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In search of fluctuations: Another look at China's incredibly stable GDP growth

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Abstract

Economic statistics, and especially GDP figures influence policy analysis, political discussions and decisions. As one the world's largest economies, China's GDP growth rate is also of great international importance. During the past few years, China's official real GDP growth has remained surprisingly stable. Taking the nominal GDP growth and price index data as given and experimenting with alternative deflators, this paper tries to track the missing fluctuations of the real GDP growth of recent years. While taking no stand on the level of the growth rate, this paper manages to reveal fluctuations extending the year 2014. Based on the constructed growth series, real GDP growth decreased during 2015–2016 before picking up in 2017. For the current year, growth rate is again decelerating.

1. Introduction

Economic statistics influence policy analysis, political discussions and decisions. Being the world's second largest economy by nominal GDP and the largest by purchasing power parity, Chinese gross domestic product figures are of great interest internationally. Nearly one fifth of the world's aggregate GDP and a third of world's GDP growth is contributed by China. However, the reliability of these GDP figures has been debated widely for years. An appendix in Jia (2011) offers an extensive literature review on the studies of China's macro data quality. For ex. Rawski (2001) argues that Chinese economy might have been growing a couple of percentage points slower than the official figures of about 7 % during 1997–2001 would suggest. Others (for ex. Maddison and Wu, 2007; Maddison, 2006; Young, 2003) agree by comparing official GDP figures with various supply side indicators. However, there also exists studies for the opposite. For ex. Holz (2006a, 2006b and 2014), Clark et al. (2017a and 2017b) and Perkins and Rawski (2008) find that the official data is generally accurate or can be in fact understating the true economic growth.

As a result of this broad debate, various alternative GDP measures have emerged. The Conference Board *Total Economy Database* provides an alternative estimate for Chinese GDP data based on a working paper by Wu (2014). They presume biases are related to misreporting at a local level and a lack of clarity in methods especially with regards to price deflators. Conference Board's alternative series is constructed bottom up on a sector-by-sector basis, relying both on official and constructed series. This alternative GDP series indicates much larger volatility in the year-on-year estimates, sometimes showing faster growth rates than the official numbers (de Vries and Erumban, 2017).

Another widely cited alternative is the Li Keqiang index, named after the current premier. A US State Department memo released by Wikileaks revealed how Li, then a Party Committee Secretary in Liaoning, told in 2007 an US ambassador how the official GDP figures were so unreliable that he himself used three alternative indicators instead when wanting to know the true state of the economy: electricity volume, bank loans and railway cargo volume. The Li Keqiang index reveals an economy great deal more volatile also for recent years than the official figures would suggest.

Fernald et al. (2015) proxy China's economic activity with trade partners' export data. Because imports co-move very closely with GDP in economies with good statistical systems, they utilize export data to China or Hong Kong as reported by the United States, Euro area and Japan. With a dataset ending in 2014, they find that since 2008, reported Chinese GDP figures have been notably more reliable in capturing fluctuations in economic activity than earlier.

Alternative Chinese GDP growth has been estimated as far as from outer space. Growth in nighttime light intensity has been proven to be a good proxy for economic growth and immune to falsification and misreporting (Henderson et al., 2012). Satellites measure the brightness of nighttime lights across Chinese provinces over time. The estimated GDP in Henderson et al. (2012) for 1992–2006 indicates a sizable gap to the officially reported GDP figures. Clark et al. (2017a and 2017b) further utilize this nighttime light data to estimate an alternative weighted average of the three indicators in the Li Keqiang index. Since 2012, their estimate of Chinese GDP was never lower than the official statistics and shows an acceleration in 2016, even as the official growth rate remained virtually unchanged.

Other alternative indices include e.g. Barclays' index using purchasing managers' indices (PMIs), as well as Bloomberg and Capital Economic (CE) indices using linear combinations of various variables such as value added of industrial production, freight, passenger traffic, electricity production, floor space completed and retail sales. The Lombard Street Index (by TS Lombard) takes the official nominal GDP and a range of price indices covering all expenditure components of GDP to compute an alternative deflator, and then calculate an alternative real GDP growth rate.

Based on the broad range of alternative estimates, the current "true value" of Chinese GDP growth could be anywhere between 3 % and little over 10 %. Debate will surely go on, and this paper is not even trying to take a stand on *the level* of the real GDP growth. Data discrepancies are always problematic and can distort assessments of the economic situation leading to inappropriate economic policies and bad business decisions. Equally problematic is the remarkable stability of the real GDP growth figures reported in recent years masking all changes in economic activity. The aim of this paper is to track the missing fluctuations of the real GDP growth rate by experimenting with alternative deflators.

The paper is organized as follows. A brief overview of the national gross domestic product and deflators is given in the next section. Alternative deflators and the respective real GDP growth rates are calculated and presented in section 3. Section 4 discusses the findings and concludes.

2. Chinese gross domestic product and deflators

2.1. Nominal and real GDP growth

Until 1985, national accounts in China were compiled according to the Material Production System developed in the Soviet Union and used by countries with centrally planned economies. After a transition phase, accounts have been compiled according to the Nations' System of National Accounts

(SNA) from 1992 onwards, using a more conventional value-added approach. China's GDP was first only estimated from the production side. The NBS adopted the expenditure approach formally in 1993.

Since 1992 NBS has conducted both annual and quarterly GDP estimations and quarterly GDP is estimated separately for eight industries: agriculture, forestry, husbandry and fishing; mining and quarrying; manufacturing; electricity, gas and water; construction; transport, post and telecommunications; wholesale, retail trade and catering; banking and insurance; real estate; and others. Today, China compiles its national accounts according to the SNA 2008. Holz (2014) provides a thorough and comprehensive account of Chinese GDP statistics and the compilation methods. In addition, extensive coverage in Xu (2002, 2003, 2008 and 2009) [1] presents several problems in data collection and computation and offers ideas for improvement.

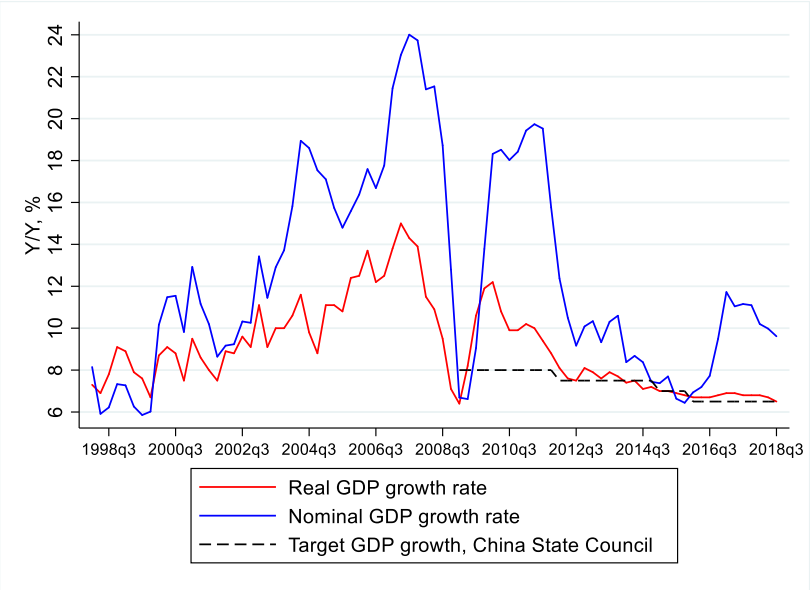
NBS is a government department under the direct control of the Party and State Council, which also appoints its major personnel and provides funding. The NBS has very little authority over provincial statistics bureaus or over the statistics divisions of other central government departments, and has direct control only over its survey teams (Holz, 2014). That is, much of the data compilation is outside its control. What is already well known, is that the aggregate provincial GDP growth figures typically indicate a much higher growth than the national figure. Revelations during the past years of extensive data falsifications at provincial level has made the NBS to rely more on economic censuses, annual data from directly reporting units and sample surveys to improve the accuracy of national figures. To address this issue further, the NBS is said to take over data collection at the regional level from 2019 onwards, replacing the current system.

While discussing the institutional scope for data falsification in China, Holz (2014) concludes that the final official GDP values may be rather haphazard values with large technical limitations to data quality. He states that it is likely that choices leading to the final official GDP values are known only to a very small number of people in the NBS and quite possibly the decisions are made by only a handful of people in an environment of implicit or even explicit expectations raised by top leaders.

Like already said, what has brought the situation problematic in recent years is the obvious lack of fluctuations especially in the real GDP growth rate. Looking at Figure 1, while the nominal GDP keeps on fluctuating after 2014, there is hardly any movement in the real GDP growth series.

[1] Xu Xianchun is the former deputy director of the NBS.

Figure 1: Nominal and real GDP growth rates, 1998Q1-2018Q3



The statistical reporting problems might be at least partly related to China's ambitious official target set in 2012 of doubling real 2010 GDP by 2020. The goal may have forced officials to pursue numbers to meet their mandated targets at many levels of the economy. Contrary to what some observers were anticipating, the official real GDP growth target was again announced for the present year to be around 6.5 %. It remains probable that the official figures will follow the GDP doubling target through 2020.

Broadly, it seems that more doubts have been raised towards the real GDP figures than the nominal ones. Clark et al. (2017b) find that while there is evident differences between the official and provincial *real* GDP growth, there is on average much less discrepancies with the *nominal* growth rates. They infer that to compute the national real GDP rates, the NBS takes the nominal growth rates reported by the provincial authorities and deflates them using a common deflator. The nominal GDP series have also been subject to revisions several times during the years. As the real growth rates at the same time are largely unchanged, it means that the implicit deflator would have been revised accordingly. This is however not plausible as price indices are final in the year they are published and neither the annual nor the monthly price indices have ever been revised (Holz, 2014).

2.2. Deflators

Chinese official economic data does not include deflators, but the implicit deflators can be obtained by dividing the official growth rate of the nominal values by the official real growth rate. While the bureaus of statistics in most countries estimate real GDP by deflating nominal GDP with a separate

independently constructed price index, it is not the case in China. Appendix A in Holz (2014) discusses how the NBS obtains both sectoral and expenditure deflators. Especially before 2004, the NBS remained heavily dependent on enterprise-provided, output-based implicit deflators to deflate the nominal value added (Young, 2003). Since around 2004, NBS started using predominantly relevant price indices to deflate the nominal value added series. One complication is indeed the fact that the NBS changes its deflator calculation methods over time without specifying which precise period is covered by which method (Holz, 2014).

The deflators NBS announces using can be found e.g. in the IMF Dissemination Standards Bulletin Board (DSBB) and are summarized in Table 1 in Appendix. The agriculture, animal husbandry, forestry and fishery nominal value added figures are deflated with the agriculture product price index. As for the industry (mining, manufacturing, production and supply of electricity, gas and water), producer price index is used. For construction, value added is deflated with the fixed-asset investment price index. Retail price indices are used for wholesale and retail trade. For transport, storage and posts, as well as for hotels and catering services the related prices indices in consumer price index (CPI) are used as deflators. Value added of financial intermediation is deflated with CPI and investment price index, and that of other services with average wage index and service sub-indices of the CPI. To deflate the value added of real estate sector, a series of price indices are used (real estate sale's price index, land exchanging price index, real estate and leasing price index and CPI).

There exists different views also regarding the quality of the deflators. Klein and Özmucur (2002-2003) argue that due to unobserved or disregarded quality changes, the deflator is overestimated and the real GDP growth could thus be severely underestimated. Others find the opposite. Movshuk (2002) argues that official implicit deflators are underestimates of the true price development and Young (2003) finds that real GDP growth reduces by almost 2 percentage points if implicit deflators are replaced by proxies of sectoral price indices. Holz (2014) derives alternative real GDP growth rates using combinations of price indices to deflate the nominal GDP data. He finds that the derived real GDP growth rates come close to official figures, deviating no more than 1 percentage point in either direction. However, his data time span ends in 2012, precisely as the real GDP growth series lose its fluctuations.

3. Computing alternative deflators

In order to come up with alternative deflators I proceed in two different ways. In both, I assume that the nominal GDP series and the published price indices are accurate and I take them as given. Data is quarterly observations dating from 1998Q1 to 2018Q3.

First, in section 3.1. I use published price indices to deflate the nominal value added (VA) data separately for each sector, aggregate the obtained real VA series and compute the growth rate. As another approach I regress the official implicit GDP deflator by sectoral price indices, and use the estimated deflator to construct an alternative real GDP growth rate.

Second, in section 3.2. I construct an alternative deflator using principal component analysis. I combine information from a relatively large set of price indices into a smaller number of components. The components are then used as explanatory variables in estimating the implicit GDP deflator. Finally, I use this estimated deflator to deflate the nominal GDP series and get another set of constructed real GDP growth rates.

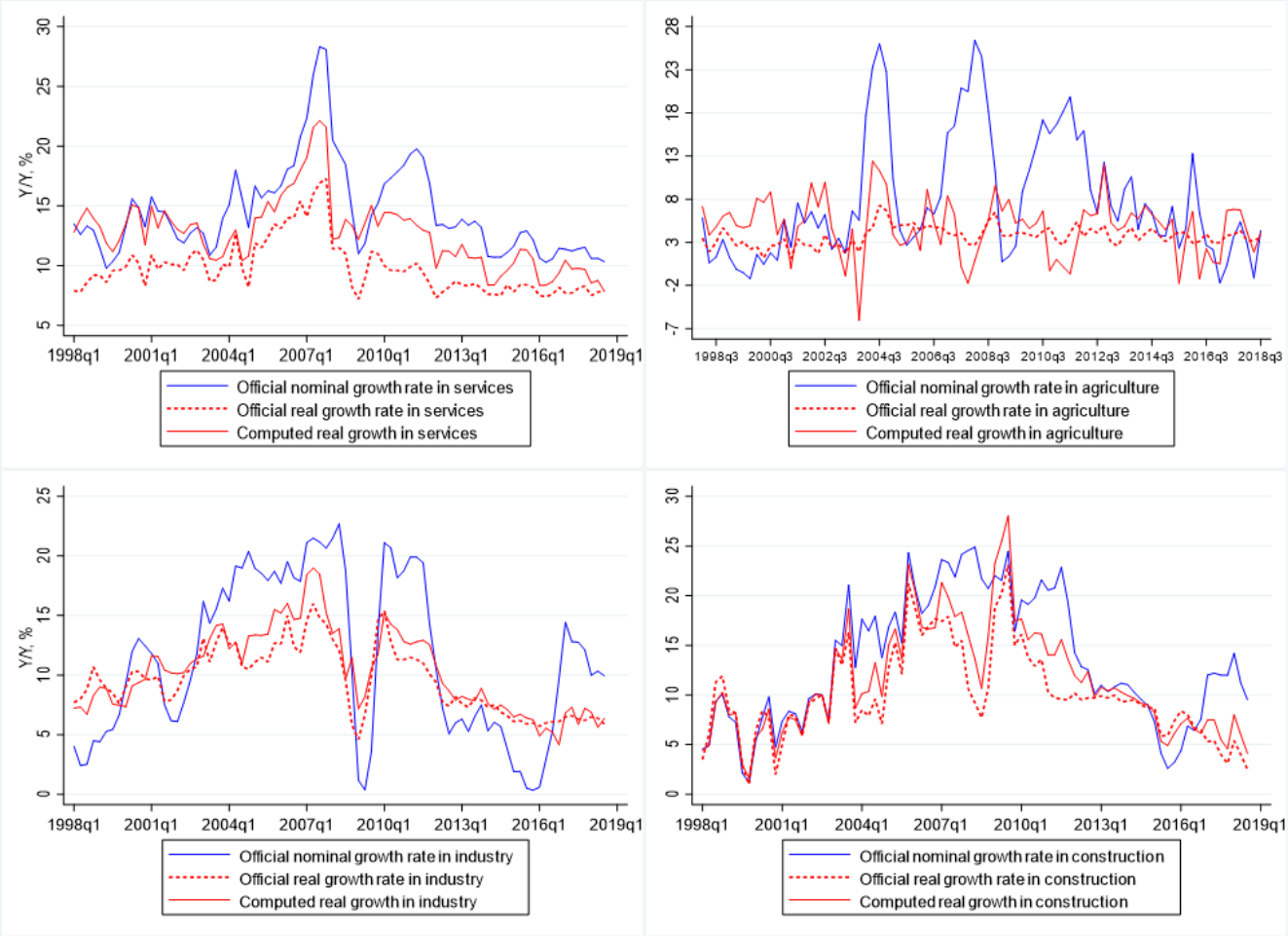
3.1. Deflating the production side nominal value added series

I focus solely on the production side of the GDP, since more data is readily available. Like stated in Holz (2014), many of the data that the NBS uses in the compilation of the real GDP are not publicly available and the task is then to find the publicly available data that best matches the price data NBS announces using. The growth rate of the nominal GDP can be reconstructed to a large degree by aggregating the nominal value added series of the four main sectors: industry, services, construction and agriculture.

First, I use the officially announced deflators (price indices) presented in Table 1 and deflate the nominal sectoral VA series to construct another real GDP growth series. I follow the idea in Holz (2014), but simplify the task at hand by using more aggregated VA and price index series. The price indices used are producer price index for the industrial sector VA, consumer price index for the service sector VA, fixed-asset investment price index for construction sector VA, and agricultural product price index for agricultural sector VA. Deflating the nominal growth series with these price indices gives the alternative, computed real growth series. Figure 2 presents the nominal value added growth (blue line), the official real growth (red dashed line) and the computed real growth deflated by the price index (red solid line) for each sector.

For services, the official real growth is below the computed growth and shows less variation. Largest differences between the official and computed real growth rates are in agriculture. There, the official nominal value added growth varies between 25 % and -2 %, while the official real growth is only fluctuating around 1 and 7 %. The computed real growth is much more volatile. For industry the computed real growth rate comes quite close to the official series, but has more fluctuations especially at the end of the time span. For construction, the computed real growth rate follows the official rate rather closely.

Figure 2: Official real and nominal growth rates of sectoral value added series and the computed real growth



After deflating the nominal sectoral VA series with the respective price indices, I take an aggregate and the annual growth rate. As a result I get the first alternative real GDP growth rate (dashed black line in Figure 3 below). This alternative real GDP growth rate is higher than the official real GDP growth rate for almost the entire time span. However, the shape is more or less uniform roughly until the beginning of 2014.

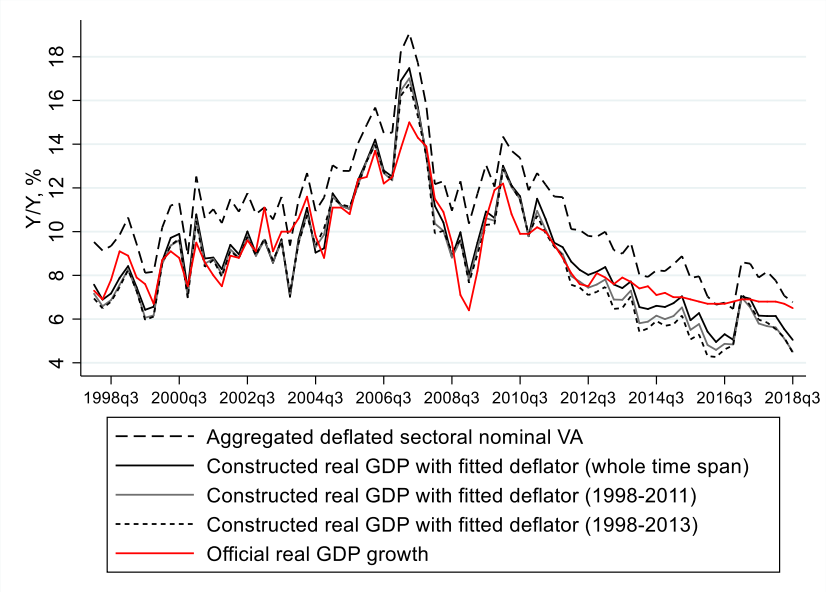
I then take a little different approach, and take as a starting point the implicit GDP deflator, for which I try to find the best match with a combination of available price indices. I regress the official implicit deflator by constructed weighted price indices for each of the four sectors using OLS estimation. As weights, I use the sectoral shares of the total value added in each quarter. This way I am able to take into account the structural change of the economy. Dependent variables are obtained by multiplying the sectoral share of the total VA by the respective aggregate price index (as described above).

It might be that the recent years of incredibly stable real GDP growth have somewhat affected the series of the implicit deflator, used as the independent variable in the estimation. One might get different results if only using observations from a time span when the fluctuations existed also in the real GDP growth rate. A Wald test for a structural break[2] performed after the estimation indicates that I can reject the null hypothesis of no structural break at the 1 % level and the estimated break date is the third quarter of 2012. The Wald test statistic points towards a spike in the value of the test statistic at the estimated quarter, but the value of the test statistic increases already quite quickly after 2011. What was already visible from Figure 1, the real GDP growth rate loses much of its fluctuations in 2012 and becomes almost identical with the official target rate at the beginning of 2014.

Thus, I use two other time spans for the estimations, one breaking at 2014 (1998Q1–2013Q4) and another one breaking at 2012 (1998Q1–2011Q4). The OLS regression results are presented in Table 2 in Appendix, with the respective estimated deflators. The estimated deflators are highly correlated, shown in Tables 6-8 in Appendix (deflators I to III). The correlation between the estimated deflators and the official, implicit deflator is about 0.96 before 2012, but decreases to 0.89 for the time span 2012–2018.

I then use these estimated GDP deflators to deflate the nominal GDP. This set of alternative real GDP growth rates is also presented in Figure 3 below (black line for the whole time span, dotted line for the shorter time span ending at 2014 and grey line for the shortest time span ending at 2012). The official real GDP growth rate is denoted in red.

Figure 3: Real GDP growth rate and constructed series



[2] Supremum Wald test for a structural break at an unknown break date.

The set of three alternative real GDP growth rates constructed with the estimated GDP deflators are following rather well the developments in the official real GDP growth rate, but again only up until the beginning of 2014. During 1998–2013, the aggregate deflated sectoral nominal VA deviates on average some 2 percentage points from the official real GDP growth rate. After 2014, the deviation halves. For the three other alternative growth rates, the average deviation was close to zero up until 2013 after which it grew to over 1 percentage point (below zero). Figure 7 in Appendix presents the deviations.

Based on all of these constructed real growth series, the economic growth was decreasing in 2015–2016, picked up in 2017 and began to decelerate again during the first three quarters of 2018.

3.2. Using principal component analysis to derive an alternative GDP deflator

As another approach, I combine a much larger amount of price index data to fit the official, implicit GDP deflator. The principal component analysis is a procedure that transforms a number of possibly correlated variables into a smaller number of uncorrelated variables called principal components (Jolliffe, 2002). The first principal component accounts for as much of the variability in the data as possible, and each succeeding component accounts for as much of the remaining variance. After the principal components are determined, a standard regression model is conducted regressing the implicit deflator on the estimated principal components.

As price indices, I use altogether 68 different sub-indices from consumer price index, investment price index, producer price index, purchasing price index and retail price index series, separately for urban and rural as well as for the national aggregate. I also include industrial, energy, and agriculture raw material indices, as well as the total raw material index excluding energy. The exact series used can be found in Table 3 in the Appendix[3].

For the whole time span, the first estimated principal component explains 44 % of the total sample variance, while 14 % is explained by the second component. The first 10 components have an eigenvalue greater than one and are able to explain cumulatively 91 % of the total sample variance, as shown in Table 4 in Appendix. As time span gets shorter (although the factor loadings of the principal components are not entirely identical), the first principal component explains an even higher share of total sample variance. Figure 6 in Appendix shows how the first principal component is driving the implicit deflator.

[3] As it is necessary that data is stationary in order to apply the principal components analysis, price index data for 1998Q1–2018Q3 is tested both by the DF-GLS test by Elliott, Rotherberg and Stock (Econometrica, 1996) and by the Phillips-Perron test, both confirm that the price index series can be considered to be stationary.

As a starting point, I regress the official implicit deflator on the first ten principal components and a constant term, using OLS estimation. I then sequentially eliminate regressors with the lowest t-values until all coefficients satisfy the 5 % significance threshold. In the resulting model, for the whole time span, I end up with principal components 1, 2, and 6. The first principal component has high factor loadings on consumer goods' and machine manufacturing producer price indices, retail price indices and aggregate consumer price indices for both urban and rural areas. The second principal component has highest factor loadings on industrial and energy raw material indices, on producer price index for petroleum and producer goods as well as on purchasing price index. The sixth principal component has high factor loadings on agricultural raw material index, on the consumer price of food (most specifically fresh vegetables) in all areas, and on textile and tailoring producer price indices.

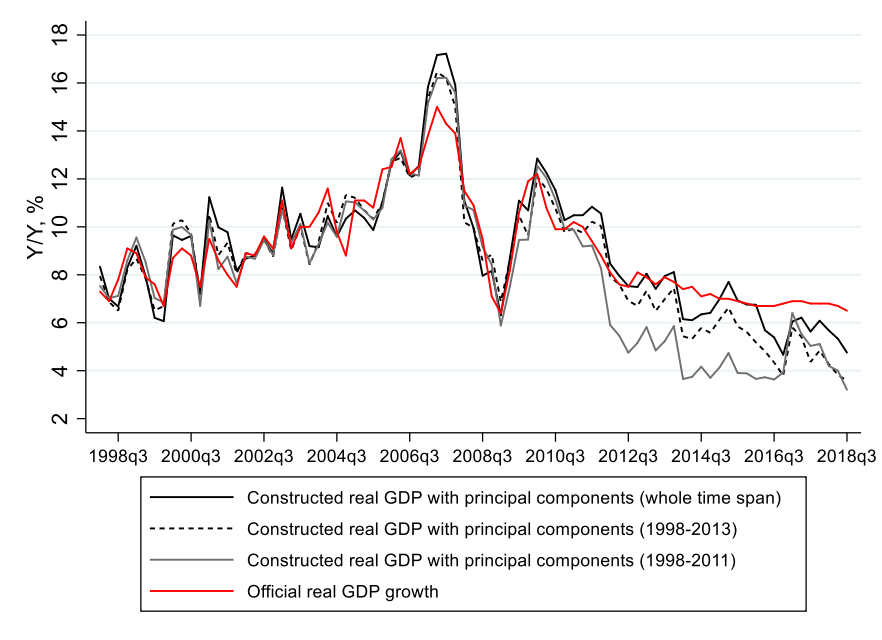
I redo the principal component analysis and the regressions also for the shorter time spans. For the time span ending in 2013, the principal components left in the regression are 1, 2, and 9. First principal component is rather similar with the whole time span case having high factor loadings on consumer goods' producer price indices, both urban and rural retail price indices and aggregate consumer price indices. The second principal component is also broadly similar having high factor loadings on metallurgical and producer goods' producer price indices, on industrial and energy raw material indices and on purchasing price indices. The ninth principal component has high factor loadings on tailoring, textile, leather and cultural articles' producer price indices.

For the shortest time span, ending in 2011, the principal components finally left in the regression are 1, 3 and 9. The first principal component is rather identical on their factor loadings with the other two time spans above. The third principal component has high factor loadings on energy and industrial raw material indices, on rural recreational consumer price index, and on producer goods' producer price index. The ninth principal component has high factor loadings on industrial and agricultural raw material indices, on cultural articles', tailoring and coal producer price indices, and on transport and communications' consumer price indices in all areas.

As a result, I get three different estimated deflators, one for each time span. OLS regression results and the respective estimated deflators are depicted in Table 5 in Appendix. For the two shorter time spans I form an out of sample prediction with the estimated principal components and their regression coefficients. Again, the correlation matrices between these estimated deflators and the implicit deflator is shown in Tables 6-8 in Appendix (deflators IV to VI). Also for this second set of estimated deflators, the correlation with the implicit deflator is smaller for the more recent time span. However, the two sets of estimated deflators (deflators I–III and deflators IV–VI) are highly correlated with each other, and the correlation remains broadly unchanged regardless of the time span considered.

After deflating the official nominal GDP growth rate with these estimated deflators I get another set of alternative real GDP growth rates (Figure 4 below). The official real GDP growth rate is again denoted in red.

Figure 4: Real GDP growth rate and deflated series with constructed deflators



Although estimated differently, these constructed real GDP series are behaving rather similarly to the ones estimated in section 3.1. They are following quite closely the official real GDP growth until around 2014. Compared to Figure 3, the difference in levels after 2014 is now distinctly larger between the alternative real GDP growth rates for different time spans. If the deflator is constructed based on estimated coefficients for the shortest time span (ending in 2011), the out of sample prediction of the real GDP growth rate deviates from the other series already at the beginning of 2012 for some two percentage points. However, despite the larger errors with respect the official real GDP growth rate (Figure 8 in Appendix), the direction of the fluctuations after 2014 is rather similar across estimations.

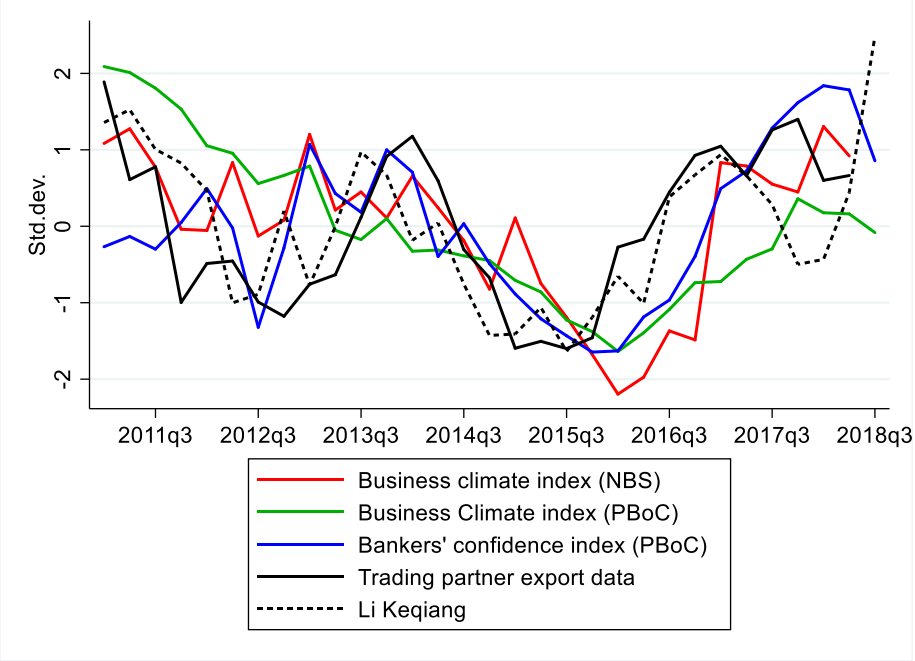
4. Discussion of findings and conclusions

Figure 9 in Appendix shows the range of all the alternative real GDP growth rates constructed in this paper. As can be seen, the constructed series are mostly above the official growth rate right until around year 2012. This is mostly due to the deflated sectoral VA growth that was clearly above as the other estimates hit rather well the official real GDP growth rate. For the more recent years, the official rate has been rather at the upper end of the range of estimates. The computed alternative deflators manage

to reveal real GDP growth rates with rather matching fluctuations that extend the year 2014. Constructed series seem to indicate that the GDP growth rate fell in 2015–2016, picked up quite abruptly in 2017, before losing speed again in 2018. But how credible are these revealed fluctuations?

Some evidence from the changes in Chinese economic activity can be obtained from publicly available survey based indicators. Figure 5 below depicts some of the publicly available Chinese indicators for the time span 2011–2018. There is two business climate indices and a separate confidence index aimed at the banking sector. Business Climate Index published by the NBS (red line) focuses on entrepreneurs in the industrial sector. Another Business Climate Index published by the People's Bank of China (green line) is based on a survey covering around 5,800 enterprises and constructed similar to the widely used purchasing managers' indices, so that an index value over 50 means a positive trend and under 50 means a worsen climate or retraction. PBoC also conducts a banking survey that delivers a Bankers' Confidence Index (blue line). These indicators (normalized in Figure 5 with zero mean and unit standard deviation) seem to be rather consistent with the alternative real GDP growth rates constructed in this paper in that they have been decreasing in 2015–2016, increasing in 2017 and again dropping to some extent in 2018.

Figure 5: Normalized indicators of economic activity in China 2011-2018



Following Fernald et al. (2015), I have also included the real growth rate of China's imports from US, euro area and Japan (black solid line). The same pattern seems to emerge. Real export growth obtained from trading partner data decreased in 2015, increased during 2016–2017 and is decelerating again in 2018. Last, I also included the Li Keqiang index (black dashed line). The development of the Li Keqiang

index is somewhat different. Although there was a drop in the index in 2015, there was another drop in 2017 and to the contrary from the other indices in the figure, the Li Keqiang index is sharply increasing in 2018.

Further evidence can be drawn from assessments and analysis regarding the Chinese economy during these years. The following are extracts from BOFIT's Forecasts for China[4] from 2015–2018. They are reinforcing the findings of this paper and depict more or less the same picture of China's business cycles behind the smooth GDP growth figures.

Year 2015 *saw a stock market rally that ended with a crash in the summer. Thereafter, capital outflows from China increased substantially, putting depreciation pressure on the yuan. Inconsistent and confused policy by authorities in the summer of 2015 with regard to stock and forex markets implied significant costs for the government and added to market uncertainty. Structural change in the economy was further driven by weakness in export demand and slowing construction and fixed investment growth. Demand for the products of heavy industry fell and a number of industries suffered from severe overcapacity problems.*

During 2016, *growth in China's economic output was boosted as a result of the government's stimulus policy. Capital outflows and expectations of yuan depreciation reflected however mounting uncertainty in financial markets. Confidence surveys conducted by the NBS, the PBoC and several private institutions pointed to exceptionally weak economic performance especially in late 2015 and early 2016, as well as substantial rebound in growth thereafter. After a couple of lackluster years, China's foreign trade experienced rapid growth since late 2016.*

In 2017 *it appeared that economic conditions were improved compared to 2015–2016 on the recovery of the external demand and steady growth in domestic consumption. China used economic stimulus and pursued expansionary policies to keep the country on track to meeting its official 2020 growth target and maintain favorable economic conditions ahead of the convening of the 19th National Congress of the Communist Party of China in October. The accommodative monetary stance fueled indebtedness, which continued to rise rapidly.*

In the course of 2018 *uncertainty is again reflected in plunging prices on stock exchanges and yuan depreciation. Indeed, many indicators suggest an economic slowdown is underway, with particular interest focusing on weak growth in fixed investment, a key driver of demand. In the first half of this year, there were still news about the central government's efforts to curb indebtedness by freezing local government infrastructure projects already in progress. By summer, however, local governments were being encouraged to hurry up and issue their own bonds in order to raise funds to complete their construction projects to support growth and provide jobs. China's medium-term outlook is somewhat darker.*

[4] BOFIT Forecast for China is prepared twice a year as part of the Bank of Finland's international economic analysis and is available online https://www.bofit.fi/en/monitoring/forecasts-for-Russia-and-China/forecast-for-china/

Although this exercise says little (and in fact it doesn't even try to say anything) about *the level* of the real GDP growth rate, it manages to identify fluctuations that extend the year 2014. Based on the constructed growth series, there was a drop in real GDP growth in 2015–2016, after which the growth rate picked up before losing speed again at the beginning of 2018. This finding is consistent with some of the available alternative GDP measures as well as with observed changes in China's economic activity and policy stance.

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Appendix

Table 1: Official deflators, production and expenditure side of GDP

GDP by kind of economic activity	
Nominal series	**Official deflator**
Agriculture, animal husbandry, forestry and fishery	Agriculture product price index
Industry (mining, manufacturing, production and supply of electricity, gas and water)	PPI
Construction	Fixed-asset investment price index
Wholesale and retail trade	Retail price indices
Transport, storage and posts	Related price index in CPI
Hotels and catering services	Related price index in CPI
Real estate	Real estate sale's price index, land exchanging price index, real estate and leasing price index and CPI
Financial intermediation	CPI and IPI, etc.
Other services	Average wage index and the service sub-indices of the CPI

Final expenditure on the GDP	
Nominal series	**Official deflator**
Household consumption expenditure	Sub-indices of the CPI
Government consumption expenditure	
–Expenditure on goods and services	Relevant sub-indices of the urban CPI
–Government employee wages and salaries	Government employee average wage growth rate
–Consumption of fixed capital	Fixed-asset investment price index
Gross fixed capital formation	Sub-indices of the fixed investment price index
Changes in inventories	PPI for farm products, PPI for industrial products, purchasing price indices for industrial producers and the Commodity retail price index
Net export of goods	Price indices of exports and imports goods (compiled by Customs Authorities)
Net export of services	Chinese CPI for exports, CPI of main developed foreign countries for imports

Source: IMF DSBB

Table 2 and figure: OLS regression results and estimated deflators

	whole time span	1998Q1–2013Q4	1998Q1–2011Q4
Service PI	0.638**	1.051***	1.309***
	(0.23)	(0.24)	(0.31)
Industry PI	0.866***	0.734***	0.644***
	(0.11)	(0.12)	(0.14)
Construction PI	2.491*	2.828*	2.361
	(0.99)	(1.30)	(1.39)
Agriculture PI	1.371***	1.012***	0.936**
	(0.23)	(0.26)	(0.28)
Constant	1.735***	1.796***	1.805***
	(0.18)	(0.19)	(0.19)
Adj.R-square	0.906	0.925	0.926
dfres	78	59	51

Dependent variable: official implicit GDP deflator. Independent variables are price indices weighted by the sectoral share of total value added.

Standard errors in parenthesis.

* p<0.05, ** p<0.01, *** p<0.001

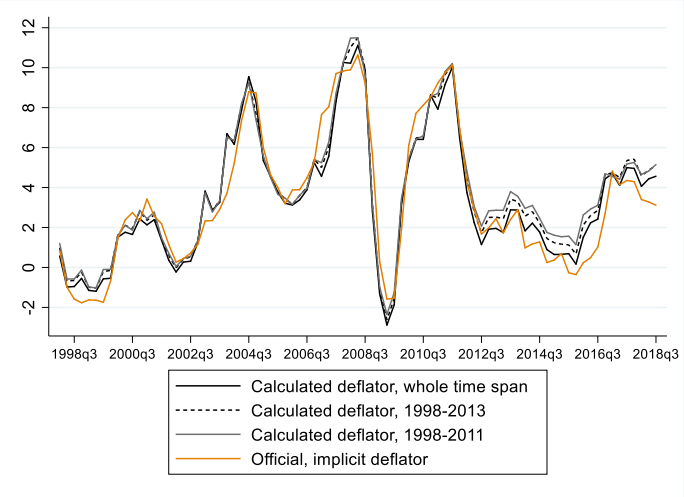

Table 3: Variables used in principal component analysis for the implicit deflator

1	Consumer Price Index, National, All Areas, Total
2	Consumer Price Index, National, All Areas, Clothing, Total
3	Consumer Price Index, National, All Areas, Food, Grain
4	Consumer Price Index, National, All Areas, Transport & Communications, Total
5	Consumer Price Index, National, All Areas, Food, Aquatic Products
6	Consumer Price Index, National, All Areas, Food, Eggs
7	Consumer Price Index, National, All Areas, Recreation, Education & Culture Articles, Total
8	Consumer Price Index, National, All Areas, Food, Total
9	Consumer Price Index, National, All Areas, Household Facilities, Articles & Services, Total
10	Consumer Price Index, National, All Areas, Health Care & Personal Articles, Total
11	Consumer Price Index, National, All Areas, Residence, Total
12	Consumer Price Index, National, All Areas, Food, Vegetables, Fresh Vegetables
13	Consumer Price Index, National, All Areas, Total
14	Consumer Price Index, National, Urban, Total
15	Consumer Price Index, National, Urban, Residence, Total
16	Consumer Price Index, National, Urban, Food, Eggs
17	Consumer Price Index, National, Urban, Food, Aquatic Products
18	Consumer Price Index, National, Urban, Food, Grain
19	Consumer Price Index, National, Urban, Food, Fresh Vegetables
20	Consumer Price Index, National, Urban, Transport & Communications, Total
21	Consumer Price Index, National, Urban, Clothing, Total
22	Consumer Price Index, National, Urban, Household Facilities, Articles & Services, Total
23	Consumer Price Index, National, Urban, Recreation, Education & Culture Articles, Total
24	Consumer Price Index, National, Urban, Health Care & Personal Articles, Total
25	Consumer Price Index, National, Rural, Total
26	Consumer Price Index, National, Rural, Food, Eggs
27	Consumer Price Index, National, Rural, Food, Aquatic Products
28	Consumer Price Index, National, Rural, Residence, Total
29	Consumer Price Index, National, Rural, Food, Grain
30	Consumer Price Index, National, Rural, Food, Fresh Vegetables
31	Consumer Price Index, National, Rural, Household Facilities, Articles & Services, Total
32	Consumer Price Index, National, Rural, Recreation, Education & Culture Articles, Total
33	Consumer Price Index, National, Rural, Food, Fresh Vegetables
34	Consumer Price Index, National, Rural, Household Facilities, Articles & Services, Total
35	Consumer Price Index, National, Rural, Recreation, Education & Culture Articles, Total
36	Consumer Price Index, National, Rural, Health Care & Personal Articles, Total
37	Consumer Price Index, National, Rural, Transport & Communications, Total
38	Consumer Price Index, National, Rural, Clothing, Total
39	Investment Price Index, National, Fixed Assets, FAI, Construction & Installation
40	Investment Price Index, National, Fixed Assets, Purchase, Equipment & Instruments
41	Investment Price Index, National, Fixed Assets, FAI, General
42	Investment Price Index, National, Fixed Assets, Producer, Other Charges
43	Producer Price Index, National, By Branch of Industry, Core, Core Branch, Petroleum
44	Producer Price Index, National, By Branch of Industry, Core, Core Branch, Paper
45	Producer Price Index, National, By Branch of Industry, Core, Core Branch, Metallurgical
46	Producer Price Index, National, By Branch of Industry, Core, Core Branch, Food
47	Producer Price Index, National, By Branch of Industry, Core, Core Branch, Textile
48	Producer Price Index, National, By Branch of Industry, Core, Core Branch, Building Materials
49	Producer Price Index, National, By Branch of Industry, Core, Core Branch, Coal & Coking
50	Producer Price Index, National, By Branch of Industry, Core, Core Branch, Others
51	Producer Price Index, National, By Branch of Industry, Core, Core Branch, Machine Manufacturing
52	Producer Price Index, National, By Branch of Industry, Core, Core Branch, Timber
53	Producer Price Index, National, By Branch of Industry, Core, Core Branch, Power
54	Producer Price Index, National, By Branch of Industry, Core, Core Branch, Leather
55	Producer Price Index, National, By Branch of Industry, Core, Core Branch, Tailoring
56	Producer Price Index, National, By Branch of Industry, Core, Core Branch, Cultural, Educational & Handicrafts Article
57	Producer Price Index, National, By Branch of Industry, Others, Coal Mining, Washing & Dressing
58	Producer Price Index, National, By Branch of Industry, Others, Food Manufacturing
59	Producer Price Index, National, By Commodity, Consumer Goods, Clothing
60	Producer Price Index, National, By Commodity, Consumer Goods, Durable Consumer Goods
61	Producer Price Index, National, By Commodity, Consumer Goods, Food
62	Producer Price Index, National, By Commodity, Consumer Goods, Total
63	Producer Price Index, National, By Commodity, Consumer Goods, Article for Daily Use
64	Producer Price Index, National, By Commodity, Producer Goods, Total
65	Purchasing Price Index, Purchasing Price, Total
66	Purchasing Price Index, Total
67	Retail Price Index, National, Rural, Total
68	Retail Price Index, National, Urban, Total
69	Industrial Raw Materials Index, HWWI
70	Agricultural Raw Materials Index, HWWI
71	Energy Raw Materials Index, HWWI
72	Total Raw Material Index excluding energy, HWWI

Table 4: Proportion of variance explained by 10 first principal components, three different time spans

	whole time span		1998Q1–2013Q4		1998Q1–2011Q4	
	Proportion, %	Cumulative, %	Proportion, %	Cumulative, %	Proportion, %	Cumulative, %
Comp1	0.435	0.435	0.475	0.475	0.506	0.506
Comp2	0.141	0.577	0.120	0.595	0.100	0.606
Comp3	0.079	0.656	0.093	0.688	0.093	0.699
Comp4	0.070	0.726	0.065	0.753	0.054	0.752
Comp5	0.055	0.781	0.041	0.794	0.044	0.796
Comp6	0.033	0.814	0.037	0.831	0.042	0.838
Comp7	0.031	0.845	0.032	0.863	0.026	0.864
Comp8	0.026	0.871	0.022	0.885	0.023	0.887
Comp9	0.022	0.893	0.022	0.907	0.021	0.908
Comp10	0.019	0.912	0.018	0.924	0.018	0.926

Principal components analysis

Figure 6: First principal component and the official implicit deflator

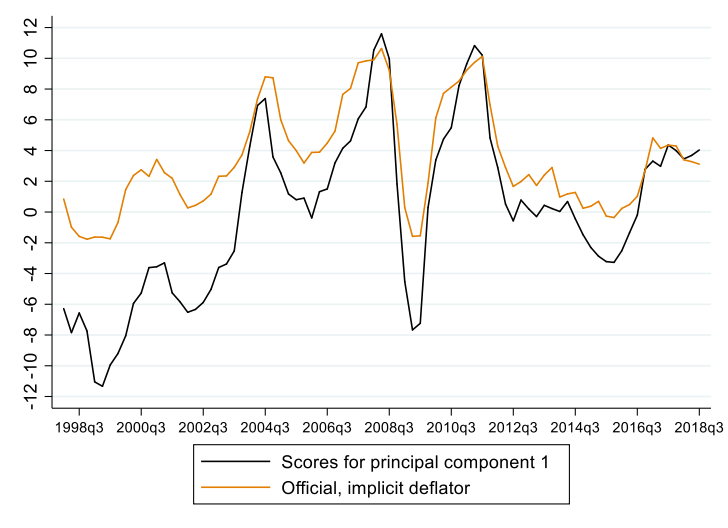

Table 5 and Figure: OLS regression results and estimated deflators

	whole time span	1998Q1–2013Q4	1998Q1–2011Q4
Comp1	0.561***	0.604***	0.629***
	(0.02)	(0.02)	(0.02)
Comp2	0.313***	0.221***	
	(0.04)	(0.04)	
Comp3			0.138**
			(0.05)
Comp6	-0.246**		
	(0.08)		
Comp9		-0.253*	-0.313**
		(0.12)	(0.10)
Constant	3.384***	3.827***	4.011***
	(0.12)	(0.12)	(0.12)
Adj.R-square	0.903	0.93	0.939
dfres	79	60	52

Dependent variable: official implicit GDP deflator.
Standard errors in parenthesis.

* p<0.05, ** p<0.01, *** p<0.001

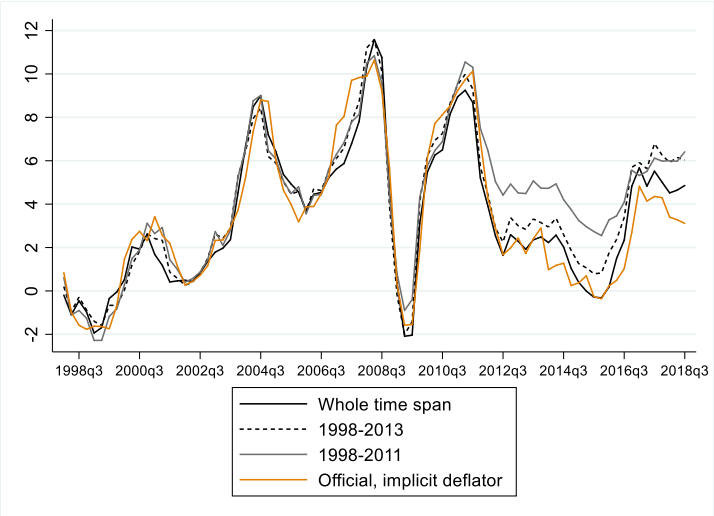

Figure 7: Residuals from first set of estimations

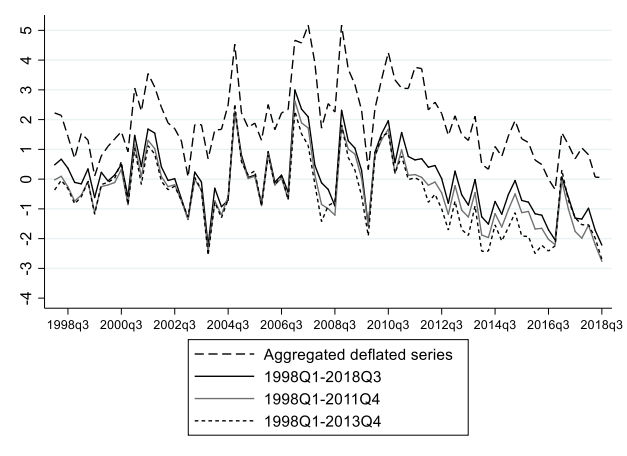

Figure 8: Residuals from principal component regressions

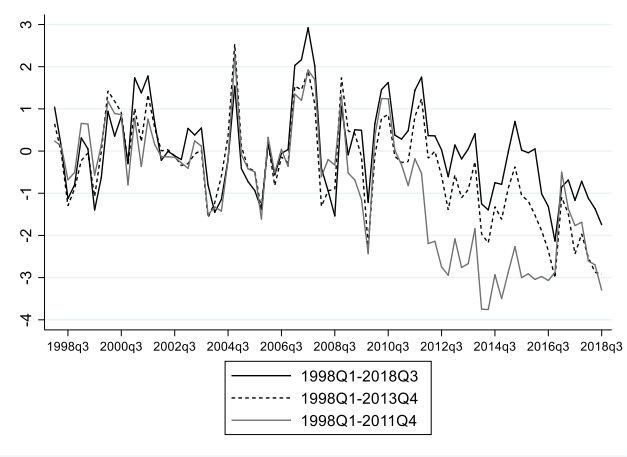

Figure 9: Range of all constructed real GDP growth rates and the official real GDP growth rate

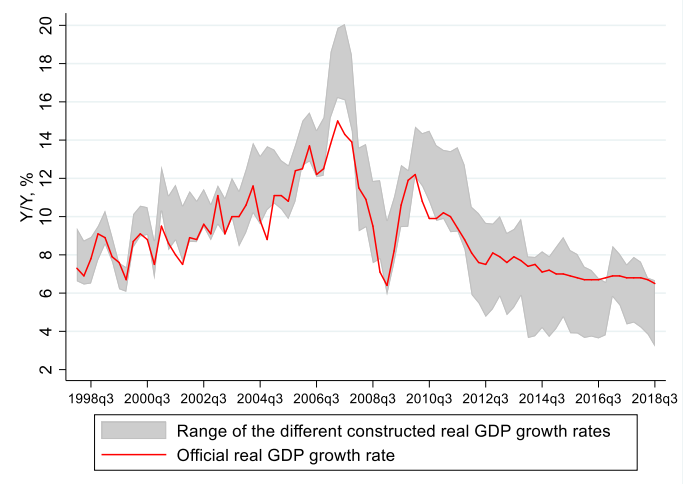

Table 6: Correlation between the official implicit deflator and constructed alternative deflators, whole time span

	Implicit	DefI	DefII	DefIII	DefIV	DefV	DefVI
Implicit	1.0000						
DefI	0.9543	1.0000					
DefII	0.9518	0.9974	1.0000				
DefIII	0.9476	0.9929	0.9985	1.0000			
DefIV	0.9545	0.9695	0.9713	0.9656	1.0000		
DefV	0.9334	0.9605	0.9673	0.9645	0.9839	1.0000	
DefVI	0.9030	0.9304	0.9468	0.9551	0.9425	0.9644	1.0000

Table 7: Correlation between the official implicit deflator and constructed alternative deflators, 1998-2011

	Implicit	DefI	DefII	DefIII	DefIV	DefV	DefVI
Implicit	1.0000						
DefI	0.9617	1.0000					
DefII	0.9645	0.9984	1.0000				
DefIII	0.9651	0.9964	0.9994	1.0000			
DefIV	0.9622	0.9701	0.9737	0.9723	1.0000		
DefV	0.9661	0.9698	0.9742	0.9744	0.9914	1.0000	
DefVI	0.9704	0.9683	0.9735	0.9751	0.9831	0.9898	1.0000

Table 8: Correlation between the official implicit deflator and constructed alternative deflators, 2012-2018

	Implicit	DefI	DefII	DefIII	DefIV	DefV	DefVI
Implicit	1.0000						
DefI	0.8951	1.0000					
DefII	0.8976	0.9962	1.0000				
DefIII	0.8886	0.9870	0.9959	1.0000			
DefIV	0.9215	0.9678	0.9662	0.9518	1.0000		
DefV	0.8837	0.9761	0.9724	0.9531	0.9867	1.0000	
DefVI	0.9062	0.9092	0.9313	0.9396	0.9456	0.9122	1.0000