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A FORENSIC EXAMINATION OF CHINA'S NATIONAL ACCOUNTS

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### **ABSTRACT**

China's national accounts are based on data collected by local governments. However, since local governments are rewarded for meeting growth and investment targets, they have an incentive to skew local statistics. China's National Bureau of Statistics (NBS) adjusts the data provided by local governments to calculate GDP at the national level. The adjustments made by the NBS average 5% of GDP since the mid-2000s. On the production side, the discrepancy between local and aggregate GDP is entirely driven by the gap between local and national estimates of industrial output. On the expenditure side, the gap is in investment. Local statistics increasingly misrepresent the true numbers after 2008, but there was no corresponding change in the adjustment made by the NBS. Using publicly available data, we provide revised estimates of local and national GDP by re-estimating output of industrial, construction, wholesale and retail firms using data on value-added taxes. We also use several local economic indicators that are less likely to be manipulated by local governments to estimate local and aggregate GDP. The estimates also suggest that the adjustments by the NBS were insufficient after 2008. Relative to the official numbers, we estimate that GDP growth from 2010-2016 is 1.8 percentage points lower and the investment and savings rate in 2016 is 7 percentage points lower.

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A data appendix is available at <http://www.nber.org/data-appendix/w25754>

## 1. Introduction

China's national accounts are primarily based on data collected by local officials. However, as documented by Xiong (2018), local officials are rewarded for meeting growth and investment targets. Therefore, it is not surprising that local governments have an incentive to skew the statistics on local growth and investment. The Statistical Agency of the Chinese government, the National Bureau of Statistics (NBS henceforth), attempts to correct this bias using administrative data and other sources of data gathered directly by the NBS. The accuracy of the final numbers of aggregate GDP and its components depends on the extent of misreporting by local officials, the data that NBS has at its disposal to correct the misreporting and the effort it undertakes to do so.

Local GDP is measured via the production approach from three major surveys (of large industrial sector firms, large service sector firms, and "qualified" construction firms). This data is supplemented with surveys of smaller industrial firms and administrative data from other government departments to obtain a number for local GDP on the production side. On the expenditure side, local officials provide estimates of local consumption, investment, government spending, and net exports (vis-à-vis other localities in China and other countries). The two main sources are surveys of household income and expenditures (similar to the US CEX), from which they estimate local consumption, and survey data on investment projects, from which they estimate local investment. Since the sum of local consumption and investment typically exceeds local GDP measured on the production side, the remainder is attributed to local net exports.

The NBS does not simply add up the statistics reported by local governments to arrive at the national aggregates. The NBS has access to the micro-data of the surveys used by local governments and supplements this data with economic censuses and administrative data such as land sales, vehicle registration, financial transactions and foreign trade. Based on this data, the NBS produces its own numbers for national GDP and its components on the production and expenditure sides. The adjustment made by the NBS to the local statistics can be seen by the discrepancies between local GDP and national GDP.

We then check which of the numbers provided by local governments differ from their national counterparts and, hence, are more likely to be inaccurate. First, we show that the sum of local GDP frequently exceeds national GDP. Second, we compare the sum of the local consumption, investment, and net exports with national consumption, investment and

net exports reported by the NBS. We find little discrepancy between local and national consumption but large discrepancies between local and national statistics of investment and net exports. Third, we compare the sum of value-added of sectors as reported at the local level with the same sectors at the national level. We find large discrepancies for the industrial sector and smaller gaps in the non-industrial sectors.

We then use two approaches to determine the accuracy of adjustments to the local numbers by the NBS. First, we adjust national GDP by the difference between value added growth reported by NBS and value added tax revenue growth reported by the State Administration of Taxation in the sectors where value added tax is a major type of taxation. Our estimate suggests that the adjustments made by the NBS were roughly accurate until 2007/8. However, the adjustments made after this date no longer appear to be accurate. Our baseline estimate of GDP growth from 2010 to 2016 is 1.8 percentage points lower than the official growth rate. Furthermore, our estimate of the aggregate investment and savings rate in 2016 is 7 percentage points lower than the official numbers.

We use the same approach to adjust local production and expenditure GDP for each Chinese province. There is a positive relation between our adjustments to local GDP and investment across provinces. This evidence suggests that local governments inflate local GDP by overestimating local production as well as local investment.

A second approach is to estimate a statistical model where we estimate the relationship between a set of economic indicators (which are less likely to be manipulated) and local GDP prior to 2008. We then use parameters of the estimated model along with the same set of the indicators after 2008 to predict local GDP after 2008. The indicators include satellite night lights, national tax revenue, electricity consumption, railway cargo flow, exports and imports. We use the method developed by Su, Shi and Phillips (2016) to control for (hidden) economic structure heterogeneities across regions. Using this method, we also find that the corrections made to national GDP no longer appear appropriate after 2008. Encouragingly, the adjustments to local GDP by the two approaches are highly correlated. This provides additional support to our adjustments.

Our revised numbers of the Chinese national accounts thus indicate that the slowdown in Chinese growth since 2008 is more severe than suggested by the official statistics. At the same time the true savings rate has probably declined by 11 percentage points from 2009 to 2016, with about more than 80% of the savings decline showing up in the investment rate and

the remainder in the external surplus. In this sense, our revised numbers of China's national accounts also indicate that Chinese growth is associated with consumption growth rather than investment and external surpluses.

## 2. China's GDP Accounting System

The Chinese national and local GDP statistics are compiled separately. Local statistical bureaus provide estimates of local GDP and its components on the production and expenditure sides. The NBS uses the same data collected and used by local governments, along with the data it collects independently, to arrive at a number for national GDP. The number provided by the NBS is the "official" number of Chinese GDP.

Although the local statistical bureaus are de jure branches of the NBS and are supposed to follow the statistical procedures set by the NBS, de facto they are branches of local governments. The budget of the local statistical bureaus come from local governments, and officials of local statistical bureaus are evaluated and promoted by the local government. Because of this structure, local statistical bureaus are susceptible to pressure by local officials who may have an incentive to report inaccurate statistics. The NBS is aware of this bias and adjusts the numbers of local GDP provided by the local statistical bureaus.

To assess the quality of the official numbers for local and national GDP, we proceed in three steps. First, we compare the sum of local GDP with aggregate GDP provided by the NBS (hereafter, we use the term aggregate GDP to refer to the number provided by the NBS). Second, we assess the data used to estimate GDP on the production side. Third, we assess the data used to construct GDP on the expenditure data.

### 2.1 Comparing Local GDP with Aggregate GDP

The solid line in Panel A of Figure 1 shows the magnitude of the adjustment made by the NBS to the local statistics.<sup>1</sup> The figure shows the gap between the sum of GDP of each province and aggregate GDP provided by the NBS as a percentage of aggregate GDP. Local

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<sup>1</sup> All the national account data between 1993 and 2017 were extracted from the NBS website on December 10, 2018. Some numbers (GDP in the primary and tertiary sectors in 2007-2016) were updated in February 2019. The changes are very small and our results are essentially unchanged with the updated numbers. The 1992 provincial data is from Hsueh and Li (1999).

governments *understated* GDP relative to the NBS in the 1990s. The sum of local GDP was about 5 to 6 percentage points *lower* than aggregate GDP in the mid-1990s. This pattern changed after 2003. After this date the sum of local GDP surpassed aggregate GDP and the gap was about 6 percentage points higher than aggregate GDP in 2006. The gap between these two numbers for China's GDP stabilized around 5% of GDP after 2006.

[Insert Figure 1]

Local statistical authorities and the NBS also provide estimates of local and aggregate GDP by broad sectors. Figure 1 shows the gap between the sum of local GDP and aggregate GDP of each sector as a share of aggregate GDP (of all sectors). The top panel in Figure 1 shows the ratio of the sum of local GDP to aggregate GDP for agriculture ("primary"), industry and construction ("secondary"), and services ("tertiary"). Prior to 2003, the sum of secondary GDP at the local level was *lower* than aggregate secondary GDP. Furthermore, from about 1997 to 2003 almost all the gap between local and aggregate GDP came from the gap in the industrial sector. Prior to 1997, some of the gap is due to the discrepancy between local and aggregate statistics of the service sector.

After 2003 all of the discrepancy between local and aggregate GDP comes from the industrial sector. The bottom panel in Figure 1 shows the comparison of industrial (mining, manufacturing, and public utilities) and construction GDP reported by local governments with that provided by the NBS. As can be seen, the gap between local and national statistics after 2003 is entirely in industry. This finding echoes Holz (2014) and Ma et al. (2014) who also find that the inconsistency between provincial and national GDP mainly came from the industrial sector,

Figure 2 compares GDP expenditures provided by local governments and the NBS. On the expenditure side, there are substantial differences after 2003 in investment ("Gross Fixed Capital Formation") and net exports reported by the two sources. The sum of local investment was close to the national level until 2002. After that date, the sum of local investment exceeds aggregate investment. In 2016 the gap in the two measures of investment reached 13% of GDP. The mirror image is the growing discrepancy between the sum of local net exports and aggregate net exports. This gap reached 8% of GDP in 2016. In contrast, the

national and local differences in final consumption and changes in inventory are essentially zero after the mid-2000s.<sup>2</sup>

[Insert Figure 2]

We summarize the main findings. First, the sum of provincial GDP is 5% higher than national GDP after the mid-2000s. Second, after 2003 the NBS adjusts downward industrial GDP and investment and adjusts upwards net exports reported by local governments. Third, the NBS does not adjust local consumption -- the sum of local consumption is roughly the same as national consumption provided by the NBS.

## 2.2 Production GDP

We do not know whether the adjustments to local GDP by the NBS are appropriate. To answer this question, we need to delve into the details of the data used by the local statistical offices and the data sources behind the adjustments that are used.

### 2.2.1 Industrial GDP

Remember that the gap between the local and aggregate numbers on the production side is entirely driven by the industrial sector. The backbone of the industry data is the Annual Survey of Industrial Firms (ASIF henceforth). This data is a census of state-owned firms and privately owned firms with sales above 5 million Yuan (until 2011) or 20 million Yuan (after 2011). The Chinese statistical system calls the firms covered in the ASIF the “above-scale” firms. Local statistical bureaus then add to the data from the ASIF an estimate of value added of industrial firms with sales below 5 million Yuan (20 million Yuan after 2011), referred to as “below-scale” firms in the Chinese statistical system, and businesses of self-employed individuals.<sup>3</sup>

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<sup>2</sup> Final consumption includes urban and rural household consumption and government consumption. The sum of each of the local consumption component is very close to its national counterpart.

<sup>3</sup> The ASIF was conducted by local statistical bureaus until 2012. Orlik (2014) documents that a more centralized system was implemented nationwide in 2012 where firms would enter the statistics directly into an online database controlled by the NBS. While the goal of the direct reporting system was to prevent local statistical officers from manipulating the data, local governments can still find ways to skew the data. See a case of data manipulation reported by Gao (2016) that is well-known by the NBS.

We first investigate the data on value added in the ASIF. The micro-data from this survey prior to 2007 has been widely used by researchers. After this date however, the NBS clamped down on access to the micro-data. We also believe there are good reasons to believe that the accuracy of this survey has declined over time. First, we can compare the sum of value added in the ASIF with aggregate industrial GDP reported by the NBS. This is shown in the solid line labeled “raw data” in Figure 3. Aggregate value added in the ASIF should be lower than aggregate industrial GDP because the latter also includes output by small firms (“below-scale” firms) and the self-employed. However, the sum of value added in the survey exceeds aggregate industrial GDP reported by the NBS in 2007. So, the NBS must have adjusted downwards value added in the ASIF.

[Insert Figure 3]

The ASIF does not report firm value added after 2008 so after this date local statistical bureaus used data on gross output in the survey to impute value added.<sup>4</sup> We do the same using the ratio of gross output to value added in the Input Output tables.<sup>5</sup> Figure 3 presents aggregate value added imputed in this way from micro-data on firm sales in the ASIF as a share of industrial GDP reported in the national accounts. The share exceeded 100% in 2012 and 2013. Again, the only explanation for this is that the NBS adjusted downward firm sales in the ASIF.

Remember that the ASIF only provides information for above-scale firms. For below-scale firms and the self-employed, the local statistical bureaus and the NBS rely on survey of these two types of establishments (Xu, 2004). However, the micro-data of this survey is not publicly available, nor is there information about the sampling and how aggregates are constructed from the survey.

We therefore take two approaches to measure aggregate value added of small industrial firms and the self-employed. First, we use the micro-data of the 2004 and 2008 economic censuses. These two censuses are a complete enumeration of all Chinese firms (including the small ones), with the exception of the self-employed. Column 1 in Table 1 shows that total value added of above- and below-scale firms in the micro-data of the 2004

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<sup>4</sup> For above-scale industrial firms and wholesale and retail firms below, we use their total sales revenue from China Statistical Yearbooks to proxy total gross output.

<sup>5</sup> The IO tables for 2002, 2007 and 2012 are from NBS (2006, 2009 and 2015). The data for 2005, 2010 and 2015 are from the NBS website. For the years without data, the ratio is calculated by linear interpolation. In 2007, for example, the value added share in industrial gross output is 0.23 and 0.29 in the IO table and ASIF, respectively. See Figure A1 in the appendix for the value added shares between 2002 and 2015.



Economic Census is about 80% and 7%, respectively, of aggregate industrial GDP reported in the national accounts.<sup>6</sup> So if the 2004 national accounts are accurate, about 13% of industrial GDP in the national account is not in the census and should be attributed to the self-employed. The equivalent numbers for the 2008 Economic Census are 88% and 6% of industrial GDP in the 2008 national accounts. The sharp increase in the output share of above-scale firms between 2004 and 2008 is consistent with the fast-growing economy where a larger share of firms exceeds the 5 million Yuan sales threshold over time.

However, what is remarkable is that the increase in the share of above-scale firms between the 2004 and 2008 censuses reverses after 2008. The line labeled “Value Added Inferred from IO Table” in Figure 3 shows that the output share of above-scale firms fell by about six percentage points from 2013 to 2016. If the national accounts data is accurate, the share of below-scale and the self-employed implied by the NBS’ number of industrial GDP must have increased in recent years. These are precisely the firms for which the micro-data are not available to the public, and this is also at odds with the trend where the share of above-scale firms rises over time with a growing industrial sector.

[Insert Table 1]

We can also estimate the importance of below-scale firms by making distributional assumptions. Specifically, we assume firm sales to follow either a log normal or a Pareto distribution and estimate the parameters of the two distributions from the micro-data of the economic census.<sup>7</sup> Since the economic census does not cover the self-employed, we assume the value added share of the self-employed in aggregate industrial GDP is 13% in 2004 and 6% in 2008 (see Table 1). The share is linearly interpolated between 2004 and 2008 and set to 6% for the post-2008 period.

Figure 3 shows the share of above scale firms based on these two distributional assumptions. There are two main differences between the official and estimated output

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<sup>6</sup> Instead of using self-reported firm value added (because of the fear that value added is inflated in the censuses as it is in ASIF), we convert firm sales into value added by the ratio of value added to gross output in the IO tables.

<sup>7</sup> We fit the two distributions by choosing parameters to fit the mean of log sales in each size percentile of industrial firms in the 2008 economic census. Specifically, we estimate the mean and standard deviation of the log normal distribution and the mean and shape parameter of the generalized Pareto distribution to match the firm size distribution. We then assume the distribution in other years has the same standard deviation (for the normal distribution) or shape parameter (for the Pareto distribution) but a different mean parameter. We calibrate the mean parameters in the other years by targeting the average sales of above-scale industrial firms in each year. Applying the threshold of 5 and 20 million Yuan for sales before and after 2011, we can infer the output shares for above- and below-scale industrial firms.

shares of above-scale industrial firms. First, the adjustment of the sales threshold in 2011 should generate a drop in the output share of above-scale firms in our estimates. However, there is no such drop in the official numbers.<sup>8</sup> Second, our estimates suggest a modest increase in the value added share of above-scale firms since the sales threshold adjustment.<sup>9</sup> In contrast, the share declined after 2013 in the official numbers, which does not seem plausible.

Another way to gauge whether the accuracy of the NBS' estimate of industrial GDP growth is to use information on the growth of revenue from value added taxes on industrial firms. China imposed a 17% value added tax on essentially all industrial firms until 2018. There were three main exceptions. First, the value added tax imposed on small firms (with annual sales below 0.5 million Yuan) was 3% of their sales. Second, the value added tax rate was 13% for a selected set of industrial goods. The appendix shows that the different tax rates have negligible effects on value added tax revenue growth. Third, a significant proportion of domestic industrial value added tax (41% in 2015) is refundable through export tax rebates, which varied considerably across goods and over time. To make sure that our estimates are not affected by tax rebates, we will use data on revenues from value added taxes **gross** of rebates for exports.

Furthermore, after 1994, there is little fraud and evasion from the value-added tax. The State Administration of Taxation (SAT) implemented the so-called "Golden Taxation Project" in 1994. A computerized taxation data network has also been in full operation since 2005, which allows the tax authorities to cross-check the input and output value added tax at each stage of production and distribution of goods and services. The effective value added tax rate, defined as the ratio of industrial value added tax to industrial GDP net of value added tax, increased from 10.4% in 2001 to 12.9% in 2007, reflecting the improved tax enforcement in the period. There are several possible reasons why the effective tax rate was below the main statutory tax rate of 17%. The different tax rates mentioned above matter but cannot be quantitatively important. Another possibility is inflated industrial output. To account for the four percentage points difference, industrial GDP would have to be overestimated by nearly a quarter in 2007. While tax evasion is hard for transactions within

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<sup>8</sup> In the Appendix, we present evidence that the 2010 ASIF covers fewer above-scale firms than what it should. In other words, firm sales data is likely to be manipulated, disguising the otherwise discontinuous sales proportion of above-scale firms.

<sup>9</sup> If we assume the value added share of individual businesses to fall after 2008 as in the 2004-2008 period, the increase in the estimated value added share of above-scale firms would be more pronounced.

the industrial sector, it may be easier for industrial output sold to the sectors for which value added tax doesn't apply.<sup>10</sup> But even if there are some fraud and evasion, as long as their degree does not increase, revenues from the value added tax on industrial firms should be proportional to industrial GDP.

Figure 4 (Panel A) compares the growth rate of revenues from domestic value added taxes with the growth rate of industrial GDP. The growth rate of revenues from value added taxes exceeds that of industrial GDP prior to the mid-2000s, consistent with the improved enforcement of value added taxes. However, after 2007, the growth rate of tax revenues is lower than the growth rate of industrial GDP. Furthermore, the gap has been widening over time. In 2010 to 2012, for instance, value added tax revenue growth is about two-thirds that of industrial GDP. The growth in tax revenues dropped to half the growth rate of industrial GDP growth in 2013 and 2014 and even became negative for 2015 and 2016. Consequently, the effective value added tax rate fell from 12.9% in 2007 to 9.3% in 2016.

[Insert Figure 4]

A few tax policies introduced after 2007 may lower the effective value added tax rate. The most relevant change is the value added tax deduction on fixed asset investment for domestic firms.<sup>11</sup> The policy was first introduced in three provinces in Northeast China in 2004 and later extended to six provinces (Cai and Harrison, 2018; Zhang et al., 2018). The central government unexpectedly increased the coverage to all provinces at the end of 2008, as part of the stimulus package in response to the financial crisis. The nationwide policy became effective on January 1, 2009. While the policy obviously reduced industrial value added tax revenue in the transition period between 2004 and 2009, it is hard to estimate the extent to which the value added tax revenue growth was affected. The main obstacle is that we don't know how much of fixed asset investment is deductible from value added tax.<sup>12</sup> A

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<sup>10</sup> The 2007 IO tables suggest that the share of industrial output to the construction and service sectors (excluding wholesale and retail) is 15.9%. If industrial firms hide all their output sold to the construction and service firms that do not have incentives to ask for value added tax invoice, the effective value added tax rate would be lowered by 2.7 percentage points.

<sup>11</sup> Foreign firms have always been eligible for the tax deduction.

<sup>12</sup> The value added tax deduction only applies to purchase of machinery, mechanical apparatus, means of transportation and other equipment, tools and fixtures related to production and business operations ("Detailed Rules for the Implementation of the Interim Regulations of Value Added Taxes", Document No. 50, the Ministry of Finance and State Administration of Taxation, 2008). According to the compositions in China's fixed asset investment survey, which severely overestimated the level of fixed asset investment as will be shown below, purchase of equipment and instruments accounts for about 40% of fixed asset investment in the industrial sector. But purchase of equipment and instruments include items such as newly built production department that are not eligible for value added tax deduction.

simple fix is to look at the value added tax revenue growth after 2009.<sup>13</sup> The average industrial value added tax revenue growth is 5.3% between 2009 and 2016, which is 3.4 percentage points lower than the average industrial GDP growth in the same period. The gap is similar to that of 3.5 percentage points in the period from 2007 to 2016.

Another important policy change is the reform of replacing business tax with value added tax initiated in 2012 and completed in 2016. Since purchase of service goods became deductible from value added tax, the reform may also lower value added tax revenue growth in the industrial sector. The pilot started in the transportation industry (excluding railway) and several “modern” service sectors in Shanghai from January 2012. The policy was extended to Beijing and other seven provinces and cities from August 2012 and then to all provinces from August 2013.<sup>14</sup> Railway transportation, post, telecommunication were added to the list of “modern” service sectors in 2014. In the appendix, we identify ten industries in the IO table according to the description of “modern” service sectors in the documents. The transportation industry and all the modern service sectors accounted for 2.4% and 2.3% of industrial input, respectively, in 2012. For the following two reasons, we assume that the reform doesn’t affect industrial value added tax revenue growth between 2010 and 2016. First, purchase of transportation services was deductible from value added tax even before the reform started. Second, the input share of the modern service sectors was not big enough to generate a significant effect on industrial value added tax revenue growth in the reform period.

Finally, the value-added tax policy for small tax payers (defined as those with annual sales below half million Yuan) was adjusted twice after 2007. From August 2013 and onwards, tax payers with annual sales below 240 thousand Yuan were exempted from value added tax. The cutoff was increased to 360 thousand Yuan in October 2014.<sup>15</sup> The

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<sup>13</sup> The remaining concern is that the effect of the policy might be persistent by increasing industrial firms’ investment rate in the subsequent periods. Using firm survey data from China’s State Administration of Taxation, Chen et al. (2019) found that the average firm investment rate increased by 2.6 percentage points in 2009 but then decreased by 0.7 percentage point in both 2010 and 2011. The diminishing effect on investment rate suggests that the policy should not lower value added tax revenue growth in 2010 and onwards.

<sup>14</sup> See “Notice of the Ministry of Finance and the State Administration of Taxation on the Pilot Work of Levying Value Added Tax in Lieu of Business Tax in the Transportation Industry and Some Modern Service Industries in Shanghai” (Document No. 111, the Ministry of Finance and State Administration of Taxation, 2011).

<sup>15</sup> See “Notice of the Ministry of Finance and the State Administration of Taxation on Temporarily Exempting Certain Small- and Micro-Sized Enterprises from Value-Added Tax and Business Tax” (Document No. 52, the Ministry of Finance and State Administration of Taxation, 2013) and “Announcement of the State Administration of Taxation on Relevant Issues concerning Exempting Small and Micro-Sized Enterprises from Value-Added Tax and Business Tax” (Document No. 57, the State Administration of Taxation, 2014). See also Lardy (2014) for the evolution of policies towards the private sector.

effectiveness of the tax reform can be seen from the share of value added tax paid by the small tax payers, which is publicly available at China Taxation Yearbook. In fact, the share was quite stable, around 4 percent, between 2010 and 2016 and even increased from 3.7% in 2012 to 4.4% in 2013. One explanation is that firms and individual businesses with annual sales below the cutoff contribute little to total value added tax revenue.

We summarize the main findings about the reliability of the NBS' estimate of industrial GDP. First, the micro-data of the ASIF has overstated aggregate output at least since 2007. Second, aggregate industrial GDP provided by the NBS implies an increasing share of below-scale firms and the self-employed in the industrial sector after 2012. Third, the growth rate of aggregate industrial GDP has exceeded the growth rate of revenues from value added taxes on industrial firms since 2008. Based on these three pieces of evidence, we conclude that despite the adjustments made by the NBS to local industrial GDP, the official numbers of aggregate industrial GDP – and by extension aggregate GDP for all sectors -- is likely to overstate the truth after 2007/8.

### 2.2.2 Non-Industrial GDP

Turning to the non-industrial sector, NBS conducts surveys for all “qualified” construction firms, above-scale wholesale and retail firms, above-scale hotel and catering firms, and all real estate developers and operators.<sup>16</sup> We first look into the wholesale and retail sectors, which accounted for about 10% of aggregate GDP in 2016. While the published tabulations of the surveys provide total sales of above-scale wholesale and retail firms, value added is not reported. We thus convert total sales to value added, following the procedure in Bai et al. (2019).

Based on this imputation, the solid line of Figure 5 plots the value added of above-scale wholesale and retail firms in the published surveys as share of official aggregate GDP in the wholesale and retail sectors. Following the same procedure described in the previous section, we estimate the parameters of the distribution of firm size in the wholesale and retail sectors in the 2008 economic census. We then calibrate the mean parameters of the log normal and Pareto distributions to match average firm sales in each year. We further assume the value added share of the self-employed in wholesale and retail GDP is fixed at 24% (the

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<sup>16</sup> The sales threshold for wholesale and retail firms is 20 and 5 million Yuan, respectively. The sales threshold for hotel and catering firms is 2 million Yuan.

number suggested by the 2008 economic census – see Table 1). The estimated models suggest that the share of above-scale wholesale and retail firms in aggregate GDP in these sectors has increased slightly in recent years. Like what we see for the industrial sector, this is also at odds with the dramatic drop in 2014 and 2015 in the official data.

[Insert Figure 5]

Panel B of Figure 4 compares domestic value added tax revenue growth from the wholesale and retail sector with GDP growth in these sectors as provided by the national accounts.<sup>17</sup> Like what happened in the industrial sector, the tax revenue outgrew the sectoral GDP before the mid-2000s but the pattern was reversed after 2010 except for 2016. The average difference between the tax revenue and GDP growth is about eight percentage points, suggesting that true wholesale and retail GDP is also likely to be overstated in the national accounts.

The construction sector accounts for about 7% of GDP after 2010. Surprisingly, the output share of “qualified” construction firms fell in recent years (see Figure A2 in the appendix). While no sales threshold applies to construction firms, larger construction firms are more likely to be “qualified.” For the same reason discussed above, pure economic forces are hard to reconcile the observed output share change.

It is more difficult to examine the reliability of non-industrial GDP since we do not have access to firm-level data other than the 2008 economic census. Furthermore, the value added tax only applied to the industrial, wholesale and retail sectors before 2017. A close substitute is corporate income tax. Like the value added tax, a major proportion of corporate income tax revenue (60%) is paid to the central government.<sup>18</sup> Unlike the highly rigid value added tax rate, there are many exemptions and special rates for corporate taxes. For example there are special corporate income tax rates for labour-intensive and high-tech firms. The enforcement of corporate income taxes is also weaker than that of value added taxes. Figure 6 plots sectoral corporate income tax revenue as a percent of sectoral GDP for the following four sectors: industry, construction, wholesale and retail and service excluding wholesale and

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<sup>17</sup> Value added tax revenue accounts for about 40% of total tax revenue in the industrial, whole and retail sectors. See Figure A4 in the appendix.

<sup>18</sup> 75% and 50% of value added tax revenue was paid to the central government before and after 2016. The sharing mechanism prevents local governments from inflating corporate income tax revenue, which would otherwise incur direct losses to local fiscal budget. There is evidence that local governments manipulate business tax revenue, which applied to most service sectors and went entirely to local fiscal budget (e.g., Lei, 2017). The business tax was replaced with the value added tax in 2017.

retail. The corporate income tax revenue GDP ratio increased in all the sectors prior to 2007. This is likely to be driven by both growing firm profitability and enhanced tax enforcement in the period. The corporate income tax revenue GDP ratio decreased dramatically in industry, wholesale and retail after 2011, consistent with growth slowdown in the two sectors. The ratio was fairly stable in the service sector excluding wholesale and retail, about 2-3 percentage points higher than the ratio in industry, wholesale and retail in recent years. Construction is the only sector where the corporate income tax GDP ratio kept increasing until 2015.

[Insert Figure 6 and 7]

That said, corporate income tax revenue is still informative. Figure 7 compares corporate income tax revenue growth with GDP growth in the four sectors. For industry, wholesale and retail (Panel A and C), the results are similar to those in Figure 4: The sectoral GDP growth is above the tax revenue growth in recent years. For construction (Panel B), corporate income tax revenue growth is above GDP growth in most years. Given the fact that the corporate income tax revenue GDP ratio was very low in the construction sector in earlier years (Figure 6), the strong corporate income tax revenue growth might be a consequence of much improved tax enforcement in that sector. Most interestingly, Panel D shows that GDP growth seems in line with corporate income tax revenue growth in the service sector excluding wholesale and retail. Since the corporate income tax GDP ratio didn't change much, we view Panel D as evidence that official estimates of GDP growth of the service (excluding wholesale and retail) in the national accounts is reliable.

In sum, while the growth in the wholesale and retail sectors are likely to be overstated in the official statistics, there is no evidence that official statistics for the other service sectors are inaccurate. However, the effect of inaccuracies in the wholesale and retail sectors is important, as these are two large sectors. Note also that Figure 2 shows no gap between local and aggregate statistics of the service sector after 2003. Figure 2 simply tells us where exactly the NBS has adjusted the local numbers, not whether the adjustment or the absence of an adjustment is appropriate.

### Section 2.3: Expenditure GDP

We now examine the underlying data used to construct GDP expenditures. As discussed earlier, government expenditures reported by local governments is consistent with that reported by the NBS. Furthermore, this information is based on administrative and verifiable data on public expenditures so it is likely to be reliable. We will therefore focus on household consumption, investment, and net exports.

The backbone of aggregate household consumption is the urban and rural household surveys. The local statistical bureaus and the NBS directly take aggregates of household spending on food, clothing, household facilities, education, culture and recreation services, miscellaneous goods and services from these two surveys. The other components of household consumption also use the Household Surveys but are adjusted for (i) accounting discrepancies (i.e., medical expenditure paid by government is not in the Household Survey but is included in final consumption); (ii) biases in the surveys (i.e., rich households are under-represented in the Household Survey). Xu (2014) describes in detail how the NBS arrives at consumption aggregates by adjusting the data from the Household Survey. The adjustments are based on administrative data from the relevant government departments. For instance, NBS uses social security income and expenditure data to adjust medical expenditure. Another example is to use the production, sales and import data of automobiles from the Association of Automobile Industry and the Department of Public Security (where all new automobiles are registered) to adjust consumption on transportation and communication. This helps correct the bias caused by under-represented rich households who are more likely to purchase automobiles.

Investment spending is officially called “Fixed Capital Formation” (FCF) in the Chinese national accounts. This data is primarily based on reports of fixed asset investment (FAI) by local governments. FAI measures *gross* investment spending as it includes expenditures on land purchases and used capital. Therefore, local statistical authorities use a survey of land purchases and used capital to subtract these two items from FAI to estimate *net* investment spending (FCF).

However, there is abundant evidence that local data on gross investment has become more unreliable. In contrast with ASIF which is based on firm’s financial statement, local administrative data on gross investment are based on reports of investment projects by local governments. There is no audit of this data, nor are there any consequences for misreporting this information. In addition to the incentives of local officials to misreport this number, tax



considerations may also lead to the inflation of FAI.<sup>19</sup> In 2014 Xu Xianchun, a Vice Director of NBS at the time, publicly stated that that FAI is inflated by local statistical offices (Xu, 2014). According to him, “some regions set up unrealistic investment targets for sub regions and use them as indicators of performance evaluation” (pp. 4).

Figure 8 shows that the gap between FAI and national FCF has increased since the early 2000s.<sup>20</sup> In 2015, the gap between aggregate FAI and net investment provided by the NBS (FCF) reached 38% of official GDP. In theory, the gap between the two measures of investment should only reflect land purchases and spending on used capital. The purchase of land and used capital does account for most of the difference in the early 2000s, but these two items are much too small to the gap in recent years (see Figure A3 in the appendix).<sup>21</sup> The enormous gap between FAI and FCF suggests that investment spending is overstated by local statistical offices and that the NBS has made large adjustments to this data to arrive at a number for aggregate net investment.

[Insert Figure 8]

It is also evident that even local statistical bureaus adjust downwards FAI when estimating local net investment. Figure 8 shows that the sum of provincial FAI exceeds provincial FCF by 24% of GDP in 2015. The difference is, once again, too big to be reconciled by accounting discrepancies like purchase of land and used capital. But the extent to which local statistical bureaus adjust the data on FAI is obviously less than the adjustment by the NBS. The sum of FCF at the provincial level exceeds aggregate FCF by 14% of GDP in 2015.

Notice that the adjustment made by the NBS to investment spending provided by the local statistical bureaus is larger than the adjustment made to local estimates of industrial GDP. Since local GDP on the production side has to be equal to GDP on the expenditure

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<sup>19</sup> For instance, the Ministry of Finance and the State Administration of Taxation introduced a policy (“Notice of the Ministry of Finance and the State Administration of Taxation on Several Issues concerning the National Implementation of Value Added Tax Reform,” Document No. 170, the Ministry of Finance, 2008) that allows tax payers to deduct fixed asset investment from value added tax.

<sup>20</sup> National and provincial FAI data are from China Statistical Yearbook.

<sup>21</sup> Holz (2013, 2015) also documents the growing discrepancies between provincial and national investment and the widening gap between FAI and FCF. Liu, Zhang and Zhu (2016) also show that the gap between FAI and FCF cannot be explained by land sales and purchases of used assets and buildings. Data for land sales and purchases of used assets and buildings are from China Land and Resources Statistical Yearbook and Statistical Yearbook of the Chinese Investment in Fixed Assets, respectively.

side, local statistical bureaus use local net exports as the residual to balance production and expenditure GDP. This can be seen in Figure 2, where the growing discrepancy between net exports and local net outflows is the mirror image of the gap between national and local FCF in Figure 8.

The NBS completely disregards local estimates of net exports. Instead, the NBS calculates aggregate net exports from data on net exports of goods in the customs data. For this reason, aggregate net exports in the national accounts are very close to net exports reported in the customs data. In contrast, local estimates of net exports are not based on any data and are simply a residual used to equalize local production and expenditure GDP.

We summarize the main findings. Local statistical bureaus inflate investment and, to a smaller extent, output in the industrial, wholesale, and retail sectors. Since investment data is easier to manipulate (the amount of investment is project-specific and disconnected to investing firms' financial statement), the misstatement of investment spending is more severe than the bias in GDP. The gap between the two are "reconciled" by the large net inflows of goods and services reported by local governments. In contrast, consumption data based on household surveys is more reliable.

### **3. Revised Estimates of GDP Growth**

The obvious question then is what are the "true" estimates of China's GDP growth? Here we make two efforts to come up with a number. First, we use alternative data from tax records to generate alternative measures of GDP on the production side. We then use them to re-estimate aggregate investment as well as local GDP. Second, we take a data fitting approach and use external data that are not likely to be manipulated by local governments to estimate GDP.

#### Section 3.1: Adjusting National Accounts with Tax Data

Our first approach to estimate "true" GDP is built on the following three assumptions. First, we assume industrial output reported by local statistical officers has not been reliable since the late 2000s. Second, we assume that non-industrial output reported by local

statistical officers is reliable. Third, we assume industrial value added tax revenue is proportional to true industrial value added.

The validity of the first assumption comes from the facts in the previous section. In particular, industry is the only major sector for which NBS adjusts significantly locally reported output data. The second assumption is partly based on the evidence that corporate income tax revenue grew in tandem with value added in the service sector, and partly made for practical reasons as we don't have reliable data to back out true output in most non-industrial sectors.<sup>22</sup> We will relax the second assumption later. The third assumption is the strongest. It hinges on two institutional features discussed in the previous section. First, China has developed a sophisticated value added taxation system to minimize tax fraud and evasion. Second, local government does not have incentives to overstate value added tax revenue because otherwise it would incur direct local fiscal losses. We have also discussed several tax policy changes that are likely to break the proportionality between industrial GDP and value added tax revenue. The effect of replacing business tax is quantitatively small before 2016, so as the effect of value added tax exemption on small firms and individual businesses. Our adjustment begins with 2010 after the completion of value added tax deduction on fixed asset investment.

In the simplest case, our adjusted GDP assumes the following equation:

$$\text{Adjusted GDP}_t = \text{Official GDP}_t - \Delta \text{Industrial GDP}_t \quad (1)$$

where  $\Delta X_t \equiv \text{Official } X_t - \text{Adjusted } X_t$  denotes the adjustment in variable  $X$  and

$$\begin{aligned} \text{Adjusted Industrial GDP}_t \\ = \text{Adjusted Industrial GDP}_{t-1} \cdot \text{Industrial VA Tax Revenue Growth}_t. \end{aligned}$$

The dotted line in Figure 9 plots the difference between our adjusted and the official nominal GDP growth (the solid line). The adjusted growth is always below the official growth except for 2012. Figure 4 shows that industrial value added tax revenue growth is 3.4 percentage points lower than the official industrial GDP growth after 2009. The industrial sector accounts for roughly one third of China's GDP. So correcting over-reporting of

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<sup>22</sup> See also Bai et al. (2019) for more evidence on the reliability of service data in the national account.

industrial output lowers GDP growth from 2010 to 2016 by 1.1 percentage points (see Column 2 in Table 2).

[Insert Figure 9]

[Insert Table 2]

We relax the third assumption by also adjusting value added in wholesale and retail output growth. Since wholesale and retail value added tax revenue growth is also below its GDP growth in the national account (Figure 4), adjusting output in both the industrial and wholesale and retail sectors would cut further nominal GDP growth in recent years (the dashed line in Figure 9). After we also adjust the growth rate of the retail and wholesale sectors, our estimate of the growth rate of nominal GDP from 2010 to 2016 is 1.5 percentage points lower than the official rate (Column 3 in Table 2).

We next look into the expenditure-side GDP accounting. Based on the discussions in the previous section, we assume that the official statistics on aggregate consumption and net exports are accurate. FCF is then obtained by

$$\begin{aligned} \text{Adjusted FCF} = & \text{Adjusted GDP} - \text{Final Consumption} - \text{Inventory Change} \\ & - \text{Net Exports.} \end{aligned}$$

However, this adjustment is incomplete. Most of the output of the construction sector is classified as investment on the expenditure side of GDP. Although the NBS does not adjust local estimates of output of the construction sector (Figure 1, bottom panel), our estimated investment spending from the above equation suggests that output of the construction sector is also overstated. We therefore adjust GDP of the construction sector using the following formula:

$$\Delta \text{Construction GDP}_t = \frac{\gamma_t}{\theta_{con,t}^I} \cdot \Delta \text{FCF}_t, \quad (2)$$

where  $\theta_{con,t}^I$  denotes FCF per unit of construction GDP and  $\gamma_t$  is the proportion of construction value added in FCF.<sup>23</sup> The adjustment in construction GDP leads to further adjustment in aggregate GDP and, hence, another round of adjustment in FCF and

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<sup>23</sup> Note that we don't need to adjust industrial output in a similar fashion. This is because industrial output can be exported, while construction output is for domestic use.

construction GDP. The full adjustment that balances aggregate GDP, construction GDP, and FCF is given by:

$$\text{Adjusted GDP}_t = \text{Official GDP}_t + \frac{1}{1 - \gamma_t/\theta_{con,t}^I} \Delta \text{Industrial GDP}_t.$$

Compared with (1), the GDP adjustment in (3) is amplified by adjusting construction output. When we also adjust wholesale and retail GDP,  $\Delta \text{Industrial GDP}_t$  in (3) should be replaced by  $\Delta \text{Industrial GDP}_t + \Delta \text{WR GDP}_t$ , where WR GDP denotes wholesale and retail GDP.

The results are shown in the top panel of Figure 10. As can be seen, our estimate of the investment rate is significantly lower than the official numbers. In 2016, we estimate that the investment rate is 35.6% of GDP – the official number is 7 percentage points higher. Looking at the change since 2010, our estimate is that the investment rate fell from 43.9% in 2010 to 35.5% in 2016. The official number is that the investment rate increased from 45.2% to 42.7% between these two years. Figure A6 in the appendix plots the implied construction GDP growth.

Column 4 in Table 2 reports the growth rate of nominal GDP after all three adjustments (industrial, wholesale and retail trade, and construction output). With all three adjustment, nominal GDP growth since 2013 is about half the official growth rate of nominal GDP. Over the 2010-2016 period, our estimate of the GDP growth is 1.8 percentage points lower than the official growth rate.

The bottom panel in Figure 10 shows our estimate of the savings rate. Our estimate is that the savings rate fell significantly between 2010 and 2016, from 50.4% to 39.7% of GDP. The official numbers show a much smaller decrease from 51.5% to 46.4%. Figure 10 also shows that our revised estimate of the savings rate is much closer to the savings rate computed from the micro-data of the Urban Household Survey. The smaller difference implies a more reasonable saving rate in the non-household sector. Household income accounts for 62% of GDP in 2016. To reconcile the official aggregate saving rate of 46% and the household saving rate of 31%, we would need a saving rate of 70% in the corporate and government sectors. If instead the aggregate saving rate follows our estimate, the corporate

and government sectors would have a saving rate of 54%, more reasonable than what implied by the official aggregate saving rate.<sup>24</sup>

[Insert Figure 10]

### Section 3.2: Adjusting Local GDP

A similar procedure can be applied to correct provincial GDP. The published data on revenues from value-added taxes do not break down revenues by province-industries. However, value added tax revenues from industry, wholesale and retail account for more than 90% of total value added tax revenues before 2015 (see Figure A5 in the Appendix). We use provincial value added tax revenue growth to proxy industrial, wholesale and retail value added tax revenue growth in the province. The same benchmark adjustment for national GDP can then be used for provincial GDP.<sup>25</sup>

[Insert Figure 11]

Figure 11 shows a scatterplot of our adjusted growth rate of provincial GDP against the official growth rate of provincial GDP. The majority of the provinces lie below the 45 degree line, indicating that the official growth rate of most provinces exceeds our adjusted estimates. The average difference is 1.2 percentage points. Guangdong and Zhejiang, however, are located on the 45 degree line. Among the provinces that are far below the 45 degree line are Liaoning (LN) and Inner Mongolia (NM). Local leaders in the two provinces were recently arrested in corruption crackdowns, and one of the official accusations was that these leaders had overstated local GDP. In addition, after the corruption crackdown, the local statistical bureaus in Liaoning and Inner Mongolia issued new revised estimates of local GDP in 2016 and 2017, respectively.<sup>26</sup> The new numbers are 22% and 11% lower than the official numbers in the previous year. In comparison, our estimates show that the unadjusted official

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<sup>24</sup> The household saving rate may be underestimated in the surveys. Using the household saving rate of 36% in the 2016 Flow of Funds Accounts, the implied saving rate in the corporate and government sectors would be 62% and 46% by the official and our adjusted aggregate saving rate, respectively.

<sup>25</sup> We drop Shanghai and Beijing for two reasons. First, these two provinces replaced the business tax with value added tax in 2012 and 2013, respectively. The reform had a significant effect on value added tax revenue in both provincial-level cities where the service sector is substantially larger than the industrial sector. Second, it is widely acknowledged that the two cities are among the regions with the most reliable GDP data.

<sup>26</sup> Tianjin also acknowledged that the Binhai district overstated its GDP. But the Tianjin municipal government claimed that the district-level GDP overstatement didn't affect Tianjin GDP.

GDP in Liaoning and Inner Mongolia is overstated by 9% and 15% in 2015, respectively. Furthermore, the official adjustment on industrial GDP accounts for 70% of its adjustment on GDP in Liaoning. In the case of Inner Mongolia, the local statistical bureau revised downwards its estimate of total value added of above-scale industrial firms in 2016 by 290 billion Yuan, which accounts for the entire downward revision in GDP of Inner Mongolia that year.

Adjusting local FCF is more difficult. Unlike net exports at the national level that is underpinned by custom data, provincial net outflows of goods and services are not based on any data. Therefore, the adjustment for national FCF cannot be applied to provincial FCF. We can however use the following equation to back out provincial FCF:

$$FCF_{jt} = \sum_i \theta_{ijt}^l Y_{ijt}, \quad (4)$$

where  $j$  is the province index,  $\theta_{ijt}^l$  denotes the proportion of  $Y_{ijt}$ , sector  $l$ 's value added in province  $j$ , that is converted to fixed capital in province  $j$ . Instead of using regional IO tables for  $\theta_{ijt}^l$ , we assume  $\theta_{ijt}^l = \theta_{it}^l$  and rely on the numbers in the national IO table. We then plot adjustment to provincial FCF against the official FCF GDP ratio in 2015 in Figure 12. We find that most provinces over-report FCF and the extent of over-reporting is increasing in the official investment rate. The over-reporting of FCF is most severe in provinces such as Qinghai and Henan. The FCF GDP ratio was overstated by more than 50 percentage points in Qinghai. All the three provinces discussed earlier where local officials “confessed” to manipulating local statistics are also associated with severe overstatement of FCF. Their official FCF is about 30% to 50% higher than our estimates in 2015.<sup>27</sup>

[Insert Figure 12 and 13]

Figure 13 shows a positive correlation between the extent of over-reporting in provincial GDP and that over-reporting in provincial FCF (the correlation is 0.54). While our estimated provincial GDP and FCF are correlated by construction, there is no reason that the *adjustments* to provincial GDP and FCF should be correlated. If measurement errors in provincial GDP and FCF are large and independent, adjustments to the two variables would

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<sup>27</sup> We use the 2014 FCF data for Liaoning because FCF in Liaoning declined by about 30% in 2015. Without a big adjustment in GDP, Liaoning's net exports jumped from -104 billion Yuan in 2014 to 304 billion Yuan in 2015. In other words, before its GDP adjustment in 2016, Liaoning had scaled back its investment in 2015.

be uncorrelated. Figure 13 thus provides evidence that local governments overstate both GDP and FCF simultaneously.

### Section 3.3: Adjusting National Accounts with Statistical Models

A second approach is to explore the statistical relationship between GDP and a set of economic indicators outside of China's national accounts. We first estimate a model using the provincial-level data prior to 2008 and then use the estimated model and the indicators to predict provincial and national GDP after 2008. The success of the statistical approach depends on three conditions. First, the indicators are informative about local economy and unlikely to be manipulated. Second, local GDP growth data before 2008 is more reliable than afterwards. Third, the statistical model is flexible enough to capture the rich heterogeneity across Chinese provinces. We discuss the three conditions in order.

Our indicators include satellite night lights, national tax revenue, exports and imports, electricity consumption, railway cargo volume and new bank loans.<sup>28</sup> National tax revenue is collected by local government but directly paid to the central government. Cheating on national tax revenue would incur fiscal losses and, hence, is unlikely to happen. Exports and imports are from the custom data, which are hard to manipulate due to the symmetry of the custom data from China's trading partners. Electricity consumption, railway cargo volume and new bank loans are from the so-called "Keqiang Index", which Li Keqiang, China's current premier, used to monitor local economic performance when he was the Communist Party Secretary of Liaoning province.

We understand that over-reporting of local GDP started in the late 1990s. So local GDP growth data prior to 2008 cannot be entirely reliable. Yet, we also understand that GDP over-reporting has become more severe since 2008. What we will identify from the following exercise is the difference in the degree of GDP overstatement between the period prior to 2008 and the post-2008 period. Consequently, when we rely on local GDP growth data prior to 2008, which is *per se* likely to be overstated, to estimate the subsequent growth, our

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<sup>28</sup> Using bank loans (not new bank loans) delivers similar results.



adjustment has to be a lower bound. The true GDP growth might be even lower than our estimates for the post-2008 period.<sup>29</sup>

In terms of the statistical model, we will use the method developed by Su, Shi and Phillips (2016) to control for hidden economic structure heterogeneities across regions. Consider the following linear model:

$$y_{it} = \beta_i' X_{it} + v_i + \varepsilon_{it},$$

where  $y_{it}$  is log GDP of province  $i$  at year  $t$ ,  $X_{it}$  is a  $p \times 1$  vector of logarithm of the indicators,  $\beta_i$  is a  $p \times 1$  coefficient vector,  $v_i$  captures provincial fixed effect and  $\varepsilon_{it}$  is the i.i.d error term with mean zero. In the special case where  $\beta_i = \beta$ , the model reduces to the standard fixed effects regression. The more general model can capture heterogeneous economic structures across regions. Intuitively,  $\beta$  for the regions where local economy heavily relies on resources might be very different from the others. Specifically, we assume  $\beta_i$  to be group-specific – i.e.,  $\beta_i = \beta_k$ , for all  $i$  in group  $k$ , where  $i \in \{1, 2, \dots, N\}$ ,  $k \in \{1, 2, \dots, K\}$  and  $K \leq N$ . Instead of grouping provinces by geographical or economic characteristics, we implement the classifier-Lasso (C-Lasso) method in Su, Shi and Phillips (2016). The method provides statistical inference for membership identification, which is totally data driven. We don't have to rely on prior knowledge about the number of groups or the number of provinces within each group. With the groups identified from C-Lasso, we can use the fixed effects model to estimate the group-specific coefficients.

It is worth mentioning the rapid expansion of China's service sector. According to the national account data, service accounted for 43% of GDP in 2007 and the share increased to 52% in 2017. This is important because some of our indicators, like electricity consumption and railway cargo volume, might be more relevant for industrial production than for service production. If  $y_{it}$  includes service output, the ongoing structural transformation would imply time-varying  $\beta_i$  and, hence, invalidate our model. To address the concern, we will use provincial industrial GDP as  $y_{it}$  in the benchmark and then use provincial GDP as a robustness check. There are two reasons why we prefer provincial industrial GDP. First, the

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<sup>29</sup> Our approach is fundamentally different from Fernald, Hsu and Spiegel (2015) and Clark, Pinkovskiy and Sala-i-Martin (2017), who use data on exports to China from its trading partners and night lights as independent measures of China's economic activities. We instead train our statistical model by provincial industrial GDP data prior to 2008, when the overstatement of industrial GDP was much less evident compared to the post-2008 period. See also Hu and Yao (2018) who use night time light data to estimate GDP in a number of countries.

stationarity of  $\beta_i$  is more defensible for industrial GDP alone. Second, we have shown the evidence that GDP overstatement is larger in the industrial sector.

Our sample consists of annual observations from 30 provinces (excluding Tibet) between 2000 and 2017. GDP, electricity consumption, exports and imports, railway cargo volume and new bank loans are all from NBS;<sup>30</sup> national tax revenue is from China Taxation Yearbook; we use the DMSP-OLS night time lights data from National Oceanic and Atmospheric Administration (NOAA) in the United States.<sup>31</sup> The time series are shorter for some variables. Satellite night lights data ends at 2013. National tax revenue data ends at 2015 because the reform “to replace business tax with value-added tax” made national tax revenue not comparable before and after 2016.

Two remarks are in order. First, night lights data, electricity consumption and railway freight are all in real terms. As a robustness check, we use GDP deflators to convert GDP, national tax revenue, exports and imports and bank loans into real terms in the regressions (see also Clark et al., 2017).<sup>32</sup> The estimated GDP will be converted back into nominal terms. The technical appendix reports the results with price adjustments. The differences are small. Second, we can use more data in the earlier period to estimate the model, with a caveat that the estimated model might be less applicable to the recent years due to structural changes. In the Appendix, we estimate the model by the data between 1995 (the year after implementation of the tax sharing reform) and 2007. The main results are very similar.

We first apply LASSO to the 2000-2007 data for model selection. K-fold cross validation, EBIC (Extended Bayesian Information Criterion) and data-driven penalty with heteroscedasticity (Belloni et al., 2012, 2014, 2016) suggest to keep all the indicators except for new bank loans. Besides the statistical evidence, there is also an economic reason for us to drop bank loans. The “fiscal stimulus” launched by the Chinese government in the late 2008 relaxed the borrowing constraint on local governments and led to a debt explosion afterwards (Bai, Song and Hsieh, 2016). Much of the fund raised by local government financing vehicles

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<sup>30</sup> All the indicators are downloaded from the NBS website. Export and import (by place of destination or origin in China) are priced in USD and converted into Yuan by annual averages of the exchange rate. New bank loan is the annual difference of outstanding bank loan in December.

<sup>31</sup> The night light data is not comparable before and after 2010 due to the satellite change. We use the average of the light growth in 2009 and 2011 to proxy the 2010 light growth for out-of-sample predictions.

<sup>32</sup> GDP deflators are inferred from the official real and nominal GDP growth.

is believed to finance infrastructure investment, rather than production. This implies a structural change in the way that new bank loans contribute to GDP.

Our estimation is done in three steps. First, using the sample prior to 2008, we run the C-Lasso estimation and to classify provinces into different groups. Second, we estimate group-specific coefficients by post-Lasso OLS regressions. Finally, the estimated  $\hat{\beta}_k$  and the same set of the indicators are used to estimate provincial secondary industry value added throughout the whole sample period. Assuming provincial agriculture, construction and service GDP are reliable, we can estimate provincial GDP, which will be added to obtain aggregate GDP. Note that the estimated industrial value added after 2008 is out-of-sample prediction, while the estimation before 2008 is in-sample prediction.

When we use provincial industrial GDP, the C-Lasso procedure doesn't find statistical evidence for grouping, suggesting that the relationship between industrial GDP and these indicators is similar across provinces. As will be seen below, the result would be different if we replace provincial industrial GDP with provincial GDP. Since the satellite night lights data is not available after 2013, it can only be used for the out-of-sample prediction between 2008 and 2013. We re-run the C-Lasso and post-Lasso OLS regressions without night lights. The estimated model can make out-of-sample predictions for the post-2013 period.<sup>33</sup>

The out-of-sample predictions are shown in Figure 14 and Table 2.<sup>34</sup> While the in-sample predictions are close to the official numbers, the out-of-sample predictions are more volatile and lower than the official numbers in recent years. The estimated GDP growth is about 0.8 to 1.3 percentage points lower than the official GDP growth during 2014 and 2016 (see the dotted and dashed line in Figure 14 and Column 7 and 8 in Table 2).

[Insert Figure 14]

We note that although our two approaches are fundamentally different, they yield similar results in terms of the magnitude of overstatement of GDP. Table 2 shows that nominal GDP growth was overstated after 2010 and more so after 2013, and the magnitude of the overstatement after 2013 was about one to two percentage points.

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<sup>33</sup> The tables with the regression coefficients are in the appendix.

<sup>34</sup> We aggregate provincial GDP growth by our estimated provincial GDP, which is based on the estimated provincial GDP growth and uses 2009 official provincial GDP as the benchmark.

One may wonder to what extent tax revenue data used by the two approaches can explain their similar results on the recent over-reporting of GDP. First to notice is that tax revenue data are very different in the two approaches. National tax includes many taxes other than value added tax (such as all consumption tax and part of corporation income tax) and only a fraction of value added tax belongs to national tax. Figure 15 plots the extent of GDP overstatement across provinces estimated by the first approach and the second approach with national tax revenue. Since the second approach only adjusts industrial GDP, we use the first approach that adjusts industrial GDP only to make the two approaches more comparable. The correlation is 0.64. In other words, the different methods using different data sources deliver positively correlated estimates on provincial GDP overstatement.

[Insert Figure 15]

We also run the regressions without national tax revenue. An advantage of dropping national tax revenue is to extend the estimation to the years after the completion of the reform to replace business tax. The results are shown in Figure 14 and the last column in Table 2. The overstatement in GDP growth after 2013 appears to be a robust finding, though its magnitude does depend on estimation method and variable selection.

We next replace provincial industrial GDP with provincial GDP for robustness check. We drop both railway cargo volume and new bank loans as suggested by LASSO. Given the huge disparity in GDP composition across provinces, not surprisingly, C-Lasso identifies two groups, with 16 provinces in Group 1 and 14 provinces in Group 2. See Appendix II for the detailed grouping results. Interestingly, Beijing, Shanghai and Hainan, the three provinces with the highest service GDP share, are all in Group 1. The fixed effects regression results for each group are reported in the appendix. Coefficients are indeed quite different across groups. We then run C-Lasso without light data, which also identifies two groups, with 11 and 19 provinces in Group 1 and 2. Appendix II shows that 10 out of 11 provinces in Group 1 are in Group 1 identified by C-Lasso with light data. Again, Beijing, Shanghai and Hainan are all in Group 1.

Figure 16 compares the GDP growth rates from the official data, our estimates using provincial GDP with light data, provincial GDP without light data, and provincial GDP without light or tax data. Estimating provincial GDP directly implies much bigger GDP overstatement. The difference between the official GDP growth and our estimate is more than

five percentage points in 2015. As discussed above, the caveat is the misspecification of the model that fails to capture how the rise of the service sector affects GDP growth.

[Insert Figure 16]

#### **4. Implications of our Revised Estimates of China's National Accounts**

We summarize here the three main implications of our results. First, nominal GDP growth after 2010 and particularly after 2013 is lower than suggested by the official statistics. Second, the savings rate has declined by 11 percentage points between 2010 and 2016. The official statistics suggest the savings rate only declined by 5 percentage points between these two years. Third, our statistics suggest that the investment rate fell about 8% of GDP between 2010 and 2016. Official statistics suggest that the investment rate fell 3% over this period.

We note that we do not have independent information on GDP deflators so our statement is only about nominal GDP growth. The literature has questioned the reliability of China's official price indices, but we do not have independent information on the deflators.<sup>35</sup> Keeping in mind the caveats, we think it is useful to convert nominal output and input into real terms using the official GDP deflators and investment goods price index.

For real GDP growth, we calculate real GDP in the industrial, construction, wholesale and retail sectors using our estimated nominal GDP (first approach) and the official GDP deflators for the three sectors. Adding adjusted real GDP in the three sectors to real GDP in the other sectors gives our adjusted real GDP shown in Figure 17. On average, the annual real GDP growth was overstated by 2 percentage points between 2010 and 2016. The official real GDP is 13% above our estimate in 2016.

[Insert Figure 17]

We now discuss the implications of our findings for capital returns, TFP growth, and the debt to GDP ratio. We begin with the return to capital. We use the following equation to estimate returns to capital:

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<sup>35</sup> See, for example, Brandt and Zhu (2010) and Nakamura, Steinsson and Liu (2016).

$$r(t) = i(t) - \hat{P}_Y(t) = \frac{\alpha(t)}{P_K(t)K(t)/P_Y(t)Y(t)} + [\hat{P}_K(t) - \hat{P}_Y(t)] - \delta(t),$$

where  $r$  denotes real returns to capital,  $i$  denotes nominal returns to capital,  $\hat{P}_Y$  denotes the growth rate of output price,  $\hat{P}_K$  denotes the growth rate of capital goods price,  $\alpha$  denotes the share of capital income in output,  $P_K K/P_Y Y$  denotes the nominal capital-output ratio and  $\delta$  is the depreciation rate.

The results are plotted in Figure 18.<sup>36</sup> The solid line uses the official data and replicates the earlier estimates in Bai et al. (2006) and the more recent ones in Bai and Zhang (2015). Recall that our adjustment of production GDP also lowers investment which increases the ratio of output to capital. In either official or adjusted data, the dramatic decline in aggregate returns to capital in the post-2007 period turns out to be a robust phenomenon.

[Insert Figure 18]

To estimate TFP, we assume the following aggregate production function:

$$Y(t) = A(t)[K(t)]^\alpha[h(t)L(t)]^{1-\alpha},$$

where  $Y$  is real GDP,  $A$  is aggregate TFP,  $K$  is real capital,  $h$  is human capital per worker and  $L$  is the number of workers.<sup>37</sup> The results are plotted in Figure 19. The aggregate TFP growth rates by our estimates appear to be more volatile than those by official data. Yet, it remains obvious that China's aggregate TFP growth slowed down substantially after 2007.

[Insert Figure 19]

Finally, Figure 20 shows the debt to GDP ratio with our revised estimate of nominal GDP. The estimation of debt follows Song and Xiong (2018). The bottom line is that our revised numbers suggest that the debt to GDP ratio has increased by more than suggested by

<sup>36</sup> We discuss the details of the data used to estimate the return to capital in the appendix.

<sup>37</sup> We set  $\alpha = 0.5$  (the results are similar if we use time-varying  $\alpha$  calibrated in the appendix for estimating returns to capital). We assume  $h = \exp(s \cdot E)$ , where  $E$  is the year of schooling and  $s$  is the return to schooling. The average year of schooling for workers in 2000 and 2005 is from the 2000 census and 2005 one-percent population survey data. We obtain the numbers between 2001 and 2004 by linear interpolation. For 2006 to 2016, we use the numbers from the labour force survey in the Statistical Yearbooks of Population and Employment. For 1990 to 1999, we assume the annual growth of  $E$  to be its average average growth in 2000-2005. We then use the 2005 one-percent population survey data to estimate returns to education by the Mincer earnings regression, which gives  $s = 0.126$ .

the official numbers. Our estimate of the debt to GDP ratio in 2016 is 2.4 – the official number is 2.1.

[Insert Figure 20]

## 5. Conclusion

A key institutional fact about China is that many administrative functions are controlled by powerful local governments. In Bai, Hsieh and Song (2019), we argue that local governments have used this power to support a large number of private businesses. The question in this paper is what local governments choose to do with their power over local statistics.

We document that local governments have chosen to use this power to inflate local statistics on GDP, particularly by overstating industrial output and investment, particularly after the mid-2000s. As evidence, we show that the sum of local GDP has exceeded aggregate GDP since 2003. One possible explanation why they do this is the introduction of local economic performance in the evaluation of local officials by the Chinese Communist Party's Organization Department in the late 1990s. The official documentation of this policy change states that local officials will be evaluated based on “the speed, efficiency and potentials of economic development, the growth of fiscal revenue, the improvement of people's living standards.”<sup>38</sup> The revision intensified economic competition between local governments, and it seems likely that many local governments resorted to inflating local GDP numbers. Xiong (2018) provides a theoretical framework where competition between local governments results in both overstatement of GDP as well as investment. And Lyu et al. (2018) present evidence that regional growth target can be achieved by fabricating data.

The possibility that local governments misreport local GDP is well known, and the Central Government's National Bureau of Statistics adjusts the numbers reported by local governments. Prior to 2003, the NBS adjusted upwards local GDP but after 2003, the NBS adjusted local GDP downwards. However, our estimates suggest that the extent by which local governments exaggerate local GDP accelerated after 2008, but the magnitude of the

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<sup>38</sup> See “Provisional Regulations on Evaluating Party and Government Cadres” (Document No.6, Central Organization Department of China's Communist Party, 1998).

adjustment by the NBS did not change in tandem. As a consequence, our best estimate is that the true growth rate of GDP is probably overstated by almost 2 percentage points from 2010 to 2016.

A final question is what tools and what incentive does the NBS have to report accurate statistics. We document that much of the underlying data behind the national accounts is out of the hands of the NBS. Furthermore, the question is what incentives does the NBS has to resist local officials who misreport data. Interestingly, although the NBS adjusts downwards local statistics, it does not report the adjusted local statistics, perhaps out of a desire to not confront powerful local leaders. Given the weak position of the NBS and the strong position of local leaders in the Chinese political system, it is not surprising that statistical data are potentially biased.



## References

- Bai, Chong-En, Chang-Tai Hsieh, and Yingyi Qian. 2006. "The Return to Capital in China." *Brookings Papers on Economic Activity*, Fall: 61-101.
- Bai, Chong-En, Chang-Tai Hsieh, and Zheng Song. 2016. "The Long Shadow of China's Fiscal Expansion." *Brookings Papers on Economic Activity*, Fall: 129-181.
- Bai, Chong-En, Chang-Tai Hsieh, and Zheng Song. 2019. "Special Deals with Chinese Characteristics." *NBER Macroeconomics Annual*, forthcoming.
- Bai, Chong-En, Xilu Chen, Zheng Song, and Xin Wang. 2019. "The Rise of China's Service Sector." Working Paper.
- Bai, Chong-En, and Qiong Zhang. 2015. "The Return on Capital in China and Its Determinants." *China Economist* 10, no. 3: 20-37.
- Brandt, Loren, and Xiaodong Zhu. 2010. "Accounting for China's Growth." Working Paper.
- Cai, Jing, and Ann Harrison. 2018. "Industrial Policy in China: Some Unintended Consequences?" *Industrial and Labor Relations Review*, Forthcoming.
- Chen, Zhao, Xian Jiang, Zhukuo Liu, Juan Carlos Suárez Serrato, and Daniel Yi Xu. 2019. "Tax Policy and Lumpy Investment: Evidence from China VAT Reform." Working Paper.
- Clark, Hunter, Maxim Pinkovskiy, and Xavier Sala-i-Martin. 2017. "China's GDP Growth May Be Understated." Working Paper no. 23323. Cambridge, Mass.: National Bureau of Economic Research.
- Fernald, John G., Eric Hsu, and Mark M. Spiegel. 2015. "Is China Fudging Its Figures? Evidence from Trading Partner Data." Working Paper.
- Gao, Jie. 2016. "Bypass the Lying Mouths: How Does the CCP Tackle Information Distortion at Local Levels?" *The China Quarterly* 228: 950-969.
- Holz, Carsten A. 2013. "Chinese Statistics: Output Data." Working Paper.
- Holz, Carsten A. 2014. "The Quality of China's GDP Statistics." *China Economic Review* 30: 309-338.
- Holz, Carsten A. 2015. "China's Investment Rate: Implications and Data Reliability." Working Paper.
- Hsueh, Tien-Tung, and Qiang Li. 1999. "China's National Income, 1952-1995." Boulder: Westview Press.
- Hu, Yinghao and Jiaoxong Yao. 2018. "Illuminating Economic Growth." Johns Hopkins University mimeo.
- Lardy, Nicholas R. 2014. "Markets over Mao: The Rise of Private Business in China." New York, NY: Columbia University Press.
- Lei, Yu-Hsiang. 2017. "Quid Pro Quo? Government-Firm Relationships in China." Working Paper.

- Liu, Fang, Jun Zhang, and Tian Zhu. 2016. "How Much Can We Trust China's Investment Statistics?" *Journal of Chinese Economic and Business Studies* 14, no. 3: 215-228.
- Lyu, Changjiang, Kemin Wang, Frank Zhang, and Xin Zhang. 2018. "GDP Management to Meet or Beat Growth Targets." *Journal of Accounting and Economics* 66, no. 1: 318-338.
- Ma, Ben, Guojun Song, Lei Zhang, and David A. Sonnenfeld. 2014. "Explaining Sectoral Discrepancies between National and Provincial Statistics in China." *China Economic Review* 30: 353-369.
- Nakamura, Emi, Jón Steinsson, and Miao Liu. 2016. "Are Chinese Growth and Inflation Too Smooth? Evidence from Engel Curves." *American Economic Journal: Macroeconomics* 8, no. 3: 113-144.
- National Bureau of Statistics. 2006. "Input-Output Tables of China 2002." Beijing, China Statistics Press.
- National Bureau of Statistics. 2009. "Input-Output Tables of China 2007." Beijing, China Statistics Press.
- National Bureau of Statistics. 2015. "Input-Output Tables of China 2012." Beijing, China Statistics Press.
- Orlik, Tom. 2014. "Reform at China's National Bureau of Statistics under Ma Jiantang 2008-2013." *China Economic Review* 30: 304-308.
- Song, Zheng, and Wei Xiong. 2018. "Risks in China's Financial System." *Annual Review of Financial Economics* 10: 261-286.
- Su, Liangjun, Zhentao Shi, and Peter C. B. Phillips. 2016. "Identifying Latent Structures in Panel Data." *Econometrica* 84, no. 6: 2215-2264.
- Wang, Xiaolu, and Lian Meng. 2001. "A Reevaluation of China's Economic Growth." *China Economic Review* 12, no. 4, 338-346.
- Xiong, Wei. 2018. "The Mandarin Model of Growth." Working Paper no. 25296. Cambridge, Mass.: National Bureau of Economic Research.
- Xu, Xianchun. 2004. "China's Gross Domestic Product Estimation." *China Economic Review* 15, no. 3: 302-322.
- Xu, Xianchun. 2014. "Accurate Understanding of China's Income, Consumption and Investment." *Social Sciences in China* 35, no. 1: 21-43.
- Zhang, Lei, Yuyu Chen, and Zongyan He. 2018. "The Effect of Investment Tax Incentives: Evidence from China's Value-Added Tax Reform." *International Tax and Public Finance* 25, no. 4: 913-945.

**Table 1: Aggregates in Census Micro-Data vs. National Account**

	<b>Above-Scale Firms in Census/ National Account</b>	<b>Below-Scale Firms in Census/ National Account</b>
	<b>Industrial Firms</b>	
2004	79.9 %	7.5 %
2008	88.1 %	5.6 %
	<b>Wholesale and Retail Firms</b>	
2008	63.2%	12.8%

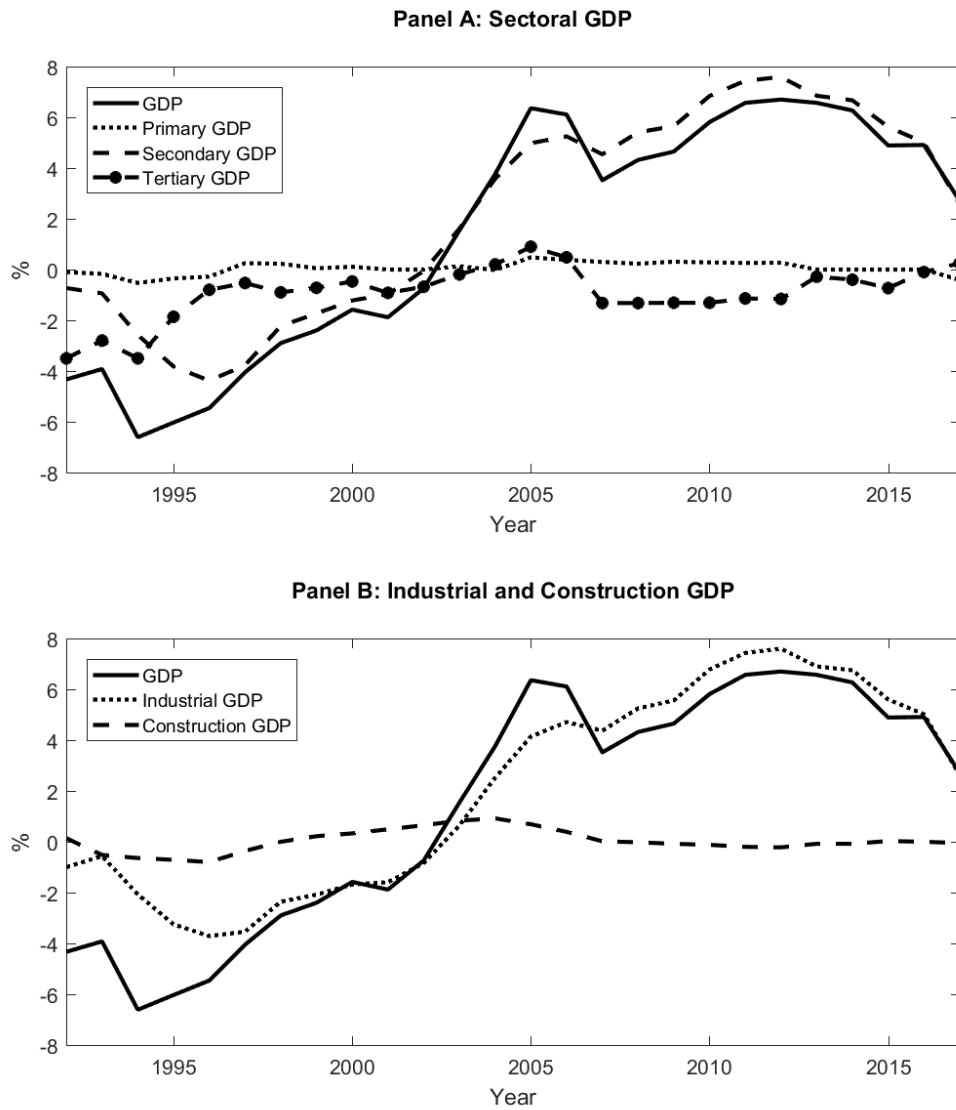
Note: This table reports total value added of above-scale (sales above 5 million RMB) and below-scale (sales below 5 million RMB) firms in the industrial sector (upper panel) and wholesale and retail sectors (bottom panel) as a percent of the corresponding sectoral GDP.

**Table 2: Adjusted Growth Rate of Nominal GDP**

	Official Data	Adjustment by Value Added Tax			Adjustment by Statistical Model on Industrial GDP		
		Adjusting Industrial GDP	Adjusting Industrial and W&R GDP	Adjusting Industrial, Construction and W&R GDP	All Variables	Without Light	Without Light and National Tax
2009	9.25	9.25	9.25	9.25	7.09	7.97	5.26
2010	18.32	15.02	15.36	14.86	20.27	19.13	19.78
2011	18.47	16.37	15.86	15.36	19.42	18.17	17.76
2012	10.44	11.38	10.00	9.88	9.98	9.95	9.33
2013	10.16	9.29	8.89	8.63	10.12	9.51	10.08
2014	8.19	7.54	6.70	6.39		7.56	7.04
2015	7.00	6.55	6.20	6.02		5.98	4.83
2016	7.91	6.46	6.69	6.43			7.33
2017	10.93						10.19
Average 2010-2016	11.50	10.37	9.96	9.65			10.88

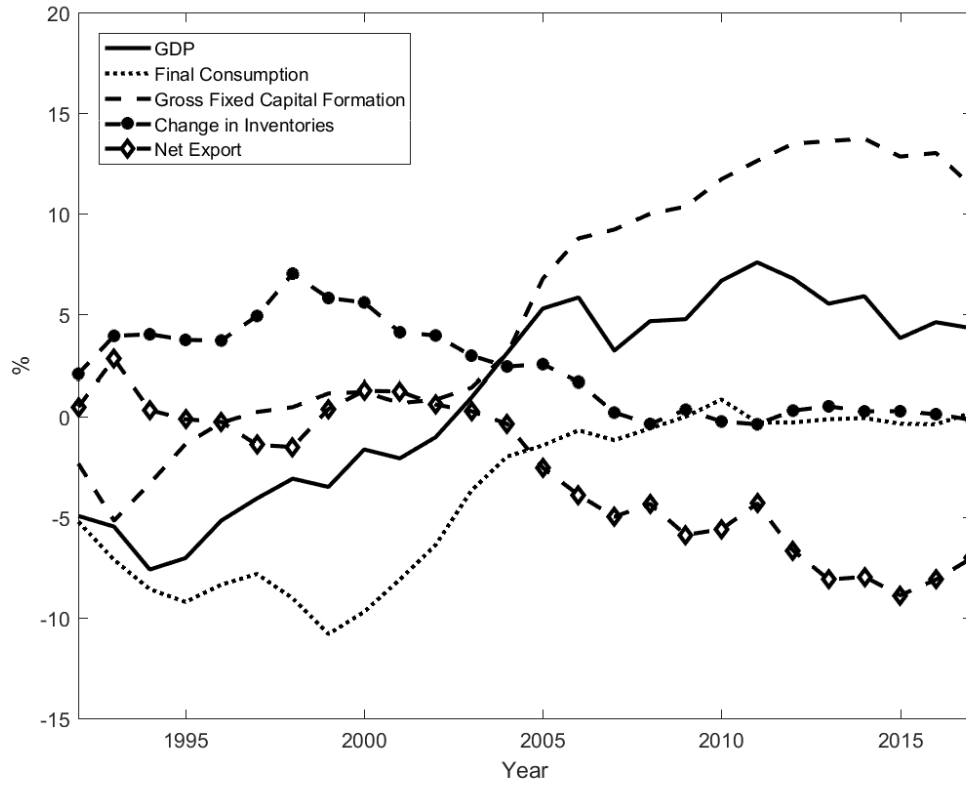
Note: W&R GDP refers to GDP in the wholesale and retail sectors.

**Figure 1: Gap between Local and Aggregate GDP by Sector**



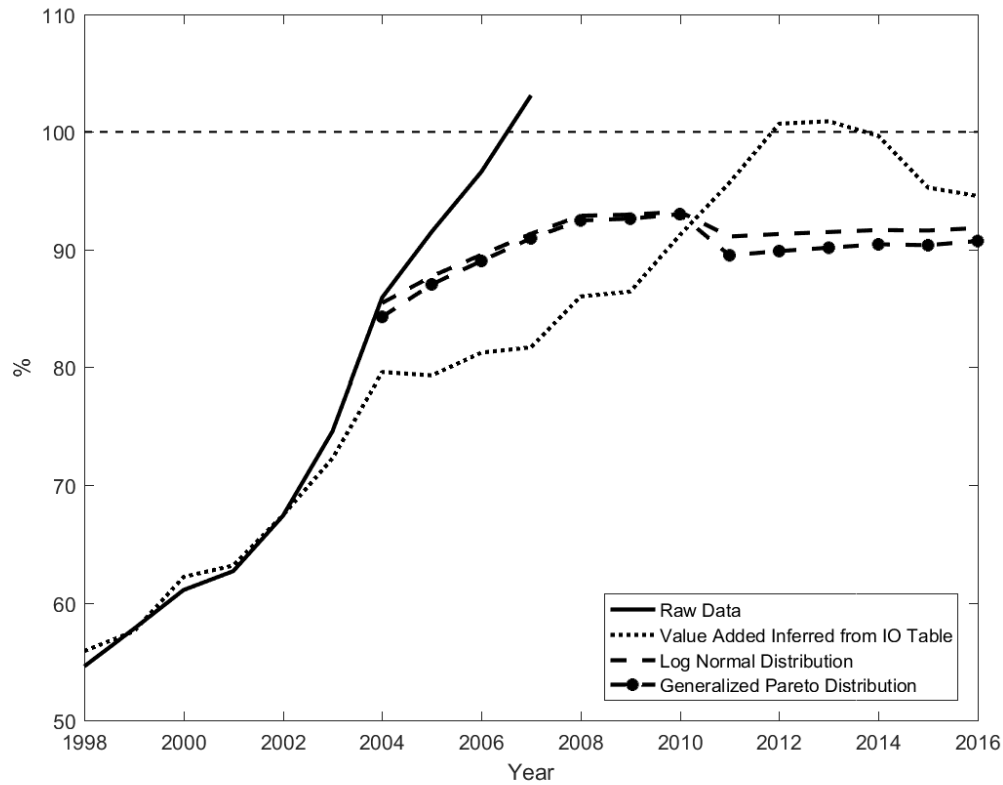
Note: This figure plots the difference between the sum of local sectoral GDP and aggregate sectoral GDP as a percent of aggregate GDP of each sector.

**Figure 2: Gap between Local and Aggregate GDP by Expenditure**



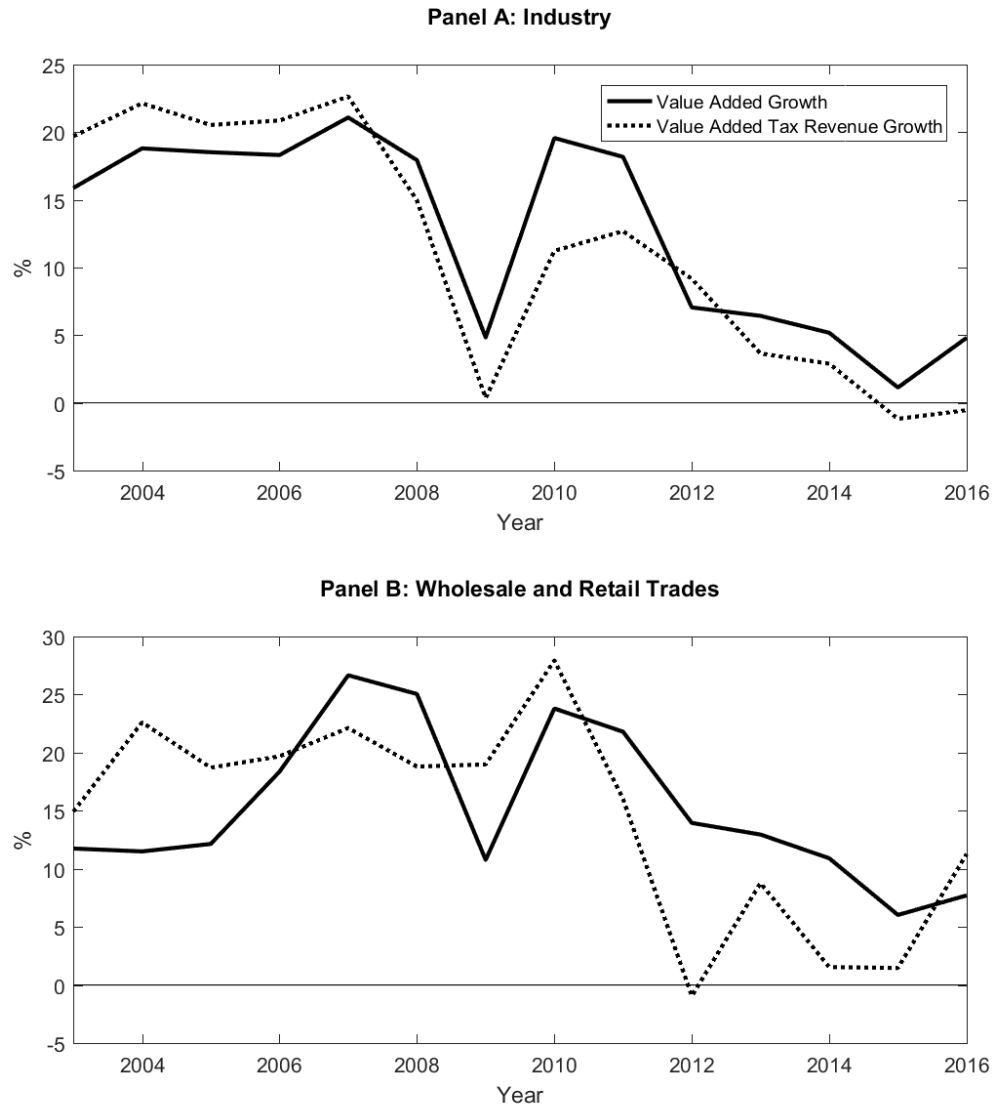
Note: The figure plots the difference between the sum of provincial expenditure and aggregate expenditure as percent of aggregate expenditure.

**Figure 3: Industrial GDP: Aggregate of Micro-Data vs. National Accounts**



Note: “Raw data” is the ratio of total value added of above scale industrial firms in the ASIF micro-data to industrial GDP. “Value Added inferred from IO Table” is total value-added inferred from total sales of above-scale industrial firms in the ASIF micro-data adjusted by the value added to gross output ratio in the IO tables. “Log-Normal Distribution” and “Generalized Pareto Distribution” are total value-added of above-scale firms inferred from fitting a log normal and Pareto distribution to the micro-data (as a share of industrial GDP in the national accounts).

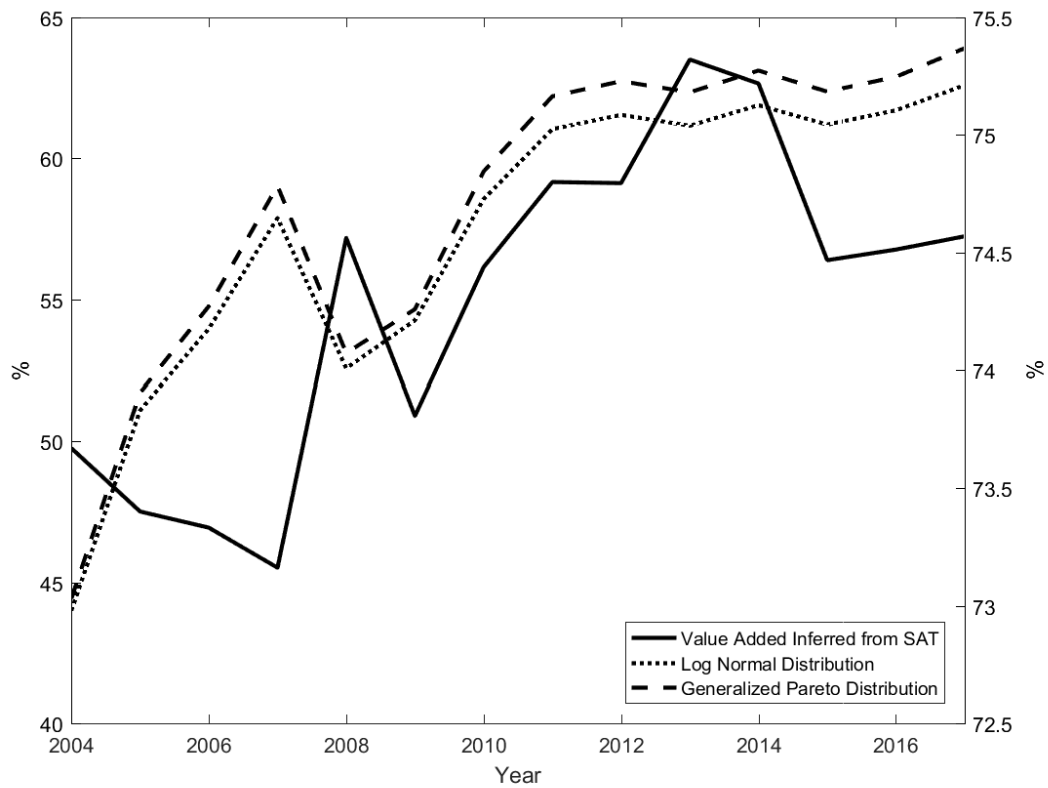
**Figure 4: Growth in Value-Added Tax Revenues and GDP**



Note: The dotted and solid lines plot value added tax revenue growth in the sector and sectoral GDP growth in the national account, respectively.

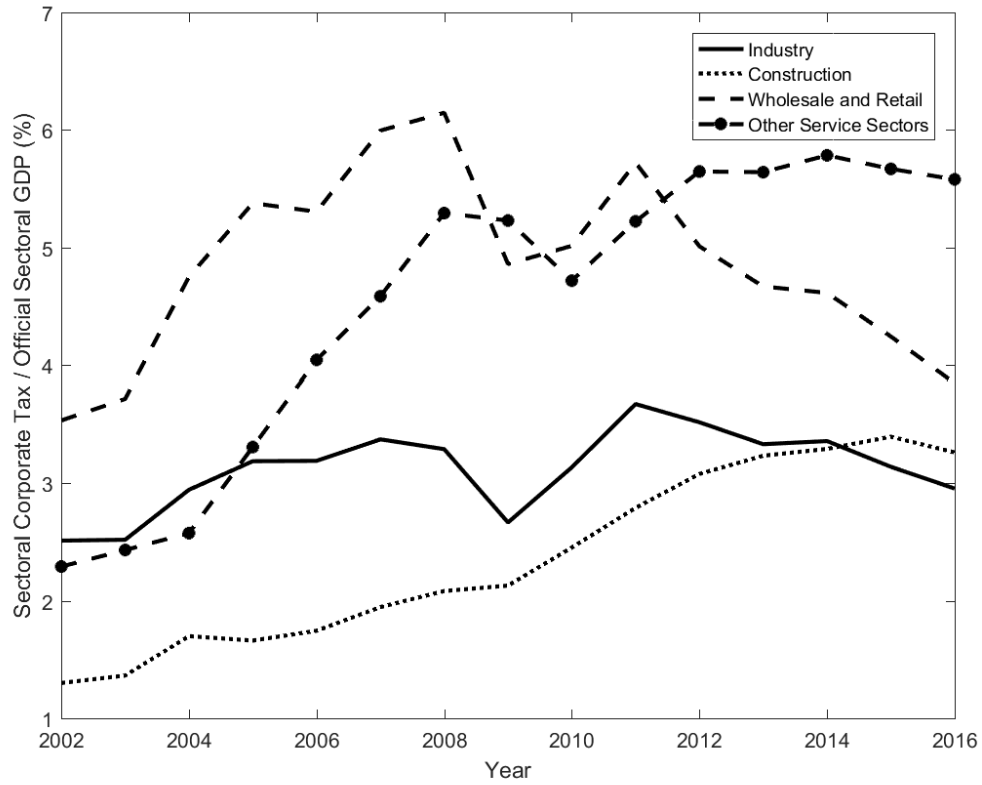


**Figure 5: Wholesale and Retail GDP: Aggregate of Micro-Data vs. National Accounts**



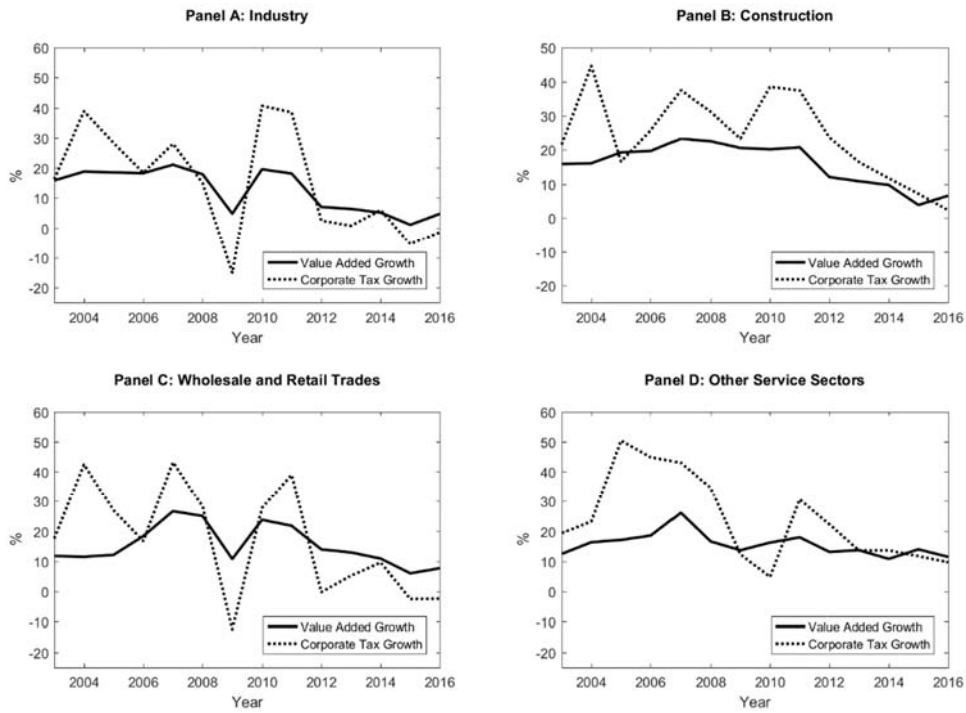
Note: Figure presents ratio of value-added of above-scale retail and wholesale firms to wholesale and retail GDP in national accounts. “Value Added Inferred from SAT” is value-added imputed from total sales of above-scale wholesale and retail firms in the firm survey adjusted by the value added to sales ratio in the data of the State Administration of Taxation. “Log-Normal Distribution” and “Generalized Pareto Distribution” are total value-added of above-scale firms inferred from fitting a log normal and Pareto distribution to the micro-data.

**Figure 6: Corporate Income Tax Revenue as share of GDP (%)**



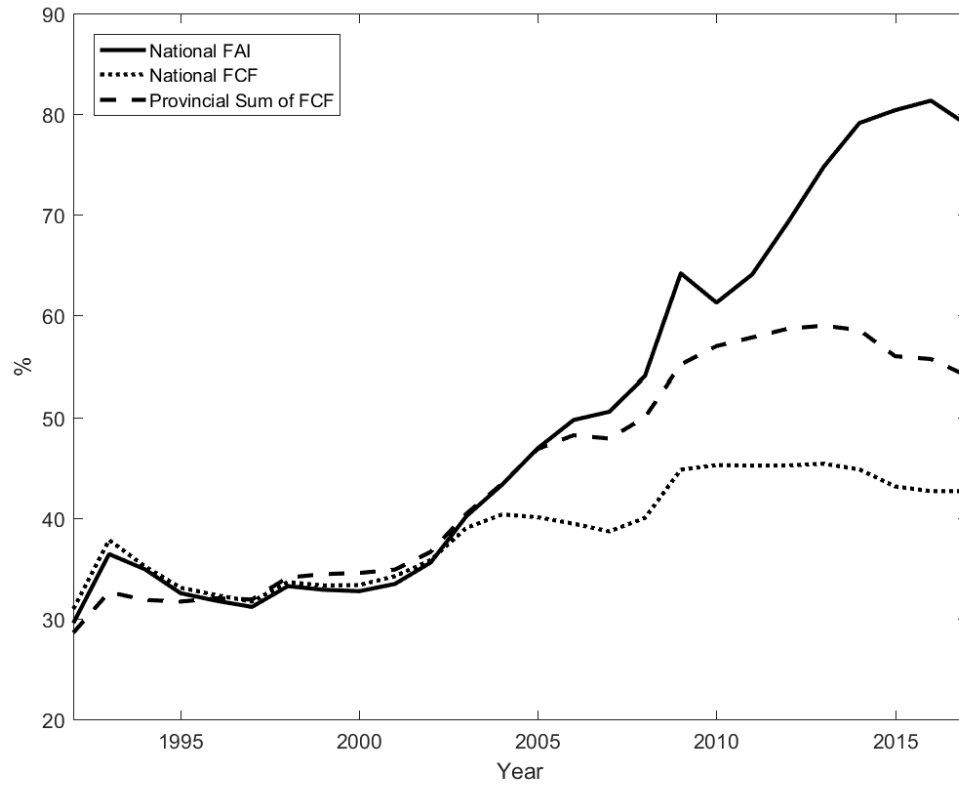
Note: This figure plots the ratio of corporate income tax revenue to GDP in the industrial sector, construction, wholesale and retail trade, and services excluding wholesale and retail.

**Figure 7: Sectoral GDP and Corporate Income Tax Revenue Growth**



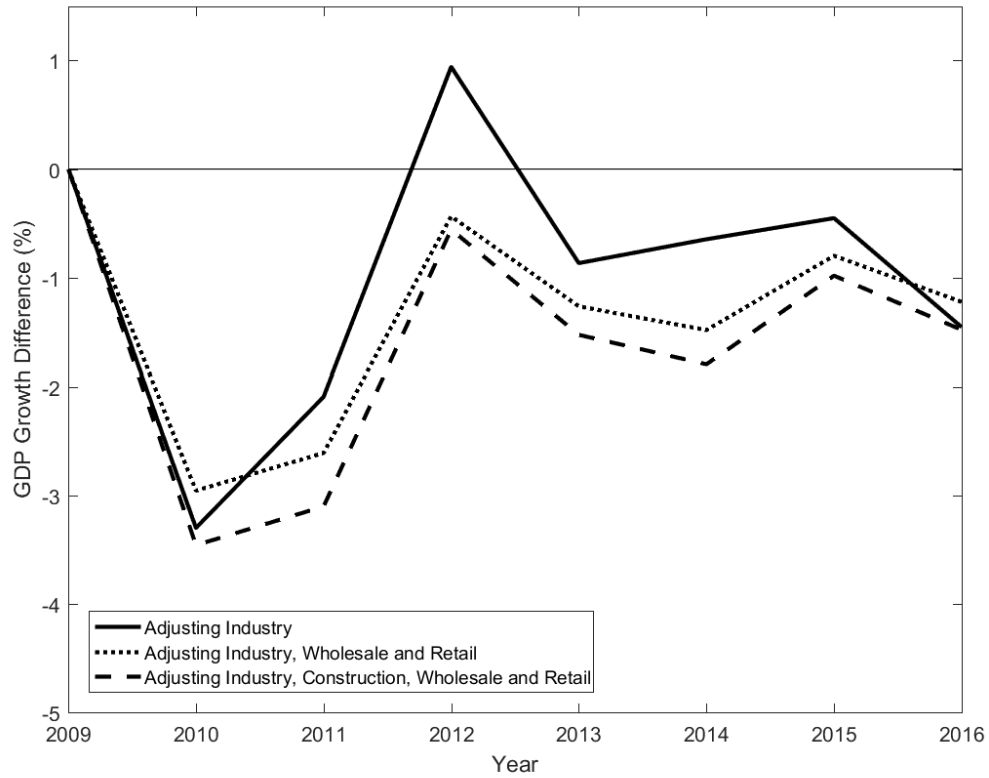
Note: This figure plots sectoral nominal GDP growth (solid line) and corporate income tax revenue growth (dotted line) in the sector.

**Figure 8: Fixed Asset Investment (FAI) vs Fixed Capital Formation (FCF)**



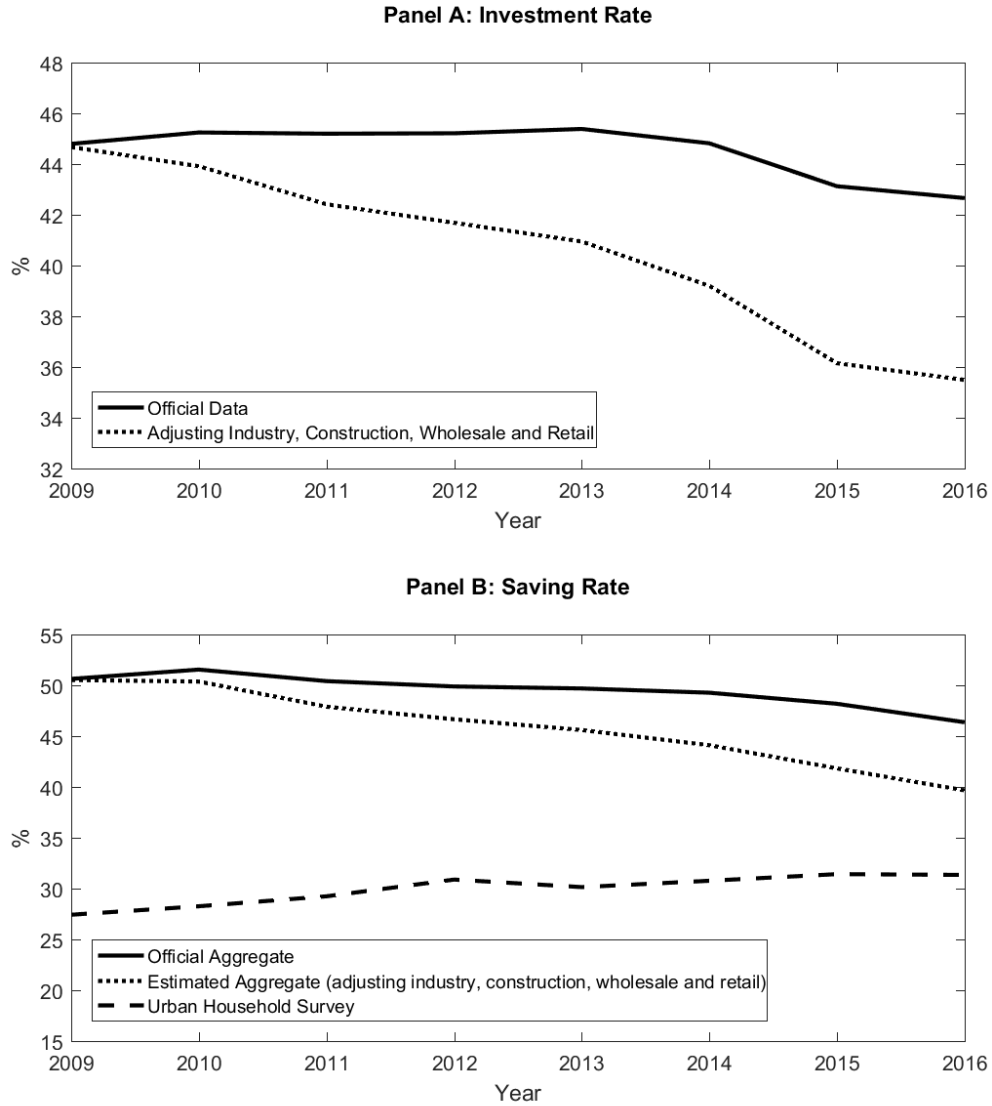
Note: This figure plots aggregate fixed asset investment (FAI), aggregate fixed capital formation (FCF) and the sum of provincial FCF as a percent of aggregate GDP.

**Figure 9: Gap between Adjusted and Official Nominal GDP Growth**



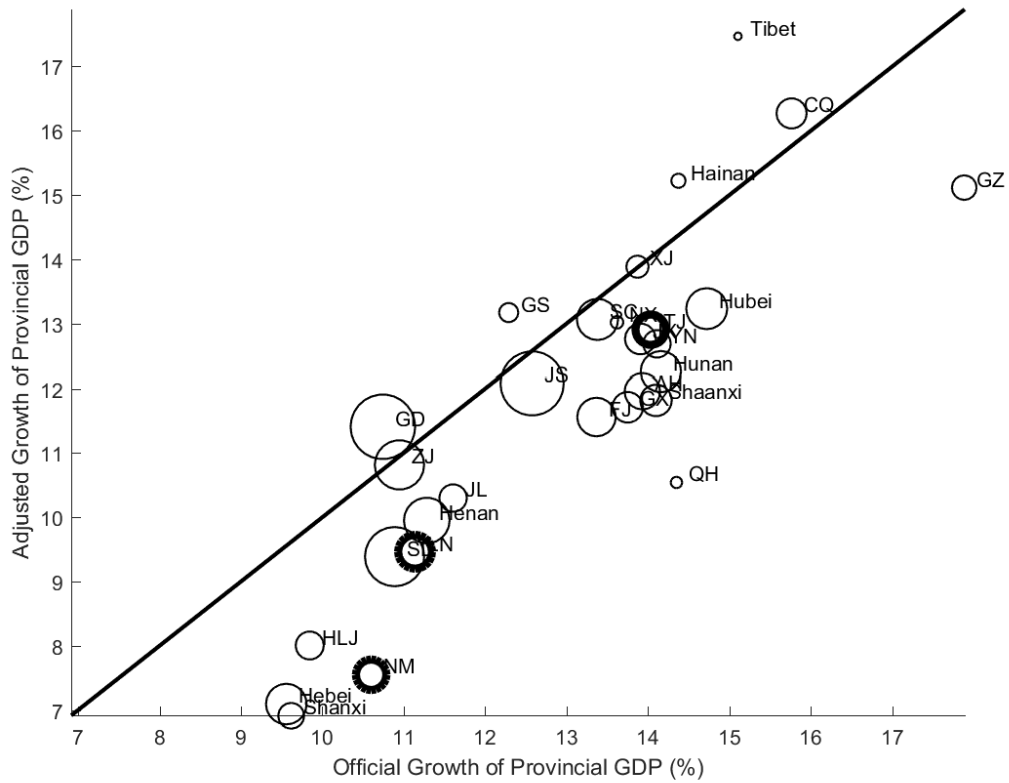
Note: This figure plots the difference between adjusted nominal GDP and official nominal GDP growth rates. The solid line adjusts industrial GDP growth only. The dotted line adjusts both industrial, wholesale and retail GDP growth. The dashed line adjusts industrial, wholesale and retail and construction GDP.

**Figure 10: Official and Adjusted Investment Rates**



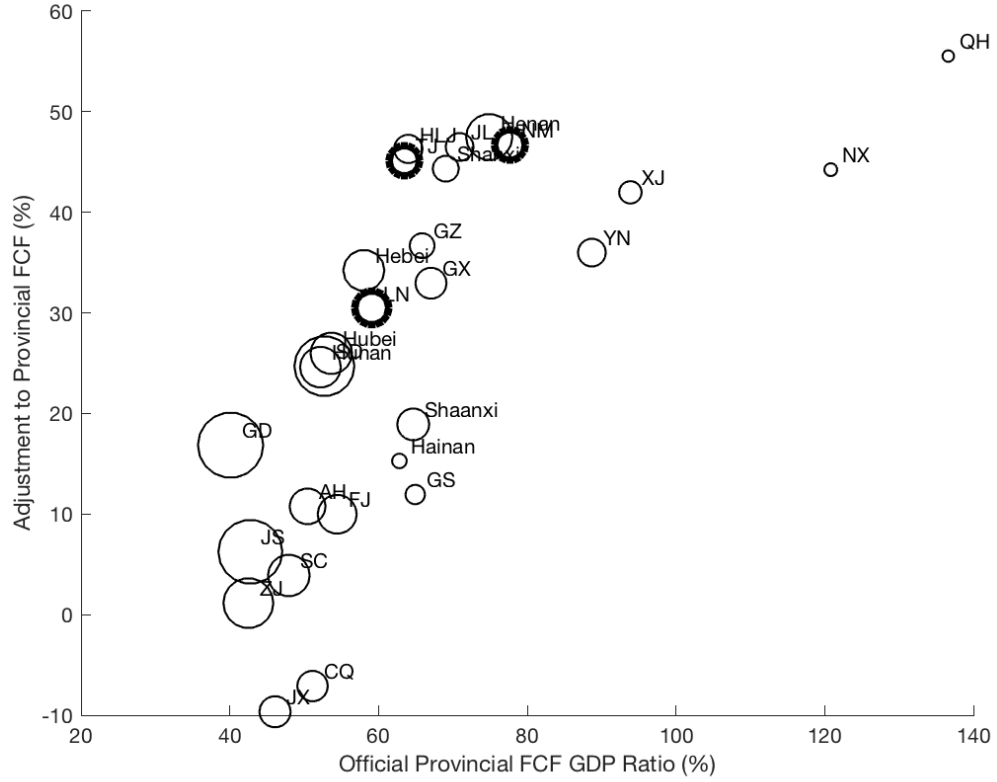
Note: The solid line in Panel A plots the ratio of official FCF to official GDP. The dotted line plots the ratio of *adjusted* FCF and *adjusted* GDP (with industry, construction, whole and retail GDP adjusted). For comparability with the adjusted FCF afterwards, in 2009, the adjusted FCF is calculated as production-side GDP minus other expenditure components. The solid line in Panel B is the aggregate savings rate in the national account. The dotted line plots the adjusted aggregate savings rate. The dashed line is the average savings rate in the urban household survey.

**Figure 11: Official and Adjusted Provincial GDP Growth 2009-2015**



Note: Scatterplot of *adjusted* (y-axis) vs. official (x-axis) provincial annualized GDP growth rate between 2009 and 2015. The three highlighted provinces are Liaoning (LN), Inner Mongolia (NM) and Tianjin (TJ) involved in GDP scandals. Solid line is 45 degree line.

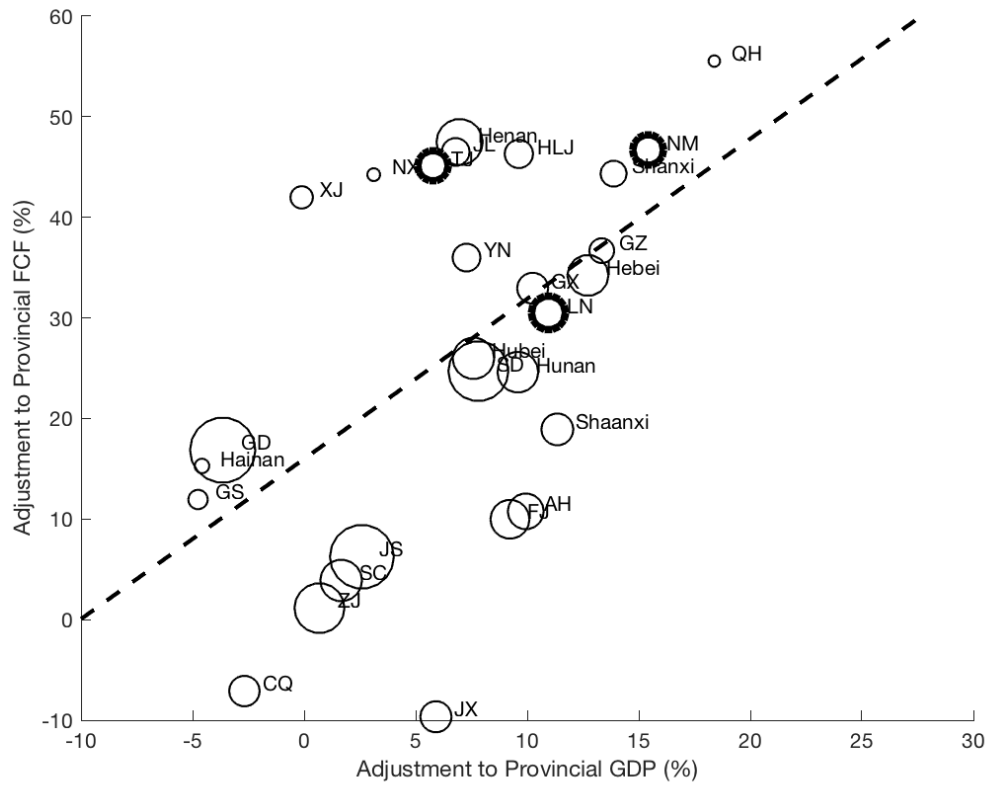
**Figure 12: Adjustment to Provincial FCF in 2015**



Note: Scatterplot of (Official provincial FCF – Adjusted provincial FCF)/Official provincial FCF (y-axis) vs. official provincial FCF/GDP (x-axis).

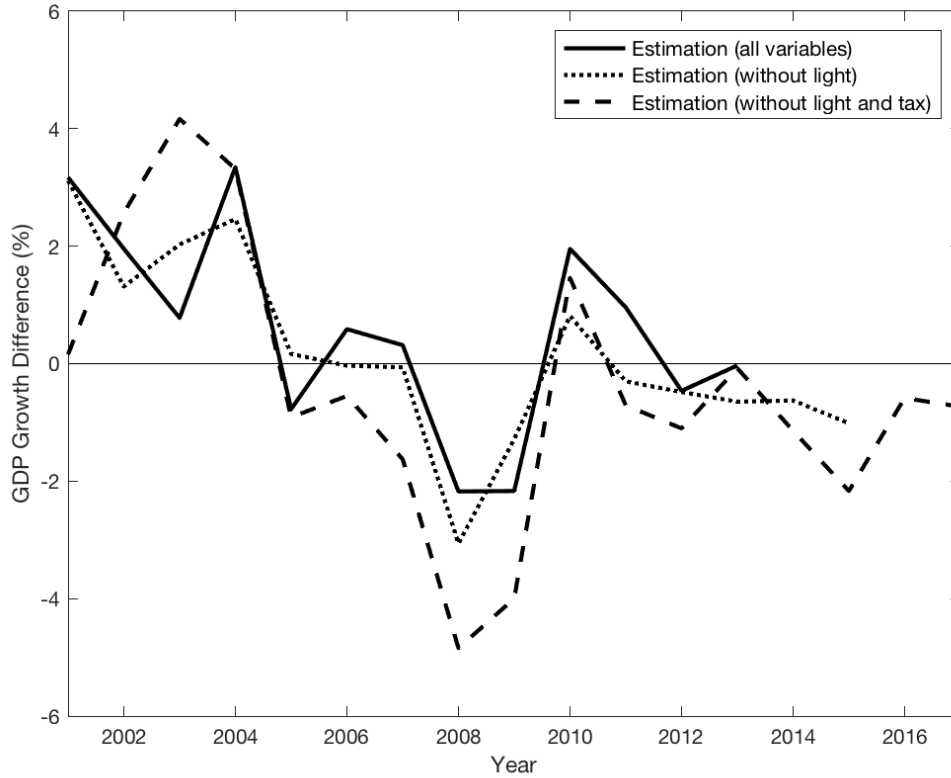


**Figure 13: Adjustment to Provincial GDP and FCF in 2015**



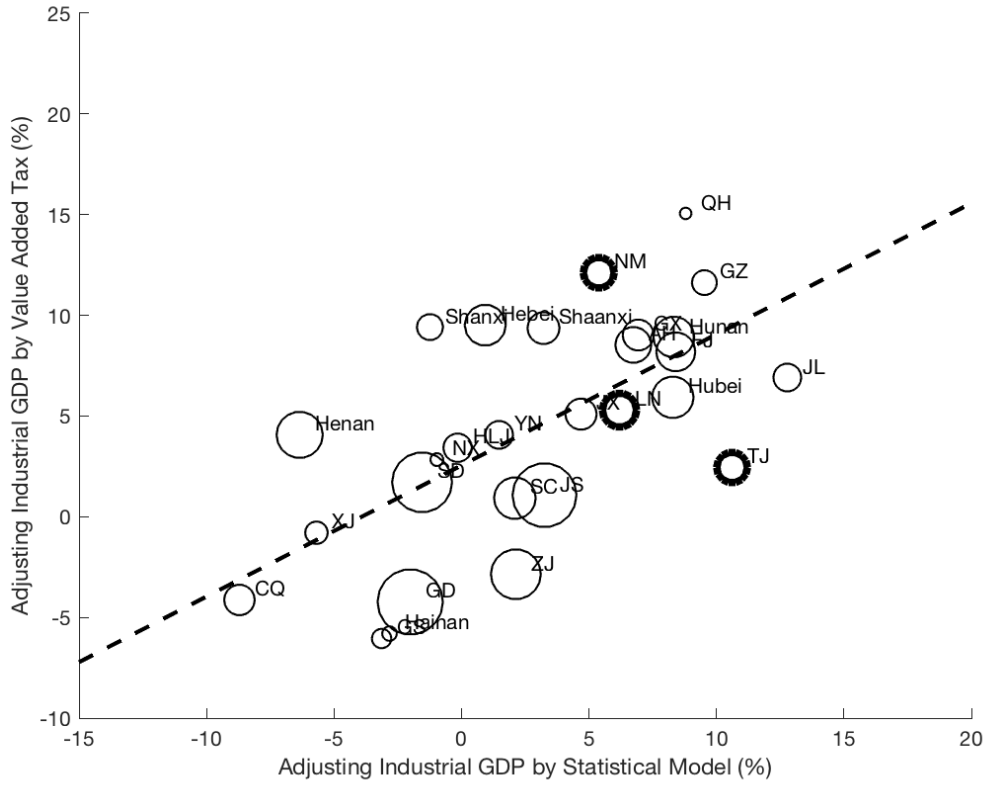
Note: Scatterplot of (Official provincial FCF – Adjusted provincial FCF)/Official provincial FCF (y-axis) vs. (Official provincial GDP – Adjusted provincial GDP)/Official provincial GDP (x-axis). Dashed line is 45 degree line.

**Figure 14: Gap between Estimated and Official Nominal GDP Growth  
(Based on Statistical Model for Provincial Industrial GDP)**



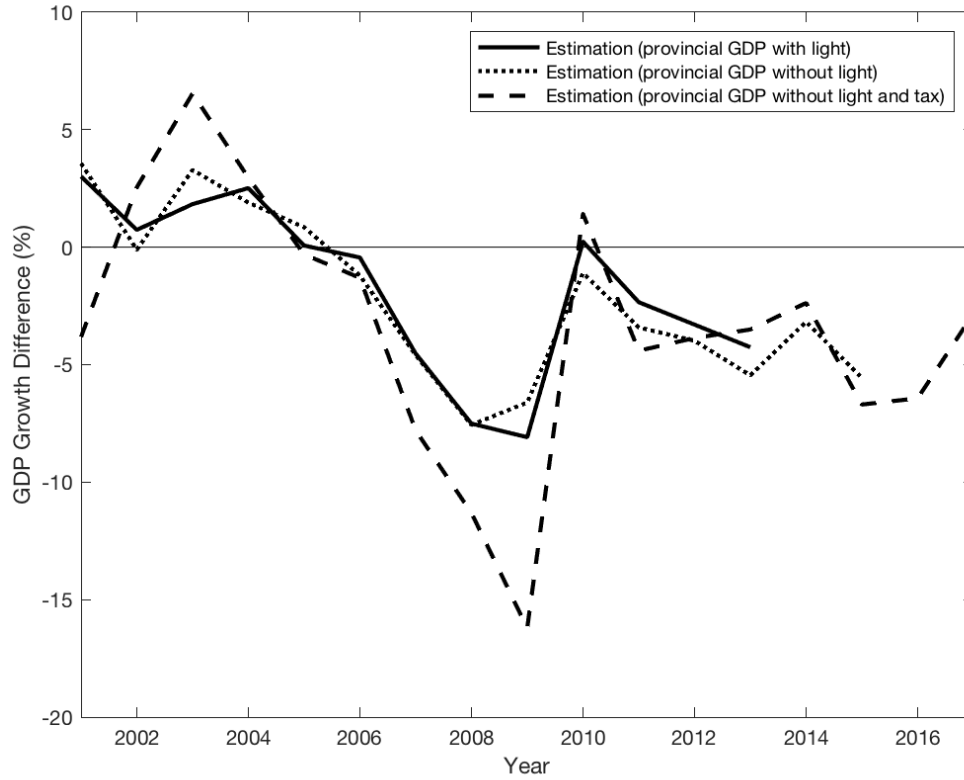
Note: This figure plots the difference between adjusted and official nominal GDP growth rates. “Estimation (all variables)” uses all variables. “Estimation (without light)” uses all variables except for night lights. “Estimation (without light and tax)” uses all variables except for night lights and national tax revenues. Estimation based on the statistical model for provincial industrial GDP only. Adjusted GDP growth rates are in-sample estimates prior to 2009 and out-of-sample predictions after 2009.

**Figure 15: Adjustment to Provincial GDP in 2015**



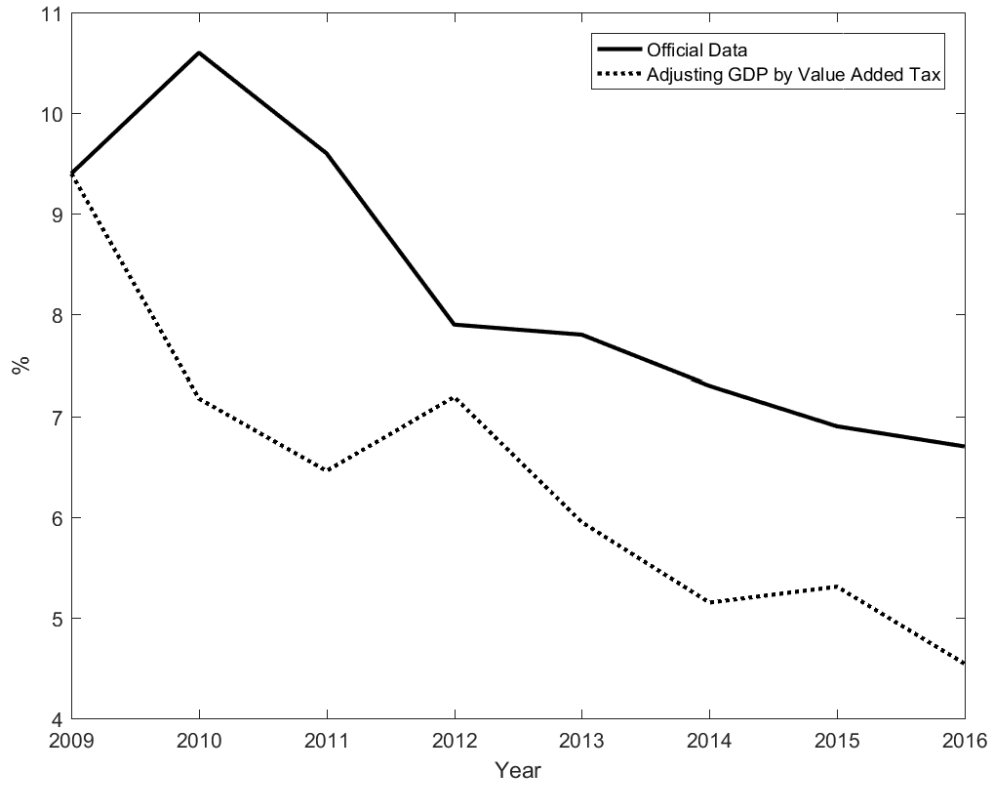
Note: Scatterplot of (official provincial industrial GDP – estimated provincial industrial GDP by value added tax) / official provincial GDP (y-axis) vs. (official provincial industrial GDP – estimated provincial industrial GDP by the statistical model with national tax revenue) / official provincial GDP (x-axis). Dashed line is 45 degree line.

**Figure 16: Gap between Estimated and Official Nominal GDP Growth (Based on the Statistical Model for Provincial GDP)**



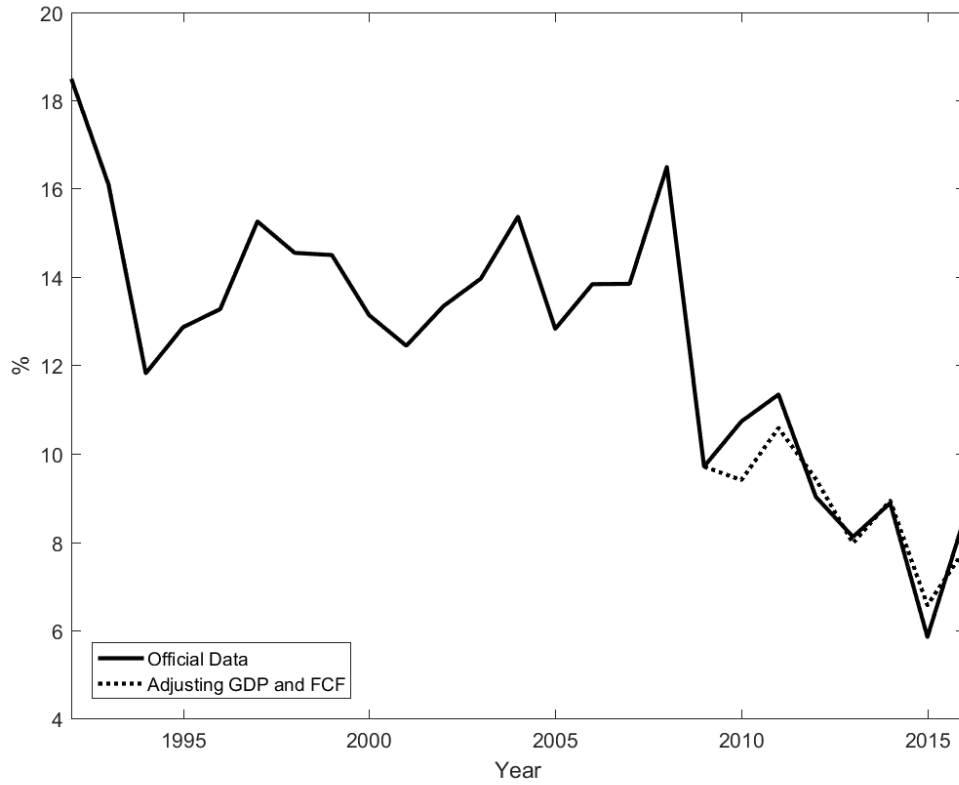
Note: See the note for Figure 14. The only difference is that the estimation here is based on the statistical model for provincial GDP instead of industrial GDP in the province in Figure 14.

**Figure 17: Real GDP Growth**



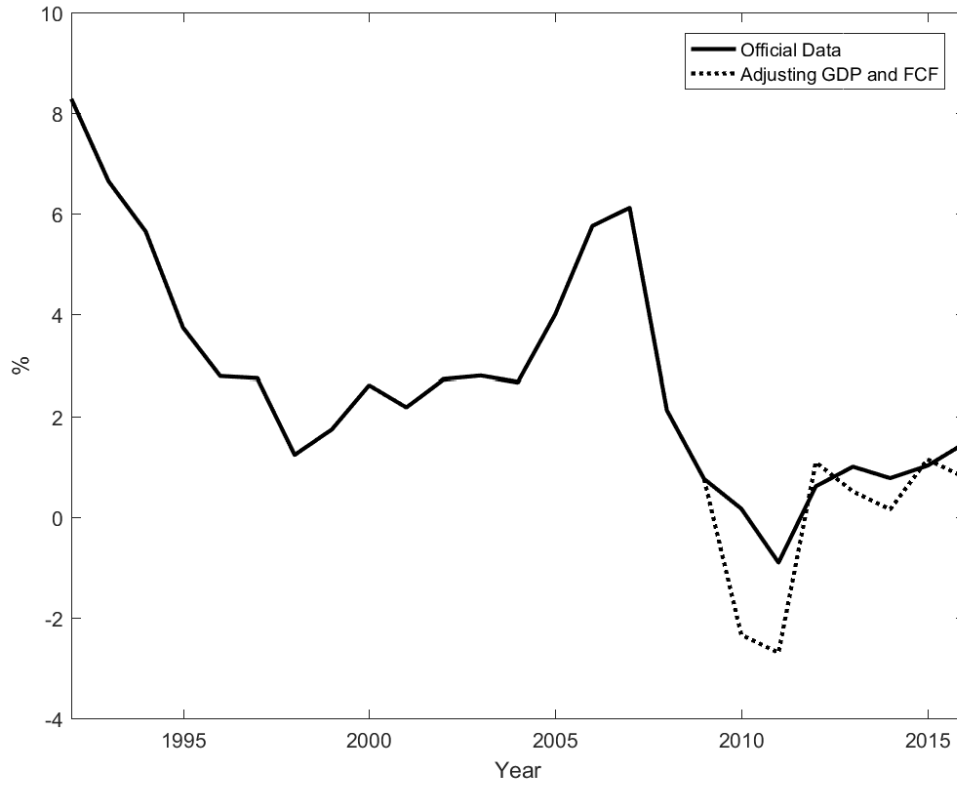
Note: Adjusted real GDP growth is the difference between adjusted nominal GDP growth rates (from the adjusted growth in Column 4 in Table 2) and the growth rate of official GDP deflator.

**Figure 18: Aggregate Return to Capital**



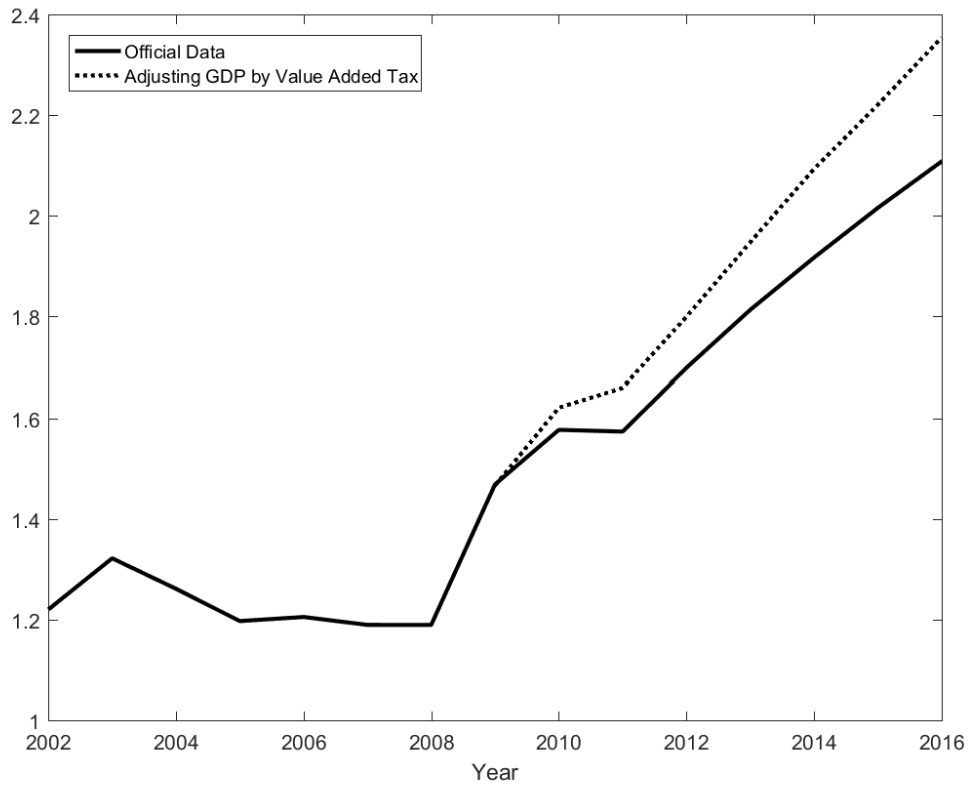
Note: “Official Data” is the return to capital computed from official GDP and fixed capital formation (FCF). “Adjusting GDP and FCF” is the return to capital calculated from adjusted FCF and GDP (using the adjusted growth rate in Column 4 in Table 2).

**Figure 19: Aggregate TFP Growth**



Note: “Official Data” is the return to capital computed from official GDP and fixed capital formation (FCF). “Adjusting GDP and FCF” is the return to capital calculated from adjusted FCF and GDP (using the adjusted growth rate in Column 4 in Table 2).

**Figure 20: Debt to GDP Ratio**



Note: Debt is from Song and Xiong (2018). “Official Data” uses official GDP in the denominator. “Adjusting GDP by Value Added Tax” uses adjusted GDP (using the adjusted growth in Column 4 in Table 2) in the denominator.