	−4.1 (Tibet)	4.3 (Ningxia)	2.1
Hotel and catering services	1.6 (Beijing)	11.8 (Hunan)	2.6
Finance	9.1 (Fujian)	19.7 (Beijing)	2.3
Real estate	−4.1 (Tibet)	7.2 (Guangdong)	2.6
Others	4.9 (Liaoning)	12.6 (Tibet)	1.6

Note: (1) The nominal value added shares are values in 2018. Provincial GDP share is the value added share of each province in the Chinese economy while that of nine sectors is the value added share of each sector in each province. (2) The growth rate is the average annual growth rate over 1992-2018. Source: Author's estimation.

The differences on development of industries can also be reflected in terms of growth rates. During 1992-2018, the average annual growth rate of Tianjin is the highest, i.e., 11.6%, while that of Heilongjiang is 2.6%. Based on the standard deviation, the degree of dispersion of the growth rates among provinces is lower than that of provincial GDP shares. The

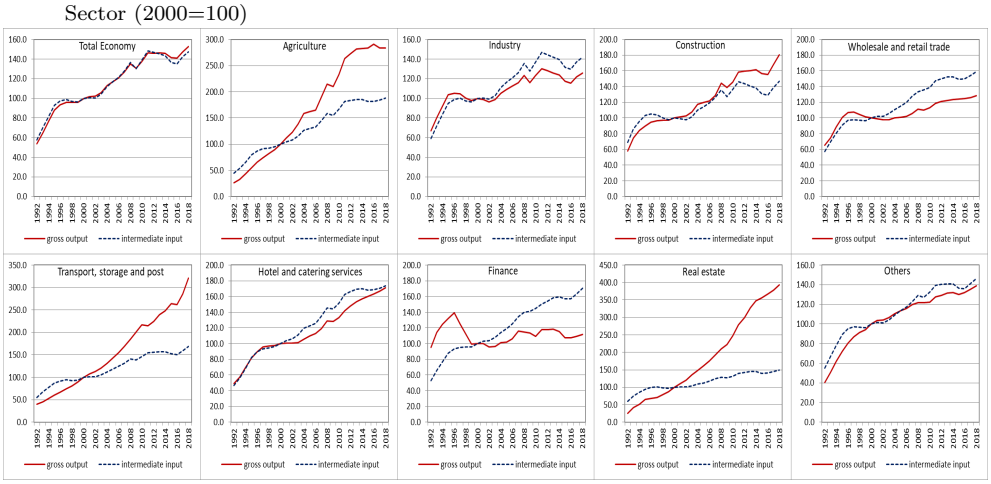
growth rates of each sector among provinces exhibit evident growth heterogeneity. For example, the average annual growth rate of industry in Fujian is 17.3% over 1992-2018 while it is 1.3% in Heilongjiang, the average annual growth rate of finance in Beijing is 19.7% over 1992-2018 while it is 9.1% in Fujian, and so on. In a word, whether in terms of industry structure or growth rate, it is clear that there exists obvious heterogeneity among Chinese provinces. This implies that it is necessary to take into account heterogeneity among provinces when measuring the growth rate of real GDP in the Chinese economy because the heterogeneity among provinces could result in inconsistent price changes of gross output and intermediate inputs at industry level and in turn transmit to the provincial economy and the Chinese economy.

To test if the deflation approach has impacts on the estimates of growth rate, Figure 1 shows the comparison of price changes of intermediate input and gross output of the whole economy and nine sectors. For the whole economy, the growth trend of the price of gross output is similar to that of intermediate input, but shows faster growth in recent years. During 1992-2018, the growth rate of the output price is 4.1% per annum, which is faster than 3.7% of intermediate input. According to Equation (5), this indicates that the growth rate of the Chinese economy would be exaggerated by adopting single deflation approach albeit applied by most of the current studies and the official statistics.

From the sectoral perspective, there exists obvious differences between the price changes of output and intermediate input. The growth of the output price of agriculture, construction, transport, storage and post, and real estate is apparently higher than that of intermediate input. Although the price index of output of the other service sector is below that of intermediate input, its growth rate is higher than the latter, which is 4.8% and 3.8%, respectively. As a result, the growth rates of real value added of these five sectors will be exaggerated by adopting single deflation approach. On the contrary, the growth of the output price of industry, wholesale and retail trade, hotel and catering services, and finance is slower than that of intermediate input, and thus their growth rates will be underestimated by using single deflation. Furthermore, the combined effect of price changes of output and intermediate input of nine sectors moderates the heterogeneity between the price changes of output and intermediate input of the whole economy.

Table 3 uses different approaches to test the bias in the estimates of growth rate of China's real GDP. The Chinese statistical yearbook reports the time series of the growth rate of the whole economy, that is, 9.5% per annum, but with no explanation about how to derive it. With the data of nine sectors from the official yearbooks, we reassess the growth rate

FIG. 1. Comparison of Price Indices of Intermediate Input and Gross Output by Sector (2000=100)



Note: (1) The price indices of intermediate input and gross output of nine sectors at national level are a weighted average of that of corresponding sectors across all provinces, and price indices of the whole economy are further a weighted average of that of nine sectors. (2) To save space, the comparisons of price indices of intermediate input and gross output of nine sectors at provincial level are not shown in the text.
Source: Author's estimation.

of real GDP in the Chinese economy by adopting different deflations and aggregation approaches.

By using the constant price value aggregation approach, the results show that there exists obvious substitution bias in both the official and alternative estimates. Specifically, the annual growth rate of the whole economy over 1992-2018 declines from 9.4% to 9.2% by using the single deflation and changing the base year of the Laspeyres price index from 1995 to 2015 with the official data, while the alternative estimate declines from 10.0% to 6.3% in the case of single deflation, and from 11.2% to 5.9% in the case of double deflation. It is clear that the degree of the decline in the growth rate of the whole economy based on the reconstructed provincial data is more pronounced than official figures, which demonstrates the expectation that the substitution bias will be more apparent with more detailed data. In order to avoid the substitution bias as much as possible, we adopt the Fisher index approach to moderate the bias introduced by fixing the Laspeyres price index at one base year, which is also verified by the results shown in Table 3. Specifically, the annual growth rate of the whole economy over 1992-2018 is now 9.3% with official data, while 7.7% and 7.8% with provincial data by using single and double deflation approach, respectively.

Meanwhile, according to the c.o.v. coefficient, the annual change of the official growth rate is quite smooth, which is always criticized by most of the current studies for losing the information about actual economic fluctuations. On the other hand, the alternative growth estimates exhibit the characteristics that the time series of the growth rate is more dispersive than official one, and the growth series in the case of double deflation tend to show stronger fluctuations than that in the case of single deflation given that the former considers to a larger extent the price conduction effect transmitted through the input-output linkage among industries and provinces.

The bottom panel of Table 3 shows the results based on Tornqvist aggregation approach that can effectively avoid the substitution bias. The annual growth rate of real GDP in the Chinese economy by using official data of nine sectors is 9.5%, which is the same as that reported in the official yearbook. The alternative growth rates by using reconstructed provincial data are 8.3% in the case of single deflation and 7.7% in the case of double deflation, respectively. This, to a certain extent, demonstrates that the price is indeed an important factor that affects the measurement of the growth rate of real GDP in the Chinese economy. Compared to official data of nine sectors, the measurement based on the reconstructed provincial data can to a greater extent consider the price changes of individual industries even if adopting the single deflation and further fully capture the price changes of intermediate inputs of each industry by adopting double deflation. The price change of each industry does not only bring about impacts on its own growth, but has an important effect on other industries via the input-output chain among industries and provinces. The wider the scope of price transmission, the greater the impact on the overall economy. The alternative growth estimates during the entire period tend to be lower than the official figures because of the consideration of price transmission effect, especially in the case of double deflation, but show stronger fluctuations than the latter.

Figure 2 shows the annual changes of the growth rate of the Chinese economy in various scenarios. The comparison between pairwise lines reflects the impacts of adopting sub-aggregate level data, double deflation approach, and Tornqvist aggregation approach on the measurement of China's growth rate. Specifically, by adopting single value aggregation based on the Fisher index approach, the difference between the results with official data and that with the reconstructed provincial data can be accounted for the adoption of more detailed data. The adoption of double deflation accounts for the difference in the result derived by adopting single value aggregation based on the Fisher index approach. Further, the adoption of Tornqvist aggregation approach is responsible for the difference between the results derived by using double value aggregation based on the Fisher index ap-

TABLE 3.

The Growth Rates of China's GDP in various Scenarios (%)

	1992-2018	1992-1996	1997-2001	2002-2007	2008-2012	2013-2018	c.o.v.[1]
Official (method unknown)	9.5	12.0	8.3	11.3	9.4	7.0	0.233
Constant price value aggregation							
Official[2]							
…Single, Laspeyres 1995	9.4	11.6	8.2	11.3	9.6	6.9	0.235
…Single, Laspeyres 2015	9.2	10.8	8.1	11.1	9.3	7.0	0.218
…Single, Fisher[3]	9.3	11.3	8.2	11.2	9.4	7.0	0.226
Alternative							
…Single, Laspeyres 1995	10.0	7.0	7.4	13.1	13.0	8.8	0.345
…Single, Laspeyres 2015	6.3	0.4	1.9	9.3	10.4	7.6	0.740
…Single, Fisher[3]	7.7	2.7	4.0	10.9	11.4	8.1	0.542
…Double, Laspeyres 1995	11.2	7.8	6.6	15.2	15.7	9.7	0.413
…Double, Laspeyres 2015	5.9	0.8	0.2	7.9	11.5	7.4	0.905
…Double, Fisher[3]	7.8	3.2	2.1	11.0	12.9	8.3	0.648
Real growth rate aggregation							
Official[2]							
…Single, Tornqvist	9.5	11.9	8.3	11.3	9.4	7.0	0.233
Alternative							
…Single, Tornqvist	8.3	7.6	5.6	10.3	10.2	7.3	0.315
…Double, Tornqvist	7.7	6.6	4.3	10.4	10.4	6.4	0.428

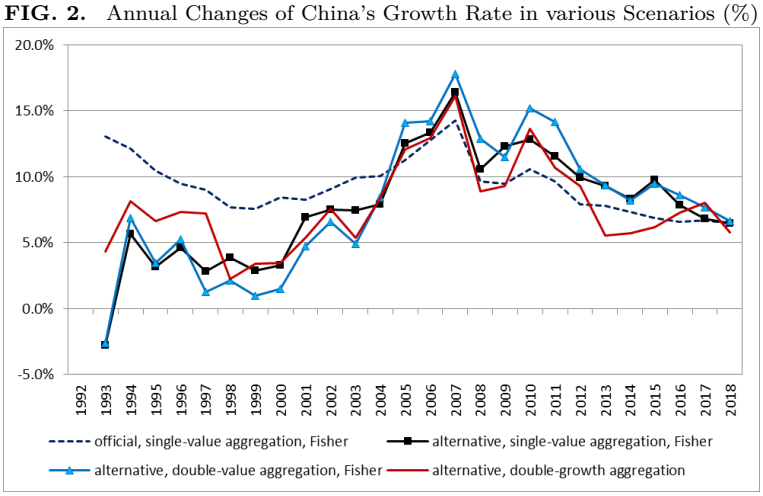
Note: (1) "c.o.v." is the coefficient of variation to test the dispersion of the entire series referred, which is defined as the ratio of the standard error of a series to its average value. The larger the value, the more dispersive the time series. (2) The official estimates are based on the economy-wide 9 sectors while the alternative estimates are based on the matrix of 31 provinces × 37 sectors. (3) The Fisher index is calculated as the geometric average of the growth rates by using Laspeyres index at five benchmarks, i.e., 1995, 2000, 2005, 2010, and 2015.
Source: Author's estimation.

proach and that derived by using double growth aggregation. Generally speaking, compared to the alternative estimates, the official figures tend to overestimate the growth rate of real GDP in the Chinese economy before 2005 while underestimate China's growth rate from 2005 onwards.

In addition, the alternative estimates are more volatile than the official ones, which could reflect the actual economic fluctuations. For example, the alternative growth estimates show that the Chinese economic growth was in the downward trend during the late 1990s, rose since 2001 when China had entered into the World Trade Organization, and peaked at 2007. The growth of the Chinese economy had always shown a downward trend since the Financial Crisis happened in 2008 although the one-off growth bonus in 2010 is accounted for the fiscal stimulus plan launched in 2008 by the

central government for getting rid of the negative influences of the crisis on the economy.

FIG. 2. Annual Changes of China's Growth Rate in various Scenarios (%)



Source: Annual data in Table 3.

To compare the growth performance at industry level, Table 4 shows the growth rates of nine sectors using official data and that based on the preferable double Tornqvist approach. As mentioned earlier, the official statistics adopt single deflation to calculate the growth rates of either the whole economy or sectors. In the official statistics, except for agriculture, the rest sectors achieve rapid growth rates over the entire period, and the growth rate discrepancy among them is very small. However, even if excluding agriculture, the alternative estimates show distinct growth heterogeneity among sectors, that is, the average annual growth rate of finance over the whole period is 16.4%, while that of transport, storage and post is 0.8%. The sectors with large difference in growth rate between the official and alternative estimates are agriculture, construction, transport, storage and post, finance, and real estate, which echoes the obvious differences in price changes of output and intermediate input of these sectors shown in Figure 1. The single deflation adopted by official statistics assumes that the price changes of output and intermediate input of each sector keep the same pattern with each other, which cannot reflect impacts of price change of intermediate input as well as price conduction effect from other sectors on the growth fluctuations of each sector. According to the annual changes of growth rates of nine sectors shown in Figure 3, it is clear that although the annual changes of alternative estimates roughly keep the same pattern as official ones, it shows strong fluctuations than the latter.

TABLE 4.

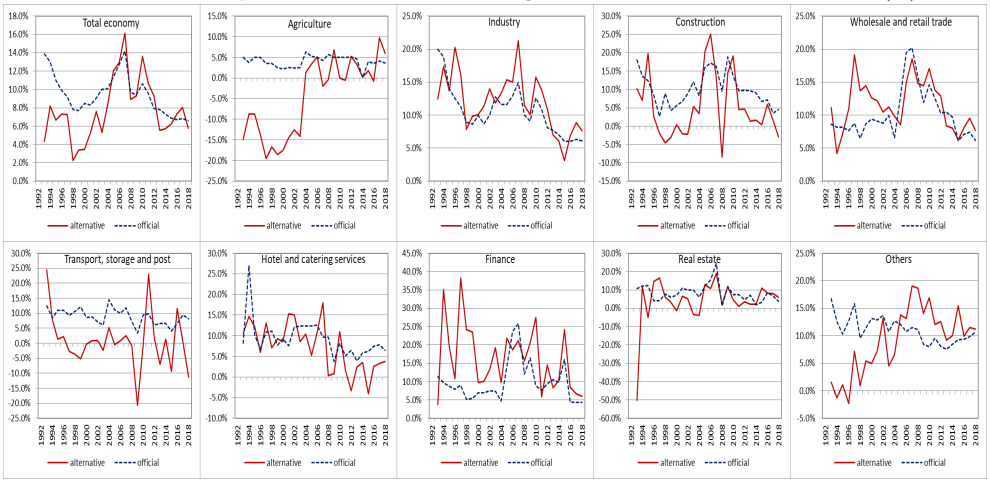
Comparison of The Growth Rates of Sectors (%)

	1992-2018	1992-1996	1997-2001	2002-2007	2008-2012	2013-2018	c.o.v.
Official (single)							
Total economy	9.5	12.0	8.3	11.3	9.4	7.0	0.233
…Agriculture	4.0	4.7	2.9	4.3	5.2	3.3	0.344
…Industry	10.6	16.3	9.5	12.3	10.1	6.5	0.341
…Construction	10.1	13.1	5.7	13.1	12.3	6.8	0.454
…Wholesale and retail trade	10.2	8.1	8.5	13.0	13.0	7.8	0.370
…Transport, storage and post	8.9	10.8	9.9	10.1	7.2	6.9	0.299
…Hotel and catering services	9.3	13.1	9.3	11.9	6.6	6.3	0.485
…Finance	10.0	9.4	6.7	13.9	10.9	8.3	0.550
…Real estate	8.3	9.8	7.2	13.0	6.5	5.2	0.586
…Others	11.0	13.1	12.6	11.9	9.1	9.2	0.210
Alternative (double, Tornqvist)							
Total economy	7.7	6.6	4.3	10.4	10.4	6.4	0.428
…Agriculture	−4.6	−11.5	−17.4	−3.1	2.2	3.4	−2.001
…Industry	12.0	15.9	11.1	15.1	12.4	6.6	0.362
…Construction	5.2	9.9	−2.3	10.8	6.9	1.3	1.661
…Wholesale and retail trade	11.5	8.4	14.4	12.3	14.6	8.0	0.327
…Transport, storage and post	0.8	8.9	−2.2	1.1	0.6	−2.4	12.065
…Hotel and catering services	7.2	10.8	10.7	11.3	2.1	1.9	0.819
…Finance	16.4	17.3	21.2	17.3	16.8	10.6	0.548
…Real estate	4.0	−7.1	6.2	6.7	4.6	6.2	3.199
…Others	9.1	−0.2	5.1	11.7	14.9	11.2	0.657

Source: Author's estimation.

It is beneficial to understand the significance of the findings and their practical implications through comparative analysis that is mainly conducted by comparing this study with Wu and Li (2021). There are two main differences between these two studies: one is that this study expands the research scope of Wu and Li (2021) to the provincial level, and the other is that this study accepts the way adopted by the official statistics for constructing price indices of each industry by province so as to enhance comparability with official statistical results. Figure 4 shows that the annual growth rates of Wu and Li (2021) are higher than our results before 2006 and the opposite is true from 2006 onwards. The average annual growth rate of the whole economy over 1992-2018 is 8.1% in Wu and Li (2021).

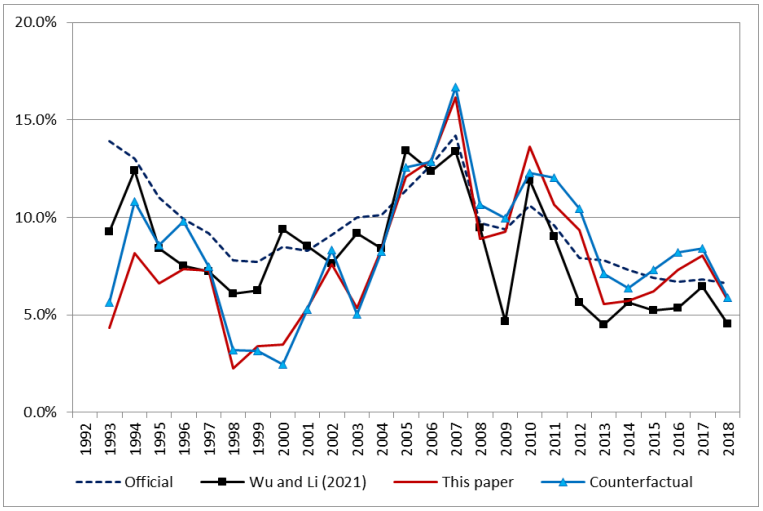
FIG. 3. Comparison of The Annual Changes of The Growth Rates of Sectors (%)



Source: Annual data in Table 4.

To explain the growth differences between Wu and Li (2021) and this study, we test the impact of overlooking price differences across provinces on the results by assuming the price indices of each industry in all provinces are the same as those in Wu and Li (2021), which denotes as the counterfactual result. The difference between the counterfactual result and Wu and Li (2021), to a large extent, can be accounted for the expansion of the research scope from industry level to provincial level. Although the average annual growth rates over the entire period in both studies are close, i.e., 8.4% and 8.1%, respectively, the differences on the annual changes between these two results are quite apparent. Moreover, the difference between the counterfactual result and this study can be accounted for considering price differences across provinces. Although the annual changes between these two results are similar, the difference between the average annual growth rates of Chinese economy over the entire period is obvious, that is, 8.4% and 7.7%, respectively. In other words, price differences across provinces can account for the differences in the results of Wu and Li (2021) and this study to a large extent, which implies that ignoring price differences across provinces caused by differences in provincial development and industrial structure could overestimate the growth rate of the overall Chinese economy. Last but not least, it is clear that the growth trend of the official estimate is smoother than alternative scenarios.

FIG. 4. Comparison of Annual Changes of The Growth Rate of Chinese Economy (%)



Source: Author's estimation.

4. CONCLUSIONS

The lack of strictly following theoretical methods to measure the growth rate of real GDP in the Chinese economy is the main reason why most of the current studies cast doubt on the quality of the official GDP statistics. This paper accepts the way adopted by the official statistics for constructing price indices at sectoral level in each province and reconstructs provincial output data by reconciling the GDP totals reported in provincial statistical yearbooks and the industry structure in provincial input-output tables. Consequently, this paper follows the theoretically sound double deflation and Tornqvist aggregation approach to reassess the growth rate of real GDP in the Chinese economy from a provincial perspective over 1992-2018. Following the theoretical methods to measure China's growth rate can not only avoid the problem of "GDP growth statistics without theory", but also provide a common ground for communication with official statisticians.

The results show that the average annual growth rate of real GDP in the Chinese economy over 1992-2018 is 7.7% based on the preferable double and Tornqvist aggregation approach, which is 1.8 percentage points below the official claimed 9.5%. There are two main reasons for such growth discrepancy between the official and alternative estimates. One is that the double deflation can reflect impacts of price changes of intermediate input of each sector as well as price conduction effect from other sectors via the input-output linkage on the growth of every sector. The other is that

the Tornqvist aggregation, which sums up the growth rate of individual sectors with their nominal value added share as weights, can avoid the substitution bias caused by fixing the Laspeyres price index at one base year. Meanwhile, the alternative estimates for either the whole economy or sectors show significant volatility of the growth, hence providing much more useful information than the remarkably smoothed official series.

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