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Rethinking China's Growth

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Abstract:

China's outsized growth has almost continually surpassed outsiders' expectations for four decades, and may continue to do so in the future. However, a key element of the growth model, heavy reliance on real estate and infrastructure construction, may finally be running into diminishing returns. This paper summarizes new city-level data on China's real estate and infrastructure capital from 2000-2022, and presents evidence suggesting that the growth returns to new building may be falling in some regions. At the same time, real estate investment in particular has been a significant contributing factor to the local government debt vulnerabilities in some regions. Finally, the paper presents new results on the combined direct and indirect impact of real estate and infrastructure construction on China's economy, which has consistently exceeded 30 percent of GDP in recent years.

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I. Introduction

In this paper, we argue that after decades of investing in infrastructure and real estate at breakneck speed, China has likely reached the point of sharply diminishing returns, so much so that simply relaxing lending curbs is unlikely to make a long-lasting difference, and might exacerbate problems faced by highly-indebted local governments, especially counting indirect claims due to local government financing vehicles, which are estimated to be over 50 percent of GDP.[1] This is especially problematic given that local governments are disproportionately reliant on land sales for revenue, which in turn could collapse if real estate falters. The problems posed may not be unmanageable in theory, but they are certainly very challenging in practice.

The story of China's inevitable growth slowdown has long been foretold, and yet has been even longer coming; there is no denying that Chinese officials have done a remarkable, indeed historic, job in stretching out the country's extraordinary growth record. One can debate what the actual growth performance has been. According to official numbers, average growth over the period 1980-2012 was 8.9 percent, slowing down to a still very fast 6.4 percent 2012-2019.[2] True, the pace seems a bit less spectacular using the latest version of the PWT data set that attempts to measure growth using international prices, 5.8 percent 1980-2012 and 3.7 percent 2013-2019. But either way, China's historic economic performance has lifted hundreds of millions of people out of poverty and into the global middle class, and transformed China into one of the world's two largest economies, almost triple the size of number three Japan. Recently, however, as China's early recovery from the COVID years falters, signs of slowing medium-term growth are becoming more pronounced.

For many economists, it has long seemed clear that China's growth rates had to eventually come down to earth, even if not necessarily crashing down. For one thing, China faces the similarly challenging demographics to Japan, Korea and most advanced economies, with a low birth rate exacerbated by its one child policy that prevailed from 1980-2016. Moreover, according to an IMF study,[3] China's total factor productivity has slowed in recent years, and the country is confronted with significant challenges which could further lower its medium- to long-term growth. Even without leading Western trade partners adopting "homeshoring" policies, and many foreign firms diversifying production through "China plus one" strategies, the country's ability to grow through export expansion has become inevitably constrained by size limitations as China's share of global GDP and exports has grown. Still, as already noted, the continuing strength of the Chinese economy has continually surprised, mostly on the upside, throughout the past four decades.

[1] The IMF estimates LGFV debt and includes it as part of general government debt under its augmented definition. For details, see *China Article IV Consultation Staff Report 2022*.
[2] The Penn World Tables only go through 2019, official growth for 2013-2022 – that is including the COVID years – is still 5.8 percent.
[3] See the Selected Issues paper on the People's Republic of China 2022, available at https://www.imf.org/en/Publications/CR/Issues/2023/02/09/Peoples-Republic-of-China-Selected-Issues-529473

Over the years, researchers have begun to recognize the full extent to which China has depended on real estate and infrastructure for growth and – very importantly – the extent to which the rate of return to new real estate and infrastructure investment might have fallen as cumulative construction equals or surpasses Western levels in many areas (Chivakul et al., 2015; Cook, Nie, and Hall, 2018; Koss and Shi, 2018; Rogoff and Yang, 2020, 2022). For 2021, the direct and indirect impact of real estate alone in China's economy is 22 percent of GDP, 25 percent if one includes imported content. As we show in new estimates here, if one includes infrastructure on top of residential and commercial real estate, their combined share reached 31 percent, albeit down slightly from its pre-pandemic peak.

A slowing real estate sector, in particular, poses multiple financial challenges to China's economy, even if the central government's sweeping power to restructure and reallocate significantly reduces the chances of a Western-style systemic financial crisis. The rapid growth in real estate has been accompanied by a massive rise in local government debt, much of which beneath the surface in the form of local government financing vehicles. Past IMF analysis highlights that servicing this debt was already challenging even before the property market downturn.[4] The combined income of LGFVs is barely sufficient to cover the interest payments. Although there certainly are policies to address this problem, for example instituting greater transfers of revenue to local governments from the central government, or allowing local property taxes,[5] they are not necessarily straightforward in the context of a broadly slowing economy that may need to look to new sources of growth as real estate and infrastructure investment are scaled back. The fact that Chinese households' wealth is overwhelmingly concentrated in real estate does not make the adjustment any easier. Again, the historic performance of the Chinese authorities in meeting such challenges has to be recognized, leading many long-time China scholars, for example Prasad (2023), to predict that any sharp slowdown in growth or a financial crisis, is quite unlikely. We do not venture any such prediction here, one way or the other; we simply identify the formidable challenges.

The first part of this paper looks at a measure of the share of China's real estate and infrastructure sectors in GDP, separately and jointly. These shares have risen substantially since 2000 and have remained remarkably large by international standards. Using a similar input-output calculation, we compare China to a range of OECD countries. Only Spain, in the runup to the global financial crisis, comes close to the level China has reached in the past decade; even Ireland, before its crisis, was well below.[6] We then show just has far China has caught up to the United States in floor space per capita, with the gap closing by almost half even since 2011,

[4] See e.g., the 2021 Selected Issues paper on LGFVs

[5] See e.g., *IMF China Article IV Consultation Staff Report 2022* for a more comprehensive analysis of potential fiscal reform measures

[6] The Asian Development Bank (2022), making use of data for China from Rogoff and Yang (2020), argues that in fact China is not so exceptional compared to low and low-middle income Asian economies, even after correcting very low estimates for China from an earlier Asian Development Bank draft paper that were reported in *The Economist* (November 2021). But China is still the highest and this comparison misses the critical point (as does the Economist article) that the level of construction has been very high in China for decades as Figure 1 illustrates, implying that the returns in China may be much lower than in say, India, which had similar income to China in 1990 but is now much poorer.

bringing China to levels similar to France and the United Kingdom, or even higher. Extending the comparisons to incorporate infrastructure investment only makes China's progress more dramatic.

The next section of the paper proceeds to exploit a newly-developed city level data base on the stock of housing and real estate investment, which breaks down the per capita floor space estimates by city tier.[7] We show that the growth in housing construction has been particularly strong in China's smaller and poorer cities that lie outside the top two tiers, which for convenience we will collectively refer to here as tier 3 cities.[8]

We then proceed to look at more formal evidence on whether, as housing stock levels in individual cities have increased, the growth benefits to further real estate investment have fallen. We find that indeed it has. We also review recent evidence suggesting that the local debt buildup is especially large in cities with the relatively high investment in real estate.

The paper goes on to extend the discussion more fully to commercial real estate where again the problems in tier 3 cities are particularly pronounced. Finally, we explore the distribution of infrastructure investment, including roads, sewer pipes, high-speed rail, etc., which again has been disproportionately directed at tier 3 cities. The final section concludes.

II. The Outsize Footprint of Real Estate and Infrastructure in China

The size of China's real estate sector is stunning. In 2021, the direct impact of the real estate construction sector was just under 5 percent of GDP, with real estate services adding almost 7 percent more. But this is only the direct impact, counting the upstream component, and using China's most recent (2019) input output table, the sector accounted for 22 percent of GDP, almost 25 percent if imported content is included (a significant consideration since we will be interested in cumulative construction when assessing diminishing returns. The table below, updated from Rogoff and Yang (2020) and expanded to include infrastructure in addition to real estate, is illustrative

[7] The data set is presented in Rogoff and Yang (2022).

[8] In this study, we categorize Beijing, Shanghai, Guangzhou, and Shenzhen as tier 1 cities. Tier 2 cities include two municipalities directly under the central government (Tianjin, Chongqing), four cities under separate state planning (Dalian, Qingdao, Ningbo, Fujian), and twenty-seven provincial capitals (Shijiazhuang, Taiyuan, Hohhot, Shenyang, Changchun, Harbin, Nanjing, Hangzhou, Hefei, Fuzhou, Nanchang, Jinan, Zhengzhou, Wuhan, Changsha, Nanning, Haikou, Chengdu, Guiyang, Kunming, Xi'an, Lanzhou, Xining, Yinchuan, Urumqi). This classification is also broadly in line with other methods of grouping cities based on GDP, income level, or population size, and widely used in the literature (e.g., Liu and Xiong, 2018).

Table 1. Demand for Real Estate and Infrastructure as a Percentage of GDP
(Including Direct and Indirect Demand)

	2016		2017		2018	
	Direct value added	Total final demand	Direct value added	Total final demand	Direct value added	Total final demand
Real estate construction	5.0%	17.5%	5.0%	17.5%	5.0%	17.5%
Real estate services	6.7%	5.2%	6.9%	5.3%	7.0%	5.4%
Imported component		2.8%		3.0%		3.1%
Total real estate activity	11.3%	25.5%	11.9%	25.8%	12.4%	26.0%
Infrastructure construction	1.9%	6.8%	2.0%	7.0%	2.1%	7.3%
Real estate and infrastructure contribution to economy	13.2%	31.3%	13.8%	32.0%	14.4%	32.9%

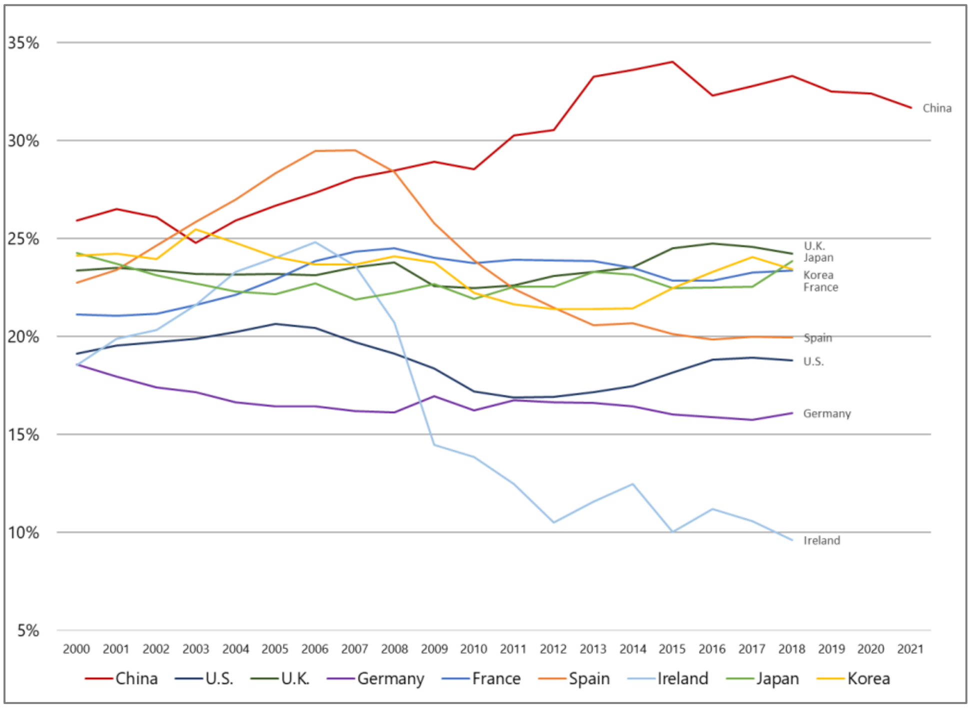
	2019		2020		2021	
	Direct value added	Total final demand	Direct value added	Total final demand	Direct value added	Total final demand
Real estate construction	5.0%	17.1%	5.0%	16.8%	4.9%	16.5%
Real estate services	7.1%	5.3%	7.2%	5.4%	6.8%	5.0%
Imported component		2.9%		2.7%		2.9%
Total real estate activity	12.2%	25.3%	12.4%	24.9%	11.6%	24.4%
Infrastructure construction	2.1%	7.2%	2.2%	7.5%	2.1%	7.3%
Real estate and infrastructure contribution to economy	14.3%	32.5%	14.6%	32.4%	13.7%	31.7%

The "total final demand" column shows the share of GDP accounted for by all the domestic economic activities embodied in final demand for that sector. In other words, the demand for buildings and other construction also generates demand for materials and other types of services—and adding the value added in construction and all of these "upstream" sectors together gives the numbers in the column. This calculation requires an estimation of the share of building construction in the construction sector, which stands at (just below) 70 percent in recent years. Note that if one includes imported component (thus measuring final demand for real estate as opposed to supply), it brings the number to 24.9 percent in 2020, and 24.4 percent in 2021.

Our measure of real estate includes both commercial and residential real estate. As the table shows, if one includes infrastructure, which is roughly 30 percent of total construction, compared to real estate at 70 percent, the share of real estate and infrastructure construction combined is above 30 percent of GDP.

As noted, by international standards, the impact of China's real estate and infrastructure investment sectors are remarkable. Figure 1 looks at only real estate and infrastructure shares (counting direct and indirect impact) across OECD countries from 2000 to 2021, making use of the OECD's harmonized input-output tables:

Figure 1. Real Estate and Infrastructure Share of GDP by Country

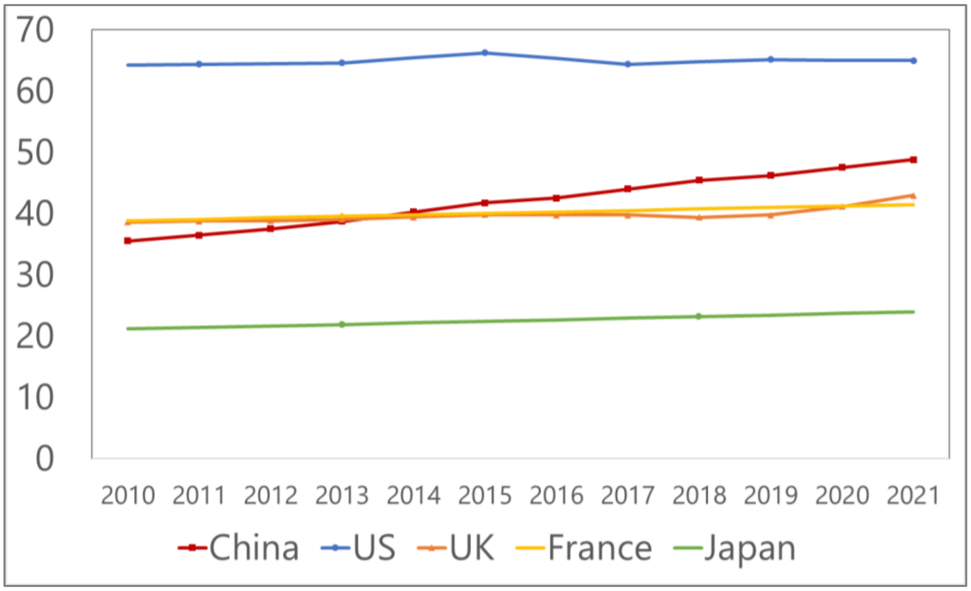


Sources: Author calculations using data from the National Bureau of Statistics of China, OECD official website, United States Bureau of Economic Analysis, United Kingdom Office for National Statistics, European Construction Industry Federation, Eurostat, Spanish Statistical Office, Statistics Bureau of Japan, and Statistics Korea

As Figure 1 confirms, at roughly 31 percent of GDP in 2021 (including imported content), China's real estate sector is far larger than Ireland's at the peak of that country's real estate bubble and rivaled only briefly by Spain in the runup to is financial crisis. The US share, by comparison, has averaged 19 percent (including imported content, 16 percent without).

One might well ask, "given that the real estate and infrastructure sectors have been relatively stable for years at a high share of GDP, "why can't this continue indefinitely?" Here it is important to look also at the stock, not just the flow. Although China still has substandard units in parts of the country, a very large share of its real estate stock is quite new and constructed since 2000. Figure 2 shows how rapidly China is catching up with the United States, even by this measure surpassing France and the United Kingdom.

Figure 2. Per Capita Floor Space of Selected Countries (square meter)



Sources: Author calculation based on data from official website of the National Bureau of Statistics of China for interim using China Statistical Yearbooks, China Population Census Yearbooks 2010 and 2020, Provincial-level Population Census Yearbooks 2010 and 2020, US Census Bureau American Housing Survey, UK English Housing Survey 2010-2021, Les Conditions de Logement en France, édition 2017, Japan Land and Housing Survey 2018

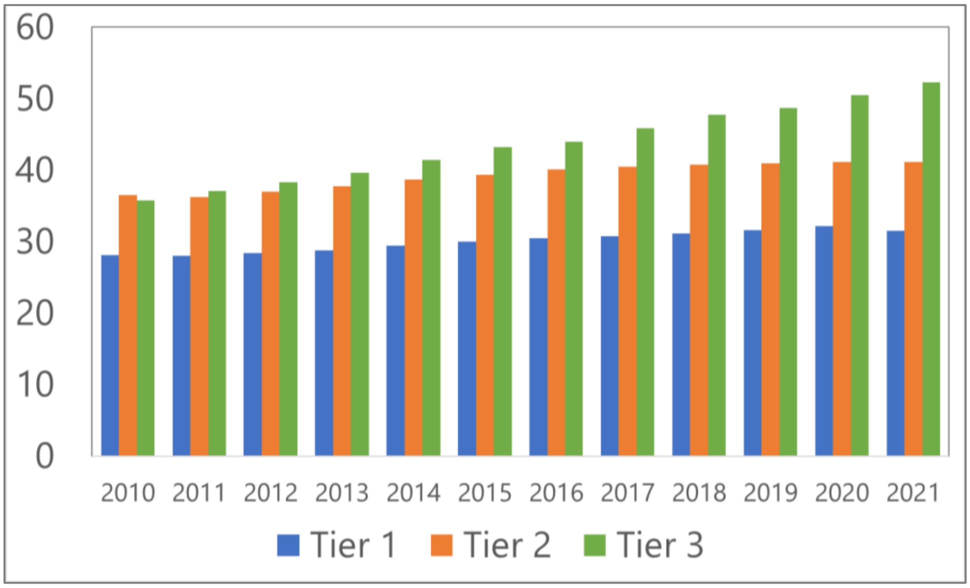
Notes: 1. See Appendix 2 for the discussion of China housing stock calculation. 2. The markers indicate years with survey data, the other data points are imputed between survey readings.

While the US housing stock per capita remained stable at 65 meters per capita, China's housing stock increased from 36 meters per capita in 2011 to almost 49 meters per capita in 2021.

While it is well known that China's premier tier 1 cities have had huge real estate construction, less well known is how much this phenomenon has radiated through the country, with high quality construction throughout the country built to exacting national standards.[9] Figure 3 breaks down the data by city tier.

[9] For example, Chapter VI Article 52 of the Construction Law of the People's Republic of China stipulates that "The survey, design and construction quality of a construction project shall conform to the safety standards as required by the State for construction projects, and the specific measures for the administration thereof shall be formulated by the State Council." An English version of the document is available at https://www.ilo.org/dyn/natlex/docs/ELECTRONIC/76995/108052/F-1117495410/CHN76995%20Eng.pdf

Figure 3. Per Capita Floor Space by City Tier (square meter)



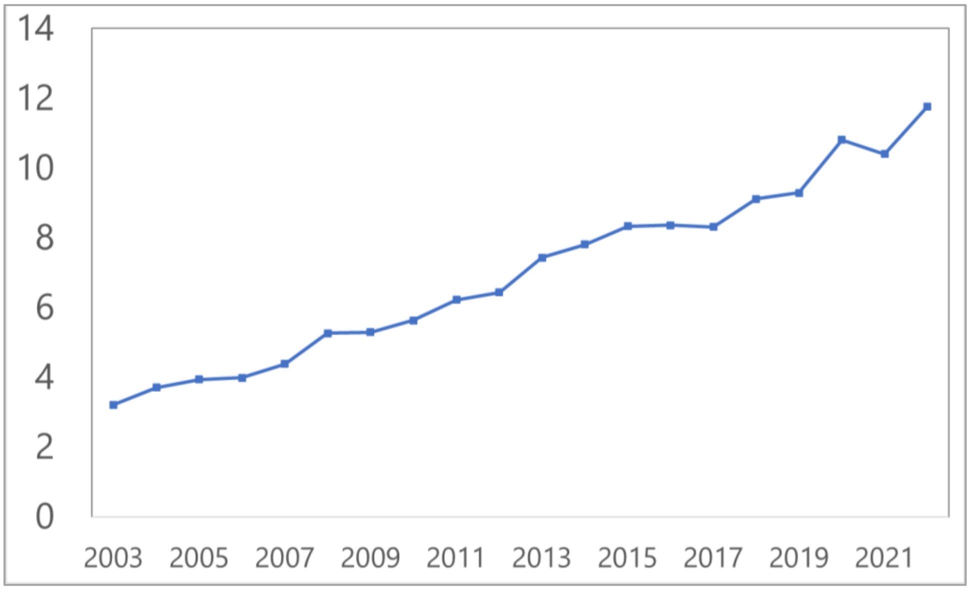
Sources: Authors' calculations, based on data from official website of the National Bureau of Statistics of China, China Statistical Yearbooks, the China Population Census Yearbooks for 2010 and 2020, as well as Provincial-level Population Census Yearbooks for 2010 and 2020

The regional distribution of construction is especially relevant because in China, as in most of the world, recent decades have seen the large, wealthier cities outperform economically due to agglomeration effects, which have grown in the tech era. The poorer, smaller cities, despite having had the lion's share of new real estate construction, have not seen the same income growth, and recently there has even been an exodus of population on top of China's overall declining population (Rogoff and Yang, 2022). Recently, as real estate prices have flattened in tier 1 cities, they have been falling in tier 3 cities, and indeed, much of the major duress that has been hitting China's construction industry has come from the failed projects in tier 3 cities.

In addition to residential housing, there have been parallel problems with commercial real estate. Figure 4 shows that over time, the ratio of commercial real estate under construction to commercial real estate completed has been steadily increasing. Given that the typical project takes one to three years to complete, it is not surprising to see a high ratio in a very rapidly growing market. But ratios over 10 as the figure illustrates are perhaps more suggestive of a market in distress, where developers cannot complete projects for lack of final buyers and funding. One can show similar evidence for residential real estate.[10]

[10] See e.g., Rogoff and Yang (2022). *IMF China Article IV Consultation Staff Report 2022* also contains the estimates for the completion costs of troubled presold housing projects at risk of noncompletion (Box 1).

Figure 4. Commercial Real Estate Floor Space Under Construction vs. Annual Completed



Sources: CEIC database and author calculations

Notes: 1. Unit is one. 2. The ratio is calculated as commercial real estate floor space under construction divided by annual commercial real estate floor space completed.

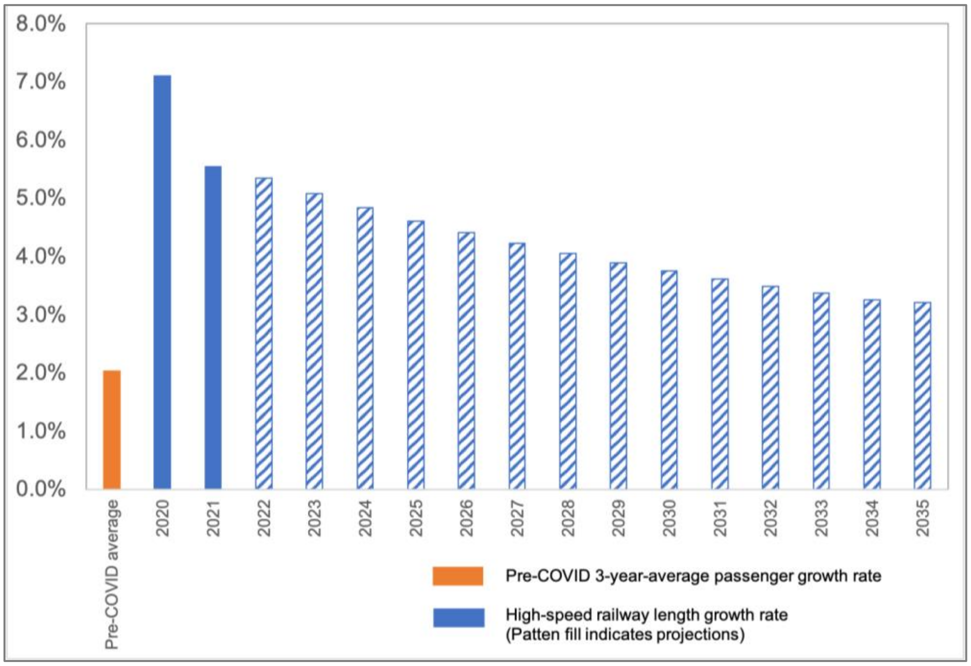
As noted in Table 1, infrastructure has also played a large role in China's development, indeed for most foreign visitors, famously so.

China boasts the world's longest and most extensively used high-speed rail network, dwarfing the preeminent Shinkansen of Japan and TGV high-speed trains of France.[11] However, despite the 6 trillion yuan liabilities and consecutive financial losses of the China State Railway Group[12], China keeps expanding its high-speed railway network at a rate that far outpaces the growth rate of passengers (Figure 5)

[11] https://www.worldatlas.com/articles/countries-with-the-most-high-speed-rail.html

[12] Formerly known as China Railway Corporation, China State Railway Group is the operator of China's high-speed rail.

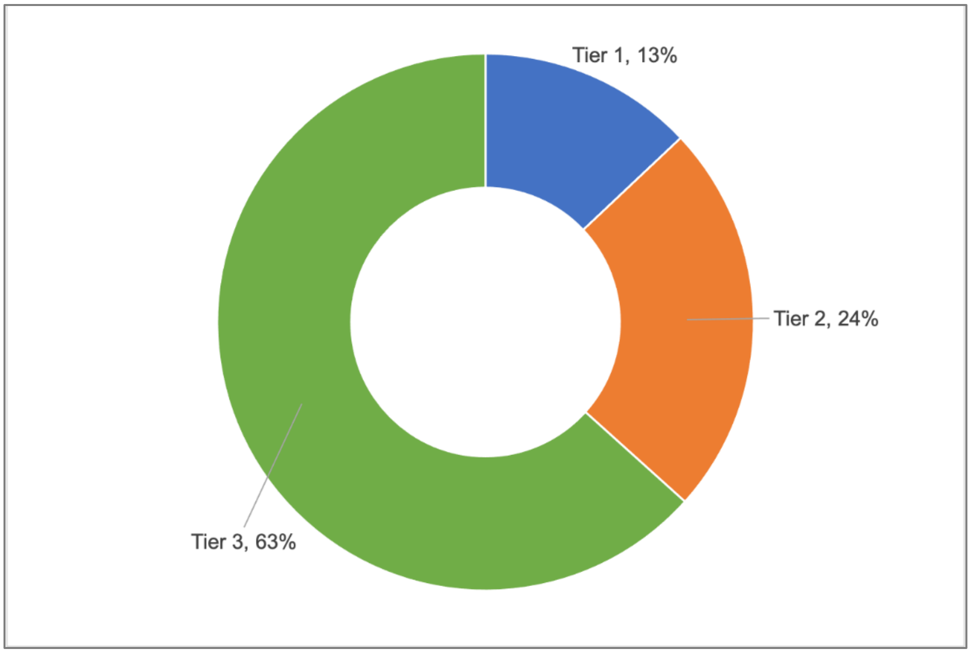
Figure 5. High-Speed Railway Passenger Growth vs. Construction Growth Rate



Sources: official website of National Bureau of Statistics of China, China Statistical Yearbooks from 2021, Outline of the Advance Planning of Railways in the New Era

Again, a very large share of the investment has been directed to smaller cities. The figure below is for the stock of sewage pipes (already put in place); a similar proportion, even more tilted towards tier 3 cities, holds for new infrastructure investment.

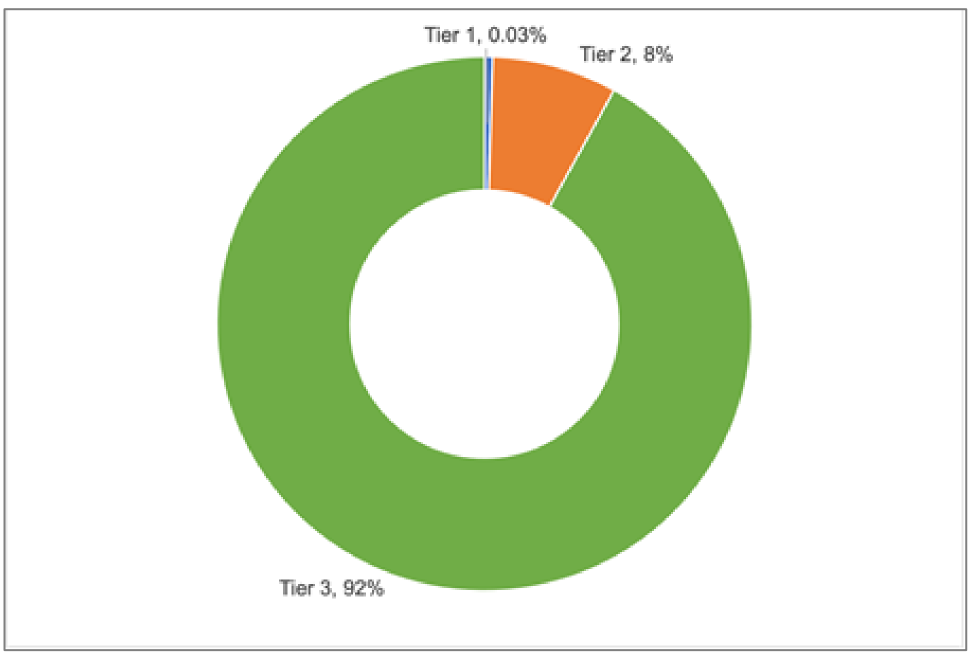
Figure 6. Length of Sewage Pipes by City Tier



Sources: China City Statistical Yearbook 2021 and author calculations

Similar data holds for roads, with Figure 7 giving this time the flow of new construction (again similar ratios hold for the stock).

Figure 7. New Road Construction from 2012 to 2020 by City Tier



Sources: China City-Level Statistical Yearbooks and author calculations

III. Regressions on Real Estate Investment and Growth

We have argued that diminishing returns to real estate investment should logically be setting in, given massive cumulative investment. We now proceed to look for statistical evidence of this phenomenon.

Table 2 looks at city level growth rates estimated based on two-stage least squares (2SLS) regression models with instruments. We create a pair of variables to instrument for real estate investment: firstly, we compute the proportion of developable land in each city,[13] and multiply it by the deviation of the economic growth target of the province in which the city is located from the national target.[14] [15] Secondly, we use the mean ratio of real estate investment in neighboring countries within the same province, a common device in the modern empirical growth literature.[16]

$$X_{i,t} = \alpha + B \times IV_{i,t} + \Gamma \times IV_{i,t} \times S_{i,t} + \Pi \times Control_{i,t-1} + \theta_i + \mu_t + \varepsilon_{i,t} \quad (1)$$

$$y_{i,t} = a + b \times \hat{X}_{i,t} + B_1 \times \hat{X}_{i,t} \times S_{i,t} + B_2 \times Control_{i,t-1} + \theta_i + \mu_t + \varepsilon_{i,t} \quad (2)$$

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[13] According to Saiz (2010), geography is a major constraint in urban development. Urban residential construction is especially curtailed by the existence of steep-sloped terrain. Areas with a larger proportion of slopes greater than 15 degrees prove to be unsuitable for building residential real estate. Thus, the amount of developable land could effectively serve as a proxy for the tendency of tapping real estate for growth. The ratio of developable land over total area of land is generated using satellite-based global terrain slope and aspect data. The NASA Shuttle Radar Topographic Mission (SRTM) has provided digital elevation data (DEM) for over 80% of the globe at 90 meters resolution. This allows us to create slope maps and calculate how much of the land in each city displays steepness below 15 degrees. All procedures are executed on the GIS mapping platform ArcGIS Pro. In each 90m*90m cell, ArcGIS Pro helps convert slopes with a certain range of degrees to a polygon feature class, and here the cutoff is set at 15 degrees. A new polygon layer containing the areas of slopes with chosen degrees is displayed in the map. Dividing it by the total area of land of each city gives a precise measure of city-level developable land.

[14] Additionally, Hu and Lü (2019) suggest that an upward revision in local economic growth targets leads to a larger scale of land transfers and a higher degree of resource misallocation. Under the "promotion tournament" hypothesis, inter-jurisdictional competition motivates local cadres to pursue economic growth for the sake of their own career advancement. (Chen, Li and Zhou, 2005; Li and Zhou, 2005; Xu, 2011; Fang et al., 2022) The formulation of the prefecture-city growth target is heavily influenced by the provincial government's growth target. The degree to which the provincial growth target surpasses the national growth target can indicate the ambition of local cadres and, consequently, the likelihood of using real estate as a means to attain the target. Meanwhile, there does not appear a strong correlation between prefecture-city debt and provincial growth targets.

[15] The economic growth target data is collected manually by compiling annual *Report on the Work of the Government* from 2000 to 2021 at both national and provincial levels.

[16] In the context of growth regressions, Cherif et al. (2018) proposed average values of the same variable as the sharp and strong instrumental variable for each endogenous determinant of growth, which helps produce variable-specific and time-varying instruments and addresses the causation vs. correlation problem in the empirical growth literature. This method has been used in a number of studies on the causes of economic growth (see for example, Acemoglu et al., 2019; Gründler and Köllner, 2020; Vu, 2022)

Here, i is indexed for city and t for time. In the first stage, we regress the real estate investment ratio[17] of city i in year t, denoted as $X_{i,t}$, on instruments $IV_{i,t}$ and a series of control variables, which include lagged real GDP growth, per capita real GDP, population growth, population size, urbanization rate, and industrial structure.[18] θ and μ represent city- and time-fixed effects, respectively, and ε signifies the residual error term.

To examine how housing stock affects the returns to real estate investment, we include an interaction term between real estate investment (as flow) and the housing stock, namely, the cumulative floor space of residential housing in each city $S_{i,t}$.

Moving to the second stage, we use $y_{i,t}$ to represent city-level real GDP growth in year t, and $\hat{X}_{i,t}$ for the instrumented real estate investment ratio. Similarly, we include the interaction term, whose coefficient, if differs significantly from zero, would indicate that the contribution of real estate investment to growth is affected by the amount of housing stock.

Our findings in Column (1) reveal that, while real estate investment is positive for growth, a trend aligned with the role that real estate has played in China's investment-driven model throughout the 21st century, the effect diminishes as the housing stock piles up.

The economic returns of the construction of a given unit of housing would decline as the housing stock increases, due to housing supply overhang (Rognlie, Shleifer, Simsek, 2018; Gao, Sockin, Xiong, 2020). More specifically, the excess housing stock lowers subsequent residential real estate investment, as housing capital is durable in nature, and an oversupply of it reduces the need for subsequent investment. Because the real estate sector (and related infrastructure) has such a large footprint in China's economy, the costs of adjustment in moving resources in production and replacing it as a source of demand are correspondingly large. the problem of diminishing returns on investment is familiar from Japan and the former Soviet Union, as well as many other once fast-growing economies.

When we replace the housing stock measure with a dummy variable for tier 3 cities, we also observe a negative sign for the interaction term. This suggests that tier 3 benefit less from real estate investment than other city tiers, likely attributable to the more pronounced housing stock overhang in tier 3 cities, which account for over 80 percent of the total housing stock in the country.[19]

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[17] Real estate investment refers to the investment made by real estate development enterprises in the construction of buildings, development of land, and value of land purchased. Data on city level real estate investment is collected from the CEIC database. The series dates back to 2000. The real estate investment ratio is defined as annual residential real estate investment over GDP.

[18] Per capita GDP refers to the natural logarithm of real GDP divided by population. Population growth is defined as the growth rate of resident population, and population size is the natural logarithm of population. Urbanization rate is computed as the ratio of urban resident population over total population. Industrial structure is calculated as industrial sector output over GDP. All control variables are obtained from the CEIC database.

[19] See Rogoff and Yang (2022) for calculations

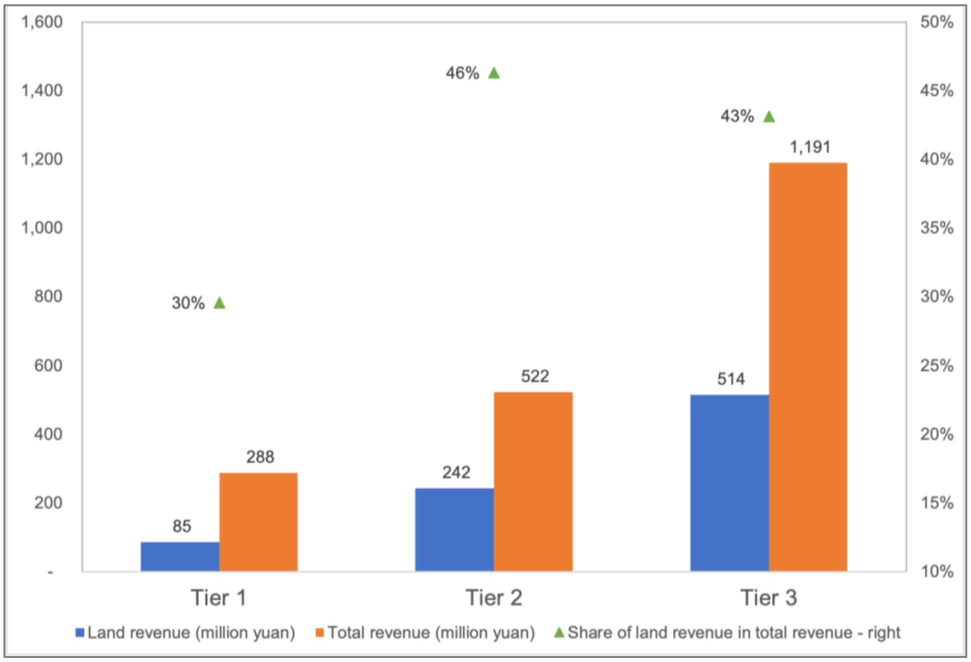
Table 2. Real Estate Investment and Growth

	(1)	(2)
Variable	Real GDP growth	
Real estate investment/GDP (Instrumented)	1.019***	2.261**
	(0.203)	(0.990)
Housing stock × Instrumented real estate investment/GDP		-0.139*
		(0.083)
Tier 3 × Instrumented real estate investment/GDP	-0.409**	
	(0.185)	
Lagged real GDP growth	0.242***	0.252***
	(0.019)	(0.020)
Per capita real GDP	-0.098***	-0.094***
	(0.007)	(0.007)
Population growth	0.035	0.036
	(0.055)	(0.056)
Population size	-0.039***	-0.021
	(0.012)	(0.015)
Urbanization rate	0.181***	0.152***
	(0.033)	(0.034)
Industrial structure	0.001	0.000
	(0.002)	(0.003)
Constant	0.780***	0.637***
	(0.102)	(0.121)
Number of observations	4,929	5,160
R2	0.358	0.356
Time FE	YES	YES
City FE	YES	YES

* p<0.1, ** p<0.05, *** p<0.01

If there is a weakening of growth, and it impact real estate prices, local governments are potentially vulnerable as they are very reliant on land sales for revenues as Figure 8 shows. Tier 3 governments depend on land sales for 43 percent of fiscal revenue. The ratio is even higher in tier 2 cities, at 46 percent. Land sales are still important in tier 1 cities, although only at 30 percent.

Figure 8. Land Revenue and Total Fiscal Revenue in 2020[20]

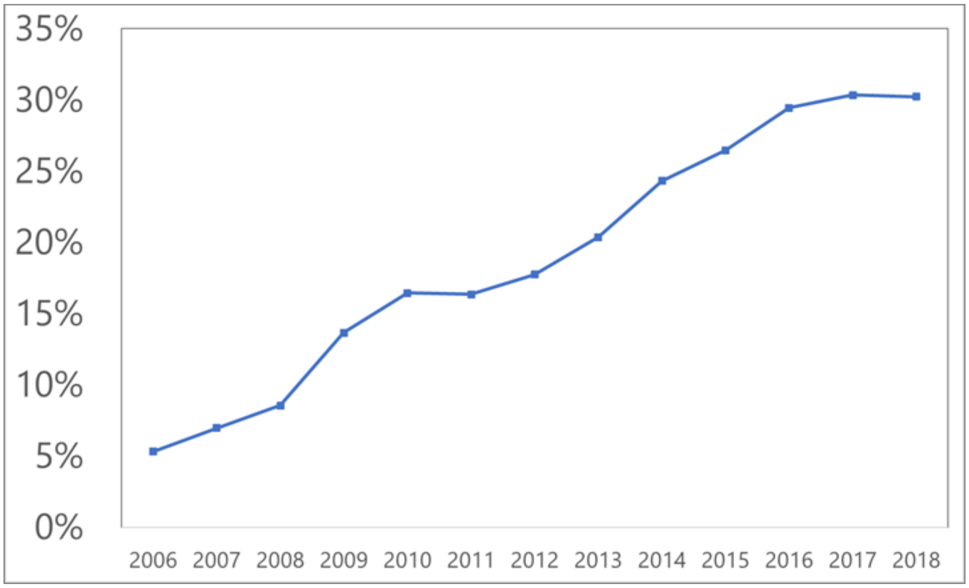


Sources: City-level Reports on 2020 Budget Execution and 2021 Budget

Our analysis here shows that it will be difficult for China to make the transition to a growth model less reliant on real estate even in the absence of a financial crisis of some type. It is certainly true that the high level of direct and indirect local government debt will make the transition more challenging, forcing China to give local governments other ways to pay for the local services, such as health and education that they require. Figure 9 is a conservative measure of local debt embodied in local government financing vehicles (LGFVs), giving a sense of the magnitude of the issues.[21]

[20] Fiscal revenues at the local level comprise four components: general public budgetary revenues, government fund revenues, state-owned capital operating revenues, and social security fund revenues. General public budgetary revenues are primarily composed of tax revenues and transfer payments from the central government. Government fund revenues are the principal form of non-tax revenue, collected for the purpose of supporting specific public service projects. A substantial part of government fund revenues come from the transferring of land use rights.
[21] The IMF (2023) estimated the scale of LGFVs to be 38 percent of GDP in 2018. The methodology adopted in this paper filtered out duplicate bond numbers in the Wind database, and therefore the debt ratio in Figure 9 should be interpreted as the lower bound of the estimates.

Figure 9. Local Government Debt to GDP from 2006 to 2018



Sources: CEIC, Wind, China Central Depository and Clearing Company Limited

Notes: 1. Local government debt is defined as all interest-bearing debt of local government financing vehicles, which includes short-term borrowings, accounts payable, short-term debentures payable, current portion of non-current liabilities, other current liabilities, long-term borrowings, and debentures payables. 2. We thank Professor Jie Mao, coauthor of Wu, Cao and Mao (2022) for data sharing.

IV. Conclusions

The Chinese economy has outperformed for decades and perhaps will continue to. However, its growth up to this point has been dependent on outsize investment in real estate and infrastructure. Now, after decades of construction, the country's capital stock in these sectors rivals that of much wealthier advanced economies, even in many of China's smaller and poorer cities. We have discussed evidence here consistent with the view that diminishing returns have set in, and the country must adapt accordingly. Aside from shifting and reorienting its labor force, the transition also poses financial challenges given the significant accumulation of local government debt that has accompanied, especially, the real estate boom. It will be important to address these issues in coming years.

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Appendix 1. The Overall Size of the Housing Sector

The remarkable productivity of China's real estate sector becomes clear when one considers the stunning scale of how rapidly housing is being built. In this appendix, we use China's input-output (I/O henceforth) tables, which describe the supply and demand inter-dependencies between industries in its economy, to estimate economy-wide effects of an autonomous decline in final demand for real estate and real estate services. The framework draws on Tilton et al. (October 2021) who as noted, find very similar estimates to those in our earlier paper Rogoff and Yang (NBER working paper August 2020, published version January 2021)

Suppose that an economy has n industries. A basic I/O framework has the following key components

<table>
<tr><td>Intermediate demand
Intermediate input</td><td>Industry 1</td><td>Industry 2</td><td>…</td><td>Industry n</td><td>Final demand</td><td>Total output</td></tr>
<tr><td>Industry 1</td><td colspan="4" rowspan="4">I</td><td rowspan="4">II</td><td rowspan="4"></td></tr>
<tr><td>Industry 2</td></tr>
<tr><td>…</td></tr>
<tr><td>Industry n</td></tr>
<tr><td>Value added</td><td colspan="4">III</td></tr>
<tr><td>Total input</td><td colspan="4"></td></tr>
</table>

Quadrant I, composed of an $n \times n$ matrix, shows flows of goods and services that are both produced and consumed in the production process. Each element in the matrix $x_{i,j}$ has dual economic significance: viewed horizontally, it represents the amount of output from industry i that is used as intermediate input in industry j; viewed vertically, it signifies the amount of input that industry j consumes that is produced by industry i. Quadrant II presents final demand for the output of each row industry i. Quadrant III contains data of value added of each column industry j. Thus, the basic equations in the I/O model can be expressed as

$$\sum_{j}^{n} x_{i,j} + Y_i = X_i \tag{1}$$

$$\sum_{i}^{n} x_{i,j} + V_j = I_j \tag{2}$$

where Y, X, V, and I signify final demand, total output, value added, and total input, respectively. Equation (1) describes the horizontal equivalence that intermediate demand plus final demand equal the total output of an industry. Equation (2) presents the vertical equivalence. More specifically, intermediate input plus value added are equal to the total input of an industry. Taking out imports, total output should be equal to total domestic input in any given industry.

Following Tilton et al. (2021), we define $a_{i,j}$ as $\frac{x_{i,j}}{x_j}$, V as an $n \times 1$ column vector of value added, and v as the diagonal matrix of value-added coefficient, namely the ratio of an industry's value added over its total output.

Then the matrix form of equation (1) can be expressed as $AX + Y = X$. Solving for total output gives $X = (I - A)^{-1}Y$. With $V = vX$, we get $V = v(I - A)^{-1}Y$. In the non-competitive I/O matrix that Tilton et al. use, total demand for imports can be denoted as $M = A_m X + Y_m$. Then equation (1) can be transformed into

$$A_d X + Y_d + A_m X + Y_m = X + M \tag{3}$$

Solving for domestic value-added gives

$$V = v[I - (A_d + A_m)]^{-1}[Y_d - A_m(I - A_d)^{-1}Y_d] \tag{4}$$

Let ΔY_d^c denote a change in final demand for construction. Then plugging into equation (4) would give us the total change in value added. Doing so symmetrically for the real estate services industry, we can obtain the change in value added due to the change in demand for real estate services.

Based on China's 2018 I/O table, Tilton et al. (2021) estimate that the share of construction and real estate in China's economy is 23.3%. They note that including imported inputs elevates that estimate to 26.3%.

We can use the exact same method to estimate the direct and indirect contribution of real estate to United States final demand. Using the Bureau of Economic Analysis's input output table series for the United States, construction activities are divided into 8 categories: 1. education, hospital, and health structures, 2. maintenance and repair construction, 3. office and commercial structures, 4. other residential construction, 5. other nonresidential structures, 6. power and communication structures, 7. single-family residential structures, 8. transportation structures and highways and streets. To avoid underestimating the share of building construction, we include all categories except 6. power and communication structures, 8. transportation structures and highways and streets.

The results indicate that building construction accounts for roughly 75 percent of construction activity in the U.S., which is slightly larger than in China, shown in the table below. The ratios (including net imported content) in China and the U.S. have been relatively stable over recent years (China 26 percent, U.S. 14 percent).

Appendix Table 1. Construction Sector Composition in China

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021
Building	64.1%	64.4%	64.2%	63.8%	63.4%	62.5%	62.1%	61.3%	61.0%
Installation	5.6%	5.5%	5.4%	5.4%	5.4%	5.3%	5.4%	5.3%	5.3%
Decoration & others	5.8%	5.0%	4.8%	4.7%	4.6%	0.7%	5.0%	4.8%	4.8%
Rea estate related construction	72.9%	73.0%	72.5%	72.0%	71.5%	70.5%	70.2%	69.3%	68.9%

Sources: China Statistical Yearbooks from 2012 to 2022.

Notes: 1. Installation is not entirely real estate related. We assign the share of installation that is real estate-related as the ratio of building construction over the sum of building construction plus civil engineering. 2. Since 2016, only the aggregate of decoration (which we assign to real estate) and other construction (which we assume is only partly related to real estate) has been provided. To identify the output value of building decoration, we apply the average ratio of decoration relative to other construction from previous years where disaggregated numbers is available. Other construction mainly comprises the repairs of buildings and structures and the production of non-standard equipment, to which we also apply the ratio of building construction over the sum of building construction plus civil engineering. Despite this rough approximation, other construction is small in scale and makes little difference to the result.

Appendix 2. Housing Stock Calculation

China's population census does contain data on per capita living space, which combined with population data would allow us to estimate total housing stock, but the census is only conducted every 10 years; moreover, depreciation rates are not stated explicitly.[22] To calculate housing stock between census readings, we obtain data from across China on construction completed to form estimates of how much space has been added between the two most recent censuses 2010 and 2020, taking into account depreciation and that some new construction is replacing older units. This methodology not only allows us to restore historical housing stock between census years, but also enables an estimation of housing stock up to the latest month possible based on higher frequency data.

Step 1: We start by calculating China's housing stock in 2010 and 2020 based on census data.[23] The equation that we use is as follows:

$$k_t = k_{u,t}^p \times h_{u,t} + k_{r,t}^p \times h_{r,t} \tag{1}$$

where k_t represents the total housing stock in year t, and here t = 2010, 2020. k_u^p and k_r^p stand for the per capita living space of urban and rural households, respectively, whereas h_u and h_r are the total number of individuals living in urban and rural households, respectively.

Part I, Volume 1 of the census contains information on the total number of individuals living in rural/urban[24] households, and per capita living space in urban/rural family households.[25] The census identifies individuals as belonging to either family household or collectives, but the per capita living space of the latter is not revealed; we estimate it using official building standards for collectives.[26]

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[22] Multiple data sources are available for measuring China's living space—the Population Census, the Household Survey on Living Conditions, the statistics from the fixed assets investment division of the National Bureau of Statistics, the statistics from the Ministry of Housing and Urban-Rural Development, and the data from the Construction Industry Association. Despite being official sources, they provide vastly different estimates. The Population Census should be the most reliable source, since the data is obtained by seven million census workers covering every household across China.

[23] The electronic versions of the two censuses are available at http://www.stats.gov.cn/tjsj/pcsj/rkpc/6rp/indexch.htm and http://www.stats.gov.cn/tjsj/pcsj/rkpc/7rp/indexch.htm, respectively.

[24] Consistent with the definition of urbanization in Chinese (*Cheng Zhen Hua, 城镇化*), we define urban regions as comprising both cities and towns in our analysis.

[25] Based on the census, individuals live in either family households—if they reside with their family, or collectives—if they reside in a shared common residence. Examples of collectives include student dormitories, nursing homes, workers' hostels, military barracks, etc.

[26] According to the *Code for Design of Dormitory Building JGJ 36-2016* issued by Ministry of Housing and Urban-Rural Development, the standard for per capita living space of dormitories is set at 4-16 m^2. To obtain a more precise estimate, we compare the building standards for various types of collectives, including *Code for Design of School GB 50099-2011*, *Design Code for Buildings of Elderly Facilities GB 50867-2013*, *Building Space Instructions for Higher Education Institutions 191-2018*, *Updated Building Space Standards for Military Barracks of People's Liberation Army of China*, etc. Taken together, we estimate the per capita living space of collectives to

One important problem with the population census data is that it only considers occupied dwelling units. To account for the presence of vacant units that have been sold but remain unoccupied by households — the most remarkable indicator of housing oversupply, we adjust the housing stock number by vacancy rates. Data on vacancies are extremely limited, and we adopt the vacancy estimates provided by the Beike Research Institute (China's Zillow), which, released in August 2022, are also the most recent data available.[27] We take them as our vacancy rates in 2020 and adjust based on the time-varying vacancy rates from the China Household Finance Survey (CHFS) to obtain the vacancy rate in 2010 for each city tier.

Another adjustment involves the addition of inventory held by real estate developers, namely the floor space waiting for sale, on top of the vacancy-adjusted housing stock number. Taken together, we estimate that China's total housing stock was close to 70 billion square meters in 2021 and tier 3 cities account for almost 80 percent of it.

Step 2: Using 2010 as the base year, we extend the time series from 2010 to 2021 by adding new residential housing construction and subtracting depreciation. For $t > 2010$, we have

$$k_t = k_{t0} + \sum_{i=1}^{t-t0} c_{t0+i} - \sum_{i=1}^{t-t0} d_{t0+i} \tag{2}$$

where k_t represents the total housing stock in year t, $t_0 = 2010$, and $2010 < t <= 2021$. c_t stands for the floor space of residential housing completed in year t, and d_t symbolizes annual depreciation.

Annual floor space of residential housing completed is available on the official website of the NBS. However, this calculation is complicated by the existence of different housing completed measures, most notably fixed assets investment residential housing completed and construction sector residential housing completed.[28] We take the larger of the two as our housing completed number.

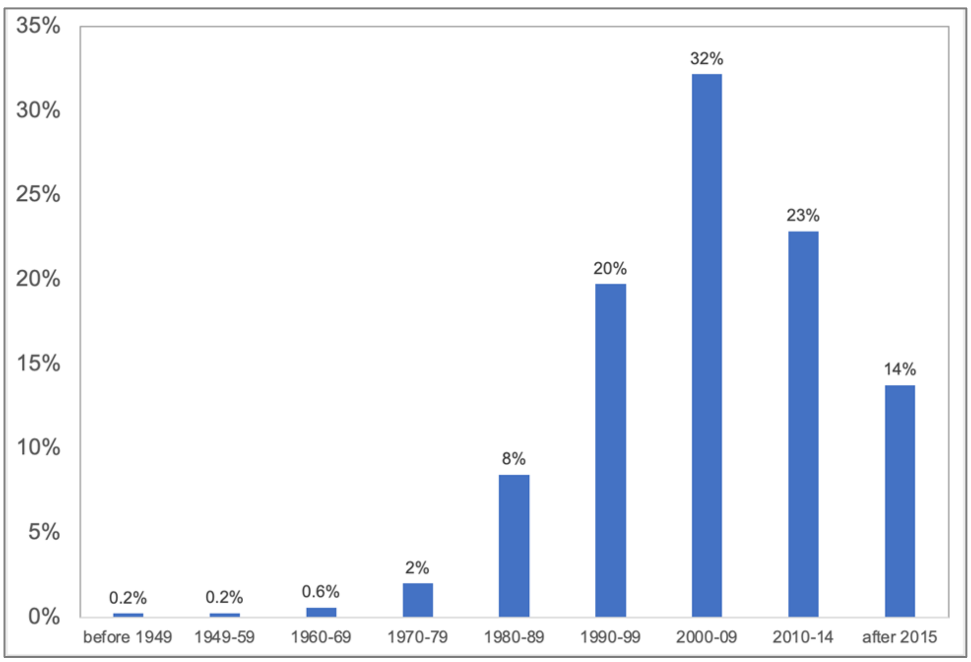
be approximately 8 m^2 in 2020, or one-fifth of that of family households. Despite the lack of precise information on per capita living space in collectives, its share in total housing stock is relatively small. Using the upper or lower bound of the living space range (4-16 m^2) would lead to less than 2 percent difference in the results.

[27] Full report available at http://m.fangchan.com/data/13/2022-08-05/6961203775998857722.html

[28] Prior to 2011, construction sector residential housing completed was smaller than fixed assets investment residential housing completed; after 2011, the former exceeded the latter. In years where both data series were available, the difference could be large. In 2016 for example, construction sector residential housing completed stood at 2,840 million square meters, whereas fixed assets investment housing completed was reported to be 1,715 million square meters. The NBS explained the difference between the two measures without reconciling the gap: construction sector housing completed data is collected from certified construction enterprises that engage in the construction of buildings and structures and in the installation of equipment, while fixed assets investment housing

To estimate annual depreciation, we rely on a *de facto* approach. Each census provides housing area constructed in different decades. (Appendix Figure 1) Assuming that only houses built before the year 2000 will be subject to demolition, while those constructed after 2000 will be exempt, we are then able to estimate the demolition area by comparing the difference in the area of housing built before 2000 in the two censuses. We find that houses built before the 1980s, from 1980-1989, and from 1990-1999 were reduced by 2, 2.7, and 2.6 billion square meters, respectively, between 2010 and 2020. This translates into an annual depreciation rate d of about 1.4-2.0 percent, consistent with a building life-span of 50-70 years, as stipulated in the *Uniform Standard for Design of Civil Buildings*.[29] The housing stock thus equals the total of new construction plus existing construction adjusted by depreciation.

Appendix Figure 1. Residential Space by Construction Year



Sources: China Population Census Yearbook 2020 and author calculations

So far, we have obtained two measures of housing stock in 2020 using two distinct methods—one based on the census data, and the other using cumulative housing construction from annual

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completed data is gathered from mostly property developers, and only includes projects that are valued more than 5 million yuan.

[29] The *Uniform Standard for Design of Civil Buildings GB 50352-2019* stipulates that the design service life of civil buildings should be at least 50 years. In practice, many buildings exist for more than 50 years, as is shown in the Table of Year of Housing Construction in the census.

statistical yearbooks. The census data gives a total housing stock of 64,867 million square meters in 2020. Following the second approach, we estimate China's total housing stock in 2020 to be 64,430 million square meters. [30] The two approaches yield extremely similar results, with less than 1 percent difference. [31]

There are several advantages of our methodology. The negligible difference between the two estimates confirms the validity of the second approach to be extended to non-census years provided we use the official house life span figures. As the Chinese census is conducted only every 10 years, one can reliably reconstruct annual housing stock between census readings by drawing on residential housing completed data, as we do here for 2021. Since housing completed data is available at a monthly level, we are able to establish higher frequency housing stock indices to analyze monthly housing price and valuation changes by city tier.

Step 3: We next proceed to identify housing stock by city tier. To do this, we first collect the data on per capita living space and total population in 2010 and 2020 of tier 1 and tier 2 cities. For the four municipalities directly under the central government (Beijing, Tianjin, Shanghai, Chongqing), the data is available in the national census. For other thirty-one cities, we resort to the subnational census of the province in which each city is located for such information.[32]

To estimate housing stock from 2010 to 2021, we gather data on city-level residential housing completed. Outside the four direct-administered municipalities, only annual data on residential housing completed by property developers is reported. However, not all residential housing projects are executed by property developers. We estimate the ratio of residential housing completed by property developers based on the data of the four municipalities, and apply the ratio to other thirty-one cities to obtain their residential housing completed figures.[33] Inserting the aforementioned data into Equations (1) and (2) gives us housing stock numbers for tier 1 and tier 2 cities.

Finally, we subtract tier 1 and tier 2 housing stock numbers from the national aggregate housing stock to obtain the total residential floor space of tier 3 cities. Appendix Figure 2 sketches the process of how we arrive at our housing stock estimates.

While a higher per capita living space, particularly when it approaches the level seen in many advanced economies, may indicate an excess in housing construction in China, it is important to exercise caution in interpreting the results. Determining whether there is an imbalance in the housing market is a complex matter that may necessitate a general equilibrium analysis of supply

[30] As with the 2010 census, we keep the assumption that per capita living space of collectives amounts to one-fifth of that of family households.

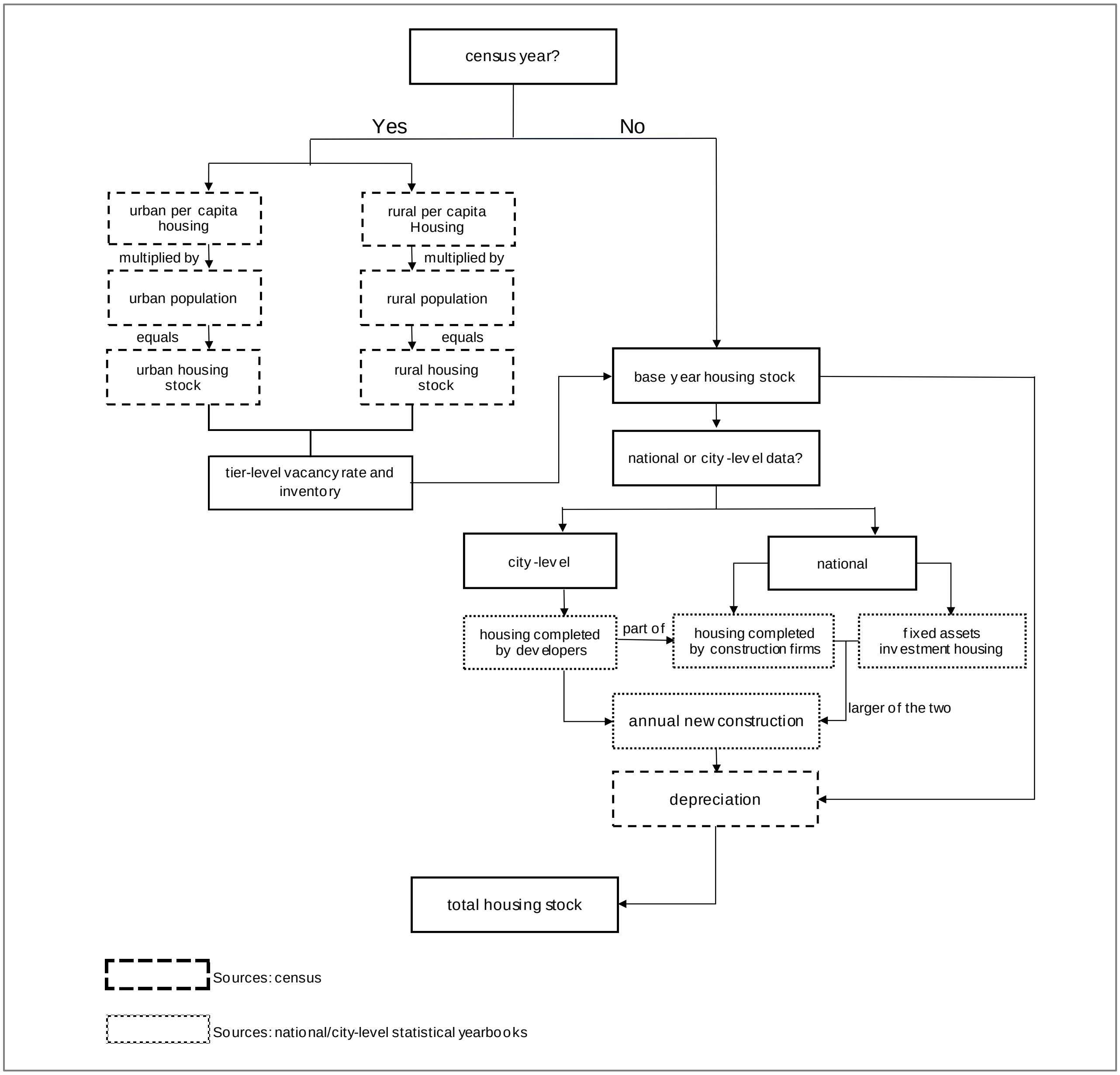
[31] The overall consistency remains intact when we extend the data from the 2010-2020 period to 2000-2010, the period between the fifth and sixth national population censuses, which indicates that the consistency between the two estimates is unlikely a coincidence.

[32] We manually collect data from 26 provincial censuses.

[33] Of the four municipalities, Beijing and Shanghai are tier 1 cities, whereas Tianjin and Chongqing are tier 2 cities. We apply the average ratio of Beijing and Shanghai to other tier 1 cities, and the average ratio of Tianjin and Chongqing to other tier 2 cities.

and demand. In addition, in lower tier cities and cities with less unaffordable housing prices, it may be natural for households to consume more living space, especially given the still rapid pace of urbanization.

Appendix Figure 2. Housing Stock Estimation



Appendix 3. First-stage Instrumental Variable Regressions

	(1)	(2)
Variable	Real estate investment/GDP	
Provincial average real estate investment/GDP excluding the city in question (Instrument 1)	0.326***	-0.807**
	(0.049)	(0.354)
Proportion of developable land × (Provincial GDP target - National GDP target) (Instrument 2)	0.003***	0.008*
	(0.001)	(0.005)
Housing stock × Instrument 1		0.113***
		(0.030)
Housing stock × Instrument 2		-0.000
		(0.000)
Tier 3 × Instrument 1	0.258***	
	(0.055)	
Tier 3 × Instrument 2	-0.000	
	(0.001)	
Lagged real GDP growth	0.031***	0.023***
	(0.007)	(0.007)
Per capita real GDP	-0.011***	-0.008***
	(0.003)	(0.003)
Population growth	0.020	0.013
	(0.017)	(0.015)
Population size	-0.018***	-0.027***
	(0.007)	(0.007)
Urbanization rate	0.037**	0.037**
	(0.014)	(0.015)
Industrial structure	0.004***	0.005***
	(0.001)	(0.001)
Constant	0.041	0.138***
	(0.049)	(0.051)
Number of observations	5,160	4,772
F-statistic	45.028	43.265
Time FE	YES	YES
City FE	YES	YES

* p<0.1, ** p<0.05, *** p<0.01