A Tale of Tier 3 Cities

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Abstract: This paper provides new estimates of the housing stock, construction rates and price developments by city tier in China in order to understand where excess supply might be concentrated, and the implications of any significant contraction. We also update estimates of the size of China's rapidly evolving real estate sector through 2021, allowing one to look at the initial impact of COVID-19, as well as extending the analysis to incorporate urban-expansion related infrastructure construction. We argue that China overall faces imbalances between supply and demand for housing stock, but the problem is significantly deeper in the generally smaller and lower income tier 3 cities[‡], which nevertheless account for more than 60% of both China's GDP and its housing stock. Regression analysis across 298 cities (including 263 tier 3 cities) for the years 2000-2021 suggests that, controlling for population, urbanization rate, and GDP growth, real estate construction has been a significant contributor to local government debt. The contribution of real estate to growth has been negative since 2018 after it contributed to positively to growth in the decade post-Global Financial Crisis.

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[‡] In China's city tier system, tier 1 cities refer to Beijing, Shanghai, Shenzhen, and Guangzhou, which represent the most developed areas of the country. Tier 2 cities include 2 direct-administered municipalities, 4 municipalities under separate state planning, and the capital city of each province. All other cities belong to tier 3. Tier 3 cities are typically less developed than tier 1 and tier 2.

I. Introduction

This paper provides new estimates of the housing stock, construction rates and price developments by city tier in China in order to understand where imbalances might be concentrated, and the implications of any significant contraction. We also update estimates of the size of China's rapidly evolving real estate sector through 2021, allowing one to look at the initial impact of COVID-19, as well as extending the analysis to incorporate urban-expansion related infrastructure construction.

In earlier work (Rogoff and Yang, 2021, 2022), we demonstrated that not only does the real estate sector in China constitute an exceptionally large part of its economy by international standards, but that after decades of break-neck paced construction, there is a risk that it has already become overbuilt. That is, for all the attention paid to the outsized share of real estate and construction in China's GDP, the more fundamental issue is that the sector has been racing ahead for several decades now, so much so that China already has, or is nearing, comparable square meters per capita of housing to many wealthy advanced economies. If real estate investment is running into diminishing returns, the implication is that the sector may need to shrink significantly over the coming decade, potentially exposing vulnerabilities in finance, government revenue, and employment. Recently, market pressures on Chinese construction firms, including Evergrande, underscore these concerns, though one must be cautious in interpreting the underlying causes which, for example, can reflect short-term policy tightening.

A fundamental question, however, that has only been touched on in the academic literature, is how the allocation of housing and construction imbalances extends across different regions, and how this might matter for any subsequent adjustment.[1] Most earlier research has concentrated either on national aggregates, or on the largest "tier 1" and "tier 2" cities.[2]

Here we show that, in fact, the problem of excess real estate stock and continuing overbuilding is particularly acute in tier 3 cites, and that the problem extends more broadly to infrastructure as well. Despite projections of declining population, and significant price declines (according to our estimates), a disproportionate share of construction continues to be concentrated in tier 3 cities. Whereas real estate construction may have helped fuel growth from 2008 to 2018, our analysis suggests that this has not been the case after 2018.

Although our main focus is on real estate and real-estate related activities, which account for nearly 70 percent of construction, we show that many similar imbalances exist in infrastructure investment which tends to track closely real estate. Perhaps in part to address inequalities across regions, and perhaps to resist Zipf's law on city size, China's far-flung and generally loss-producing high-speed rail network, has been disproportionately targeted at tier 3 cities, but this applies to many other areas of infrastructure as well, for example road construction.

We begin in the first section by updating evidence on the overall economy-wide size of the real estate sector to incorporate 2019–21; in principle, the update could make a significant difference in fast-moving Chinese economy. However, as we shall see despite efforts to contain debt imbalances the past few years, the estimated size of the real

[1] Housing imbalances are rarely evenly spread in any country; for example, the 2007–09 housing crisis in the United States was particularly concentrated in California, Nevada, Arizona, Florida and Colorado.

[2] Other existing studies on China's real estate have explored various aspects of the sector, including its price dynamics, its linkages to the financial system, and its implications for the economy (e.g., Fang et al., 2015; Chen and Wen, 2017; Glaeser et al., 2017; Song and Xiong, 2018; Liu and Xiong, 2020), However, most of them have focused on aggregate housing development or the situation in major cities, with very few casting an eye on tier 3 cities.

estate sector has remained quite stable. We next discuss the construction of our novel housing statistics by city tier, outlining the general procedure but leaving most details to an appendix. This includes estimates by city tier of the stock of housing, estimates of construction lags, GDP and price developments, all of which point to much greater concerns with overbuilding in tier 3 cities.

The next section develops some measures of fiscal and financial vulnerability, which suggest that the vulnerabilities are more acute in tier 3 cities. Residents of tier 3 cities hold a significantly larger share of their household wealth in real estate than in tier 1 and tier 2 cities, while local tier 3 city governments are particularly dependent on land sales for financing. In addition, debt burdens related to construction and real estate are also disproportionately higher in tier 3 cities, and have been growing rapidly in recent years.

It is certainly possible in principle that longer-term population growth in tier 3 cities will work off the excess supply over time. Thus, we next turn to population projections, here largely relying on United Nations estimates for national population growth and provincial-level estimates for tier 1 and tier 2 city growth. Although there are no similar estimates for tier 3 cities (which are much larger in number), combining falling aggregate population rates with expected modest population increases in the top two tiers, and taking into account expected changes in age demographics and household formation, one can infer that the need for real estate construction in tier 3 cities will need to shrink significantly between now and 2035, by roughly 30 percent in a gradualist scenario we present. Regression analysis across 298 cites for the years 2000-2021 suggests that, controlling for population, urbanization rate, and GDP growth, real estate construction has been a significant contributor to local government debt. While it contributed positively to growth in the decade post-Global Financial Crisis, the contribution of real estate to growth has been negative since 2018.

The final section of text looks at construction and infrastructure more broadly. Although real estate accounts for more than two-thirds of construction in China, infrastructure projects are also very important, and we argue that the regional allocation is highly correlated with real estate construction.

The conclusions summarize why real estate and construction vulnerabilities, and the general problem of imbalances between supply and demand for housing stock, are particularly concentrated in tier 3 cities, and why dealing with fallout will be challenging to navigate, particularly in the context of dealing with shocks such as the further waves of pandemic, a partial retreat from globalization due to onshoring, and other factors that portend a slowing of future trend growth.

II. The Overall Size of the Housing Sector

The size of China's real estate sector is remarkable (Huang et al., 2021; Shan et al., 2021). Table 1 below, updated from Rogoff and Yang (2021), illustrates the share of domestic production, including indirect demand, attributable to China's real estate.

Table 1. Demand for Real Estate-Related Activities 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	4.8%	16.9%	4.8%	16.9%	5.0%	17.3%
Real estate services	6.5%	5.0%	7.1%	5.5%	7.4%	5.6%
Imported component		2.8%		3.0%		3.1%
Total real estate activity	11.3%	24.7%	11.9%	25.4%	12.4%	26.0%

	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%	17.5%	5.1%	17.8%	5.0%	17.3%
Real estate services	7.1%	5.5%	7.3%	5.6%	6.8%	5.2%
Imported component		2.9%		2.7%		2.9%
Total real estate activity	12.2%	25.9%	12.4%	26.1%	11.8%	25.4%

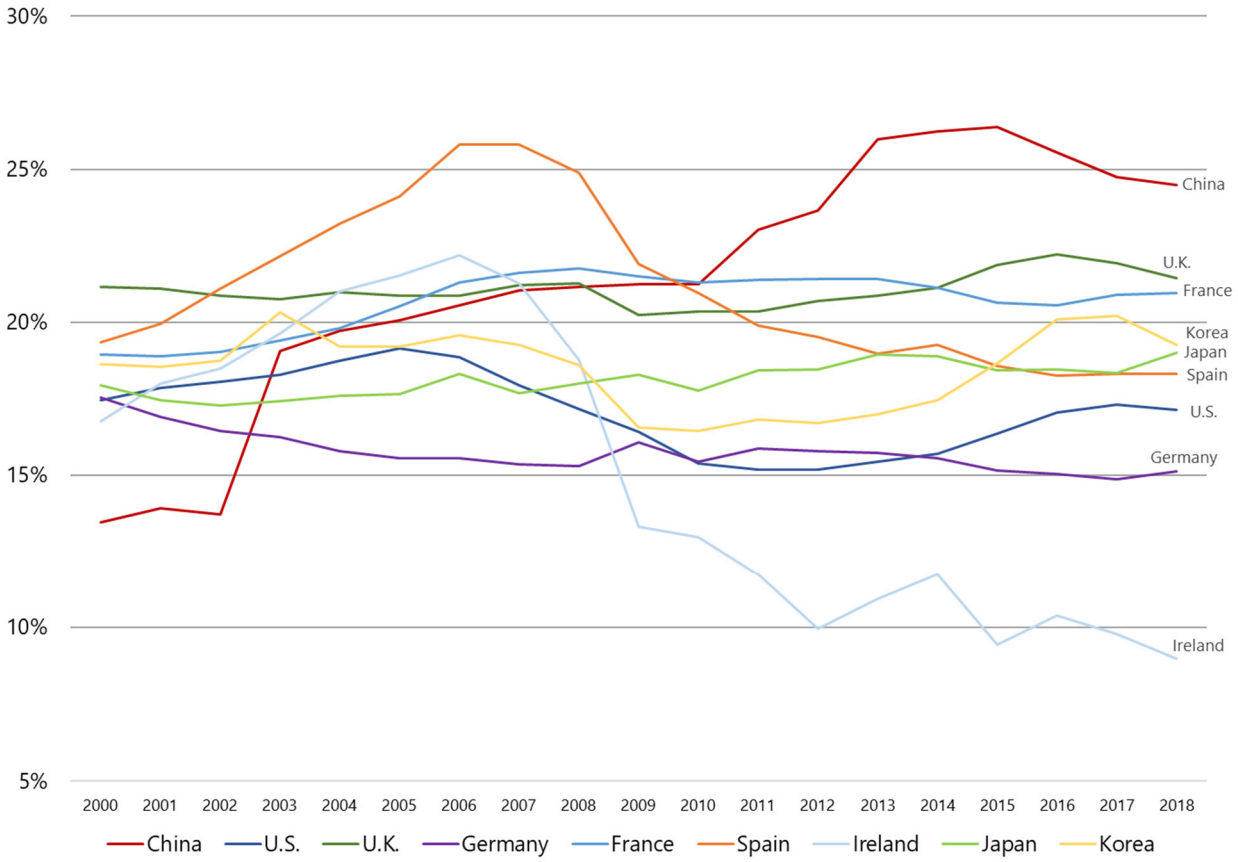
The "direct value added" column shows the share of GDP accounted for directly by activities of that sector. In other words, companies and workers engaged in all types of real estate related activities accounted for 12 percent of China's GDP in 2021.

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 including imported component will add approximately 3 percent to final demand, bringing the size of the sector to 26.1 percent in 2020, and 25.4 percent in 2021. Further details, including the precise calculation, are in the appendix.

At almost 23 percent of GDP (26 percent including imported content), real estate has remained remarkably stable since hitting this peak in 2018. The 23 percent figure including only domestic content matters especially for understanding the potential adjustment in employment from a shrinking of the real estate sector. However, the larger 26 percent figure including imported demand is useful if one is trying to understand the share of real estate in consumption and is also relevant to understanding cumulative production over time; the latter is significant for understanding the supply and demand imbalances that ultimately determine the stability of the market. As we confirm in Figure 1 using harmonized

OECD input output tables, the total domestic share of real estate in China's GDP exceeds the comparable figures for Spain and Ireland at their pre-crisis peaks, and also the United States.[3]

Figure 1. Demand for Real Estate-Related Activities as a Percentage 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

Relatedly, we note that China's construction sector is considerably more efficient than that of the United States, so when in appendix we calculate the footprint in China to be 26 percent (adding imported content) versus 14 percent in the United States, even this difference vastly understates the different rate of construction. Put differently, if we were to construct Chinese GDP using "PPP weights" (e.g., U.S. relative prices) as in the Heston-Summers-World Bank data base, the share of real estate in Chinese GDP would be even larger, as would be the implications for cumulative building during China's long construction boom period.

[3] See also, Rogoff and Yang (2021). Note that this figure includes imported content. Excluding it, the conclusion that the total domestic share of real estate in China's GDP exceeds the comparable figures for Spain and Ireland still holds (During 2006-2007, the import ratio for Spain was 4.6%). In 2018, the import ratios for China, Spain, and the United States were 3.1%, 2.2%, and 1.2%, respectively.

The remarkable productivity of China's real estate sector becomes clear when one considers the stunning scale of how rapidly housing is being built. Residential floor space in China's urban areas had increased at an annual growth rate of approximately 6 percent from 2011–21. In 2021, total urban residential floor space reached 35.6 billion square meters, nearly doubling that of 2010, which was estimated at 18.6 billion square meters. With the increase in total urban housing stock, per capita residential floor space in urban areas increased as well, up from 27.8 square meters in 2010 to around 39.0 square meters in 2021 (Appendix Figure 4), already on par with that of many advanced economies (Rogoff and Yang, 2021).

III. Real Estate by City Tier

3.1 City Tier Classification

Much of the academic literature, and virtually all the popular press, focuses on real estate data from major cities where information is more readily available. But as we shall see, that can give a significantly distorted picture on the health of the system. Agglomeration advantages favor megacities all over the world; China is no exception, and property demand reflects that. But in fact, as important as China's largest tier 1 and tier 2 cities are to its economy, as we shall see, the tier 3 cities are collectively even more important in terms of GDP and even more so in terms of real estate construction.

The importance of tier 3 cities in China reflects well-known fact that city size in China does not follow Zipf's law as tightly as most other countries, for example the United States, and that the very largest cities account for small percent of total population.[4] Zipf's law for cities basically states that the number of cities with population greater than S is proportional to 1/S (Gabaix, 1999; Arshad et al., 2018). In China, the small and medium-size tier 3 cities appear to have a significantly larger weight than in the United States, both for GDP and population (see for example, Sun et. al., 2021).

Unfortunately, it is not possible to do a general equilibrium calculation of the type done in section II, first because the input-output table is not available at the city level, and second, even if there existed city-level input-output tables, we would also need inter-city trade data, which also does not exist. Nevertheless, using municipal records, and new improved data from China's National Accounts, it is possible to get a more nuanced picture of where China's real estate imbalances might lie.

To disaggregate across tiers, the first thing we need to do is to classify membership. Despite its popular usage in areas such as commerce, transportation, tourism, education, etc., the city tier classification system is not officially recognized by the Chinese government; there is no official list of the exact cities that fit into each tier.

Beijing, Shanghai, Guangzhou, and Shenzhen are unarguably tier 1 cities. Beyond that, the National Bureau of Statistics reports main indicators of real estate projects in thirty-five large and medium-sized cities. The data is updated monthly and serves as an important housing market monitor. In addition to the four tier 1 cities, the thirty-five cities include two municipalities directly under the central government (Tianjin, Chongqing), five cities under separate state planning, and twenty-four provincial capitals. The list is available in the appendix. Due to their privileged administrative status, these cities are historically more developed and economically more important. Hence, we identify this group as tier 2 cities. 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 (Liu and Xiong, 2018). All other cities fall within tier 3.[5] Tier 3 cities account for roughly 60 percent of GDP (Appendix Figure 1).

[4] The large literature on Zipf's law (Arshad et. al. 2018) does have a longstanding debate on exactly what range of cities Zipf's law applies to, including in China. For example, it appears that in some countries, Zipf's law holds well for the top group of cities but tails off after that with city population size being more equal for smaller cities than Zipf's law predicts. That is, what is the exact shape of the power curve and does it eventually flatten. But our basic point that the larger Tier 1 and Tier 2 cities collectively are not as disproportionately large in either population or GDP (compared to the Tier 3 cities) as in say, the United States, is quite consistent with this literature.

[5] One can draw further distinctions by subdividing tier 3 cities into tier 3,4,5 etc., and further refinement is important for some issues, but would not affect the general thrust of the analysis here.

With the progress of urbanization, the total number of cities in China keeps expanding. According to *China City Statistical Yearbook*[6], there were 657 cities in China in 2010. The number rose to 685 in 2020.

3.2 Estimate of Housing Stock by City Tier

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.[7] 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. Moreover, our approach allows one to look at sensitivity to different assumptions regarding depreciation rates.

Step 1: We start by calculating China's housing stock in 2010 and 2020 based on census data.[8] The equation that we use is as follows:

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

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[9] households, and per capita living space in urban/rural family households.[10] The census identifies individuals as belonging to either

[6] Data sources are the *2011 China City Statistical Yearbook* and the *2021 China City Statistical Yearbook*. Based on administrative level, all the cities can be classified into municipalities directly under the central government, vice-provincial cities, prefecture-level cities, and county-level cities.

[7] 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.

[8] 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.

[9] 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.

[10] 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.

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.[11]

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

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

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 National Bureau of Statistics (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.[12] We take the larger of the two as our housing completed number.

For our baseline depreciation rate, we assign a 50-year lifespan to historical housing stock and a 70-year lifespan to new housing construction, assuming that buildings constructed more recently are of better quality. This translates into an annual depreciation rate d ranging from 1.4–2.0 percent. The life-span assumption (which we interpret as a conservative one, the economic lifespan is likely longer) is consistent with the design service life stipulated in the *Uniform Standard for Design of Civil Buildings* and the construction year data reported in Part II Volume 9 of the census.[13] The housing stock thus equals the total of new construction plus existing construction adjusted by depreciation.

So far, we have obtained two measures of housing stock in 2020 using two distinct methods—one based on the census data, the other using cumulative housing construction from annual statistical yearbooks. The census data gives a total

[11] 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 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.

[12] Prior to 2012, construction sector residential housing completed was smaller than fixed assets investment residential housing completed; after 2012, 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 completed data is gathered from both property developers and construction enterprises, but only includes projects that are valued more than 5 million yuan.

[13] 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.

housing stock of 54,909 million square meters in 2020. Following the second approach, and using our baseline depreciation rate, we estimate China's total housing stock in 2020 to be 54,922 million square meters.[14]

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. An application of this method is demonstrated in the next section.

The key advantage of our methodology is that it allows us to provide an estimate of the size of replacement needs. The is highly sensitive to the depreciation rate that we adopt. For example, if one replicates our year-by-year approach to infer what depreciation rate was used in constructing the 2010 census housing stock estimate, one gets a lower annual depreciation rate of 0.7 percent and a 2020 housing stock of roughly 62 billion square meters, 10–15 percent higher than in our baseline. In addition to this consideration, the housing stock in the census might be understated compared to the year-by-year comparison, as individuals have an incentive to underreport their home ownership in the census out of tax and other concerns.

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 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 2010 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.[15]

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 intermediated through 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.[16] 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. Figure 2 sketches the process of how we arrive at our housing stock estimates and Figure 3 presents the results.

[14] 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.

[15] We manually collect data from 26 provincial censuses. The list of censuses that we use can be found in the appendix.

[16] 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.

Figure 2. Housing Stock Estimation

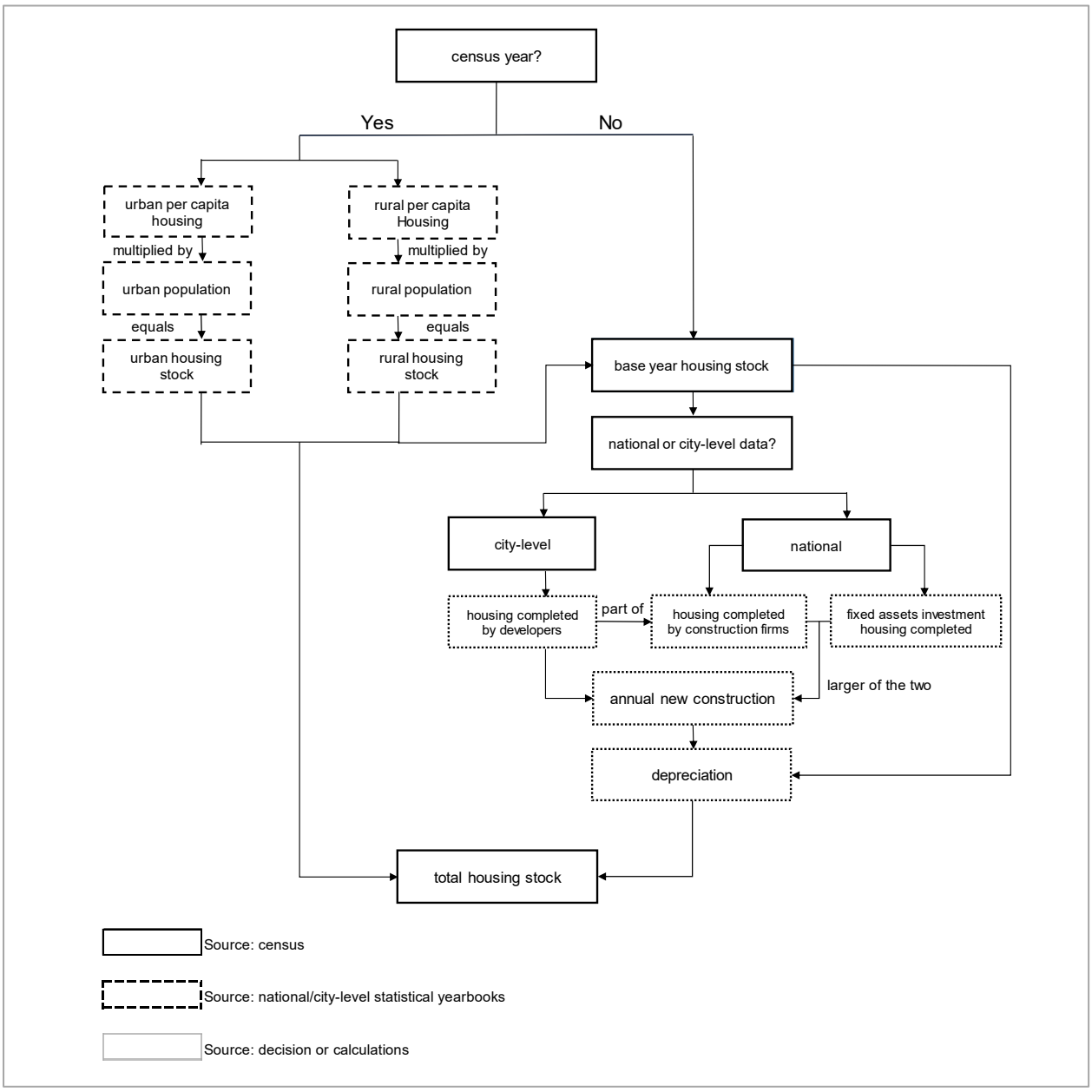
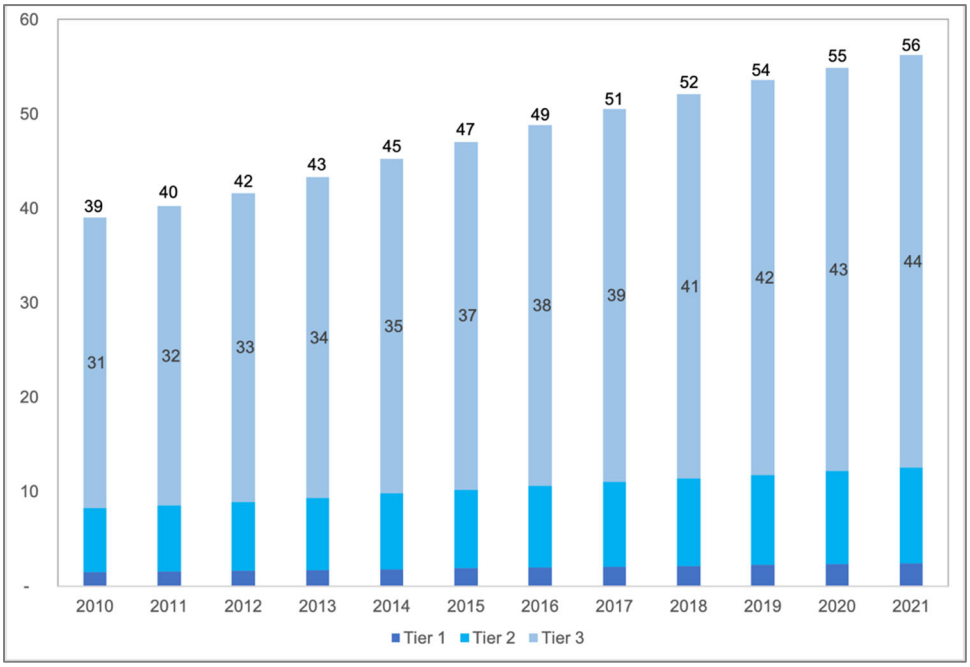


Figure 3. Total Housing Stock by City Tier (million square meters)



Sources: Official website of National Bureau of Statistics of China, China Statistical Yearbook, 2010 Chinese National Census, 2020 Chinese National Census, 2010 Chinese Provincial Censuses.
Notes: 1. The label in the center of the bar indicates the number for tier 3 cities.
2. The label at above the bar indicates the total number.

As Figure 3 shows, total housing stock in China reached 56 billion square meters in 2021, up from 39 billion square meters in 2010. Despite an unprecedented housing boom in tier 1 and tier 2 cities, their shares of housing stock remained relatively stable, accounting for 4 percent and 18 percent of the total housing stock respectively. Meanwhile, tier 3 cities consistently contributed to over 78 percent of the total housing stock.
We especially examine the housing stock in urban regions, where over 96 percent of residential property projects are executed.[17] In China, over 90 percent of rural dwellings are self-built and off market.[18] Thus China's property market is basically an urban market, and housing development in urban regions is particularly relevant for market stability.

Despite a relatively low urbanization rate, we find that tier 3 cities account for more than 72 percent of urban housing stock.[19] Meanwhile, this group of cities host 66 percent of the urban population.[20] Consequently, the per capita living

[17] 96 percent refers to the number of commodity dwellings (*shang pin fang, 商品房*)—or dwellings built by property developers—in urban regions over the total number of commodity dwellings. The data can be found in Part II Volume 9 of the 2020 census. The figure was 98 percent in 2010.

[18] 90 percent refers to the number of self-built rural dwellings divided by the total number of rural dwellings, data of which can be found in Part II Volume 9 of the 2020 census. The figure was 95 percent in 2010.

[19] Among different measures of residential floor space added each year, fixed assets investment residential housing completed series has the urban/rural classification, but the series was discontinued in 2016. In years where the series was available, we find that the proportion of urban residential housing completed is similar to China's urbanization rate.

[20] 2010 and 2020 urban population data are from the 2010 census and the 2020 census, respectively. 2021 data is from national and city-level Statistical Communiqués on the 2021 National Economic and Social Development. Other years are imputed using average growth rates during the 2010-2020 period. Again, tier 3 urban population number is obtained by subtracting tier 1 and tier 2 numbers from the national aggregate.

space in tier 3 cities grows significantly faster than that in tier 1 and tier 2 cities. Figures on urban housing stock, urban population, and per capita living space are provided in the appendix.

When analyzing construction, we care not only about floor space, but also about the scale of construction in value terms. Decomposing construction production value by city tier presents a similar picture to quantity (Appendix Figure 5). In 2020, tier 1, 2 and 3 cities account for 12 percent, 8 percent, and 80 percent of national construction production by value, respectively. Thus, taken together, tier 3 cities account for an outsize share of construction, whether by floor space or by value. This partly reflects the fact that construction projects around the country are held up to the same national construction standards and are thus of broadly similar quality.

3.3 Housing Prices by City Tier

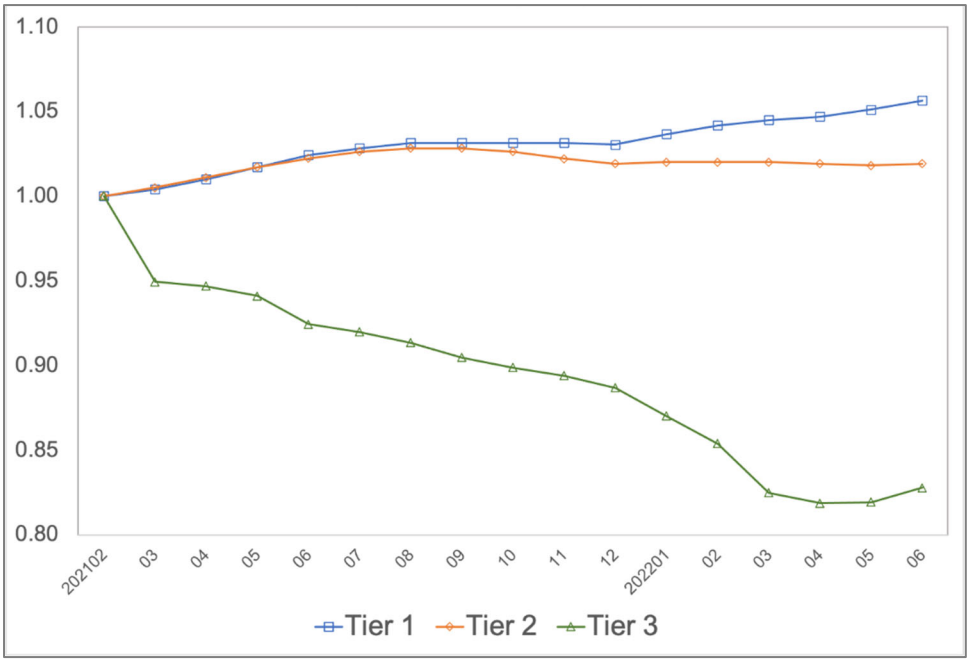
Presumably, imbalances between supply and demand for housing stock in tier 3 cities should be reflected in price developments. However, the National Bureau of Statistics only releases monthly housing price data of seventy large- and medium-sized cities (including four tier 1 cities, thirty-one tier 2 cities, and thirty-five representative tier 3 cities). The NBS also releases monthly data on floor space and volume of residential housing sold at the national level, which would enable us to calculate monthly national average housing price.

In Figure 4 below, we impute tier 3 housing price developments by subtracting from the national average housing price the housing prices of tier 1 and tier 2 cities, weighted by their respective floor space of housing sold (Appendix Figure 6). Tier 3 cities account for a rising share of housing sold, reaching around 70 percent by the end of 2020. The ratio is similar to its weight in urban housing stock.

This calculation suggests that between early 2021 and mid-2022, tier 3 cities have seen almost a 20 percent drop in residential housing prices. Prices rose modestly in tier 1 cities, whereas the rise was much smaller in tier 2 cities. Due to the lack of information on the national average selling price of second-hand, or pre-owned, dwellings, we are unable to infer the selling prices corresponding to tier 3 cities, but the monthly price indices from the NBS suggests that prices of pre-owned residential dwellings have seen an even sharper decline than for newly-built homes (Appendix Figure 7).

Combining the housing weights from Figure 3 and price changes from Figure 4, we show in Figure 8 of the appendix that China’s tier 3 housing market valuation has dropped by 15 percent over this period from 188 trillion yuan in early 2021 to 162 trillion yuan in mid-2022, and this does not even account for inflation over the period.

Figure 4. Housing Price Change by City Tier



Source: Official website of National Bureau of Statistics of China

Notes: 1. Unit is one.

2. The month of February 2021 is used as the base month and the indices measure cumulative change relative to the base month.

We caution that house price sale data anywhere in the world is difficult to interpret, for example due to changing mix and regions of home sales, and China is certainly no exception, but nevertheless Figure 4 is consistent with our broader analysis.

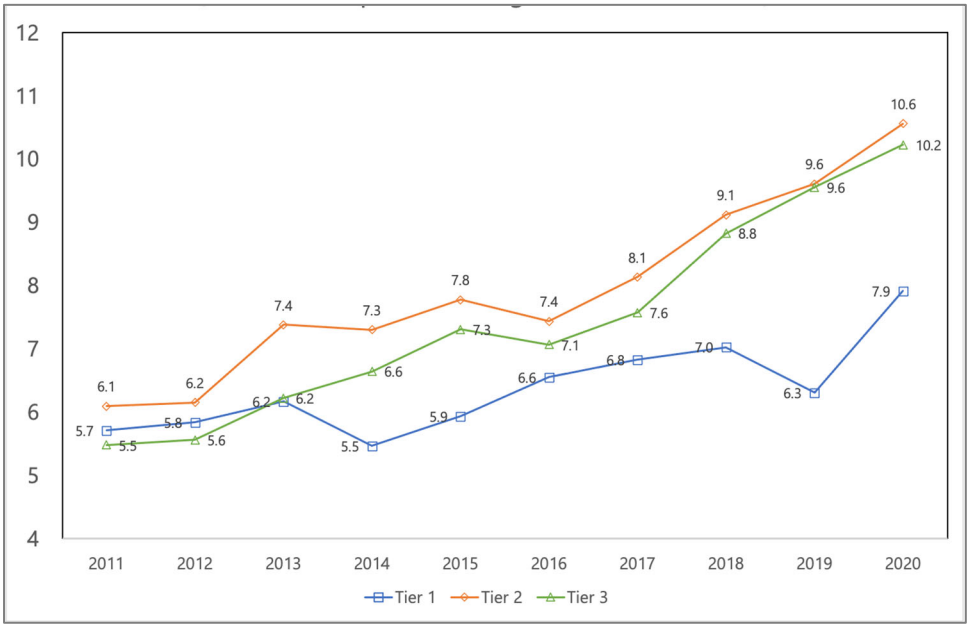
3.4 Unfinished Buildings by City Tier

Overbuilding in the real estate construction sector is evidenced by the ratio of new construction underway to projects completed. For tier 3 cities, the scale of housing under construction is 10.6 times as large as annual housing completed in 2020 (Figure 5). The ratio was just over 6 in 2011.

Obviously, in an extreme high growth scenario, the ratio of real estate under construction to housing completed in any given year, can be very high, even if the typical house takes only two to three years to build. However, the recent growth of construction sector has been nowhere near enough to explain the observed ratios, and the large scale of uncompleted buildings likely reflects the inability of property developers to carry out the project for lack of financing, or delays in projects due to disputes over property rights, quality reasons, etc., neither of which is a good sign. The 2022 mortgage boycott that swept across major tier 2 cities such as Zhengzhou, Taiyuan, Shenyang, Changchun, was a reflection of the risk posed by unfinished buildings.[21] Figure 5 shows that the low completion rate also plagues in tier 2 cities.

[21] https://www.bbc.com/zhongwen/simp/chinese-news-62149379

Figure 5. Housing Under Construction vs. Housing Completed by City Tier



Source: Official website of National Bureau of Statistics of China.

IV. Housing Sector Vulnerabilities in Tier 3 Cities

We now proceed to explore housing sector imbalances, and how these imbalances and the large size of construction and real estate activities might affect employment, debt, and growth across city tiers.

The housing sector is China's pillar industry, vital to sustaining household wealth, fiscal incomes, and employment. Compared with other city tiers, tier 3 has a larger share of household wealth linked to housing[22] and a higher level of local fiscal revenues coming from land finance (Appendix Figure 9)[23]. While tier 3 cities are home to close to 60 percent of housing under construction, they host over 90 percent of construction enterprises which hire over 85 percent of construction workers (Appendix Figure 10)[24]. Therefore, a significant deceleration will place pressure on the country's financial stability, fiscal sustainability, and labor market, especially for tier 3 cities.

4.1 Population Outflows from Tier 3 Cities

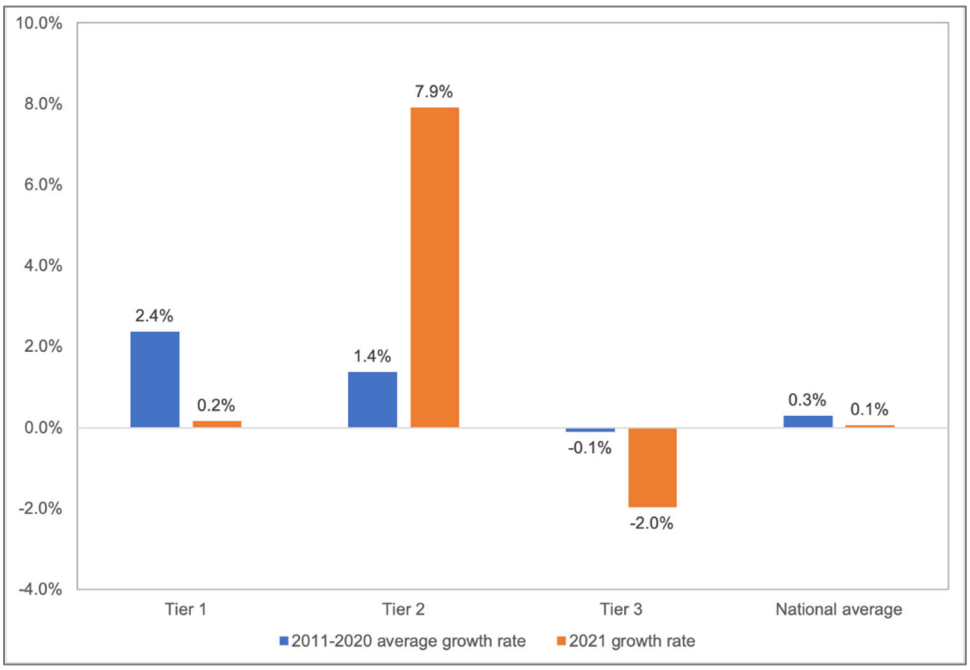
The massive housing stock in tier 3 cities stands in stark contrast with a population that has been slightly shrinking instead of expanding, as illustrated in Figure 6. Population growth across tier 3 cities, which was already flat to slightly negative period prior to the pandemic, fell by 2 percent in 2021. People are moving out of tier 3 cities and the rate of population outflows has been accelerating.

[22] According to a study conducted by the People's Bank of China (People's Bank of China, 2020), 59.1 percent of total household assets are housing assets in 2019. China Household Finance Survey (Southwestern University of Finance and Economics, 2019) gives a slightly higher estimate nationally, and finds that that housing wealth accounts for over 70 percent of total household wealth in tier 3 cities.

[23] Land finance, which refers to tax and non-tax revenues linked to the use of land, contributes heavily to local government revenues in China. Land-related tax revenues include farmland occupation tax, land value-added tax, sales tax on property developers and construction enterprise etc., whereas land-related non-tax revenues mainly comprise fees collected for the transferring, leasing and mortgaging of land use right. In 2021, the ratio of non-tax land revenues amounted to approximately 43 percent of local government fiscal revenues in tier 3 cities, a much higher level than that of tier 1 cities.

[24] The large share of construction enterprises is easy to understand given that many of these are quite small compared to construction firms in larger cities. The large share of construction workers reflects the quick expansion of the sector despite the widespread consensus that the needs for new housing construction are on the decline.

Figure 6. Population Growth by City Tier



Source: Official website of National Bureau of Statistics of China.

Population outflows compounded with a rapidly aging population point to a declining housing demand in the foreseeable future, especially for tier 3 cities. Based on United Nations data, we estimate that China's population will reach its peak in 2025 under the medium variant scenario (Appendix Figure 11).

As we have illustrated in section III, until now tier 3 cities have kept adding more homes despite already spacious per capita residential floor space. Admittedly, massive construction over the past three decades would translate into considerable replacement needs over the next 30 years, given a 1.5–2 percent annual depreciation rate.[25] However, the majority of Chinese homes were built around or after the 2000s (Appendix Figure 13), relatively new compared to homes in the U.S. Our projections of the housing demand over 2022–35 suggest that urban housing demand will decline by about 3 percent annually. In this estimate, roughly 60 percent of the demand is driven by replacement needs (Appendix 2); if depreciation is lower, say comparable to the rates used in the 2010 census, the fall in urban housing demand will be even larger.

4.2 Debt Accumulation behind the Construction Boom

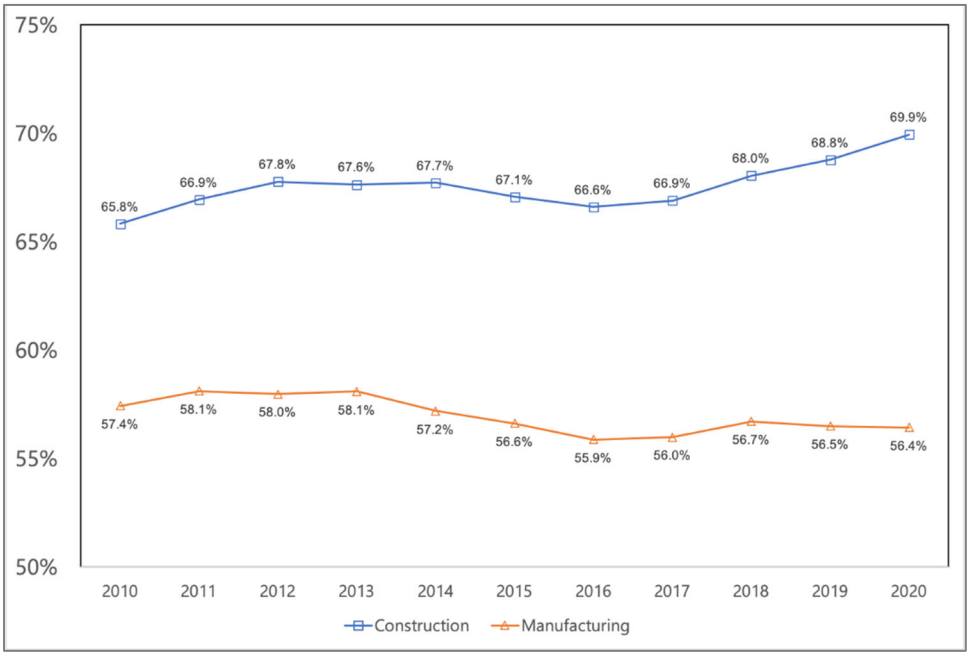
Thanks to relatively stringent down payment requirements, mortgage debt appears to be relatively low in China compared to other countries that have had housing booms, although it has been rising, and official figures may not include debt from shadow banks (Rogoff and Yang, 2021). Regardless, debt is quite high among construction firms, as the fallout from the recent Evergrande bankruptcy has highlighted. Indeed, as Figure 7 shows, construction sector debt levels, defined as the ratio of total liabilities over total assets (including projects under construction) of all registered construction enterprises, dwarf those of the manufacturing sector. Note the speed at which the sector has taken on leverage since 2016, despite

[25] 1.5 percent to 2 percent annual depreciation rate is equivalent to a 50 to 70 year lifespan.

government efforts to curb overall lending, and the widely-accepted consensus that China is facing slower trend growth and declining housing demand.

Compared with construction enterprises in tier 1 and (especially) tier 2 cities, those in tier 3 cities are more heavily leveraged, with a debt to assets level reaching almost 80 percent in 2020 (Appendix Figure 14).

Figure 7. Construction vs. Manufacturing Sector Debt Levels



Sources: Official website of National Bureau of Statistics of China, China Statistical Yearbooks from 2011 to 2021.

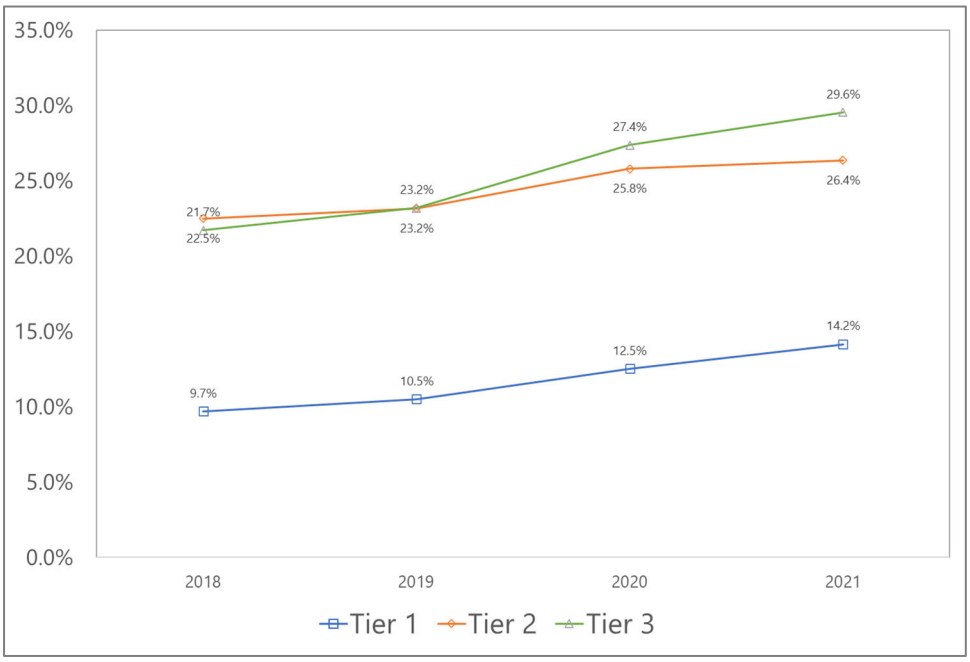
Notes: 1. Debt level is defined as the ratio of total liabilities over total assets.

2. Consistent with the China Statistical Yearbooks, we include all registered construction enterprises in the construction sector statistics, and all above grade manufacturing firms in the manufacturing sector statistics.

In addition to the household and the corporate sector, debt is quickly piling up and becoming potentially unsustainable for local governments. Figure 8 shows local government debt levels across city tiers. While all city tiers have built up substantial debt over the past few years, debt burdens are particularly heavy in tier 3 cities, which have seen the fastest growth in debt levels compared to other city tiers.[26]

[26] Note that these figures do not take into account hidden local government debt, which is kept off the balance sheets of local authorities, yet carries an implicit government guarantee of repayment. The practice is usually done through local government financing vehicles (LGFVs).

Figure 8. Local Government Debt Levels



Source: CEIC

Notes: 1. Debt level is defined as the ratio of total outstanding debt over GDP.

2. Tier 3 data is based on a sample of 217 representative cities.

4.3 Real Estate, Local Government Debt, and Growth

Land finance is generally regarded as the fundamental driver behind China's real estate boom. Under the tax-sharing system, which was introduced in 1994, local governments are granted little taxing autonomy, and have to find alternative income sources to fund infrastructure construction and other capital investments for future growth. The sale of land not only enables local governments to quickly raise capital, but also increases their debt carrying capacity, allowing them to take on more debt. Overreliance on land sales to finance growth is both volatile in the short run and unsustainable in the long run. It also creates incentives for local governments to overinvest in real estate, and to push up land and housing prices.

In this subsection, we use empirical evidence to show that investment in real estate construction, which was intended to stimulate growth, can lead to significant debt accumulation and bring about adverse growth outcomes. Our model is specified as follows:

$$y_{i,t+1} = \alpha + \beta * \bar{X}_{i,t} + \Gamma * \sum_{T-n}^{T} R_{i,t} + \epsilon_{i,t} \quad (3)$$

where $y_{i,t+1}$ represents the debt-to-gdp ratio of city i in year $t+1$, where $t \in T$. $\bar{X}_{i,t}$ stands for the average ratio of real estate investment over GDP from year 2000 to year t. $R_{i,t}$ is a vector of control variables, including population growth,

urbanization rate, and past GDP growth, and $\epsilon_{i,t}$ is the error term. We use robust standard errors to correct for heteroskedasticity.

All data are collected from the CEIC China premium database[27]. The total sample includes 298 representative cities, of which 4 are tier 1 cities, 31 are tier 2 cities, 263 are tier 3 cities, from 2000 to 2021.

The results in Table 2 show that real estate investment has consistently contributed to the accumulation of local government debt. More specifically, a 1 percent increase in average real estate investment over GDP ratio is associated with a 0.7-0.9 percent increase in debt-to-GDP ratio for the whole sample, and a 0.6-0.9 percent increase for tier 3 cities. Positive population growth, on the other hand, is associated with significant debt reduction.

Table 2. Real Estate and Debt-to-GDP Ratio

[27] The CEIC China premium database provides data on local government debt outstanding, population, urbanization rate, and GDP of 298 cities. The original data sources are the municipal bureau of statistics of each city.

	(1) All	(2) Tier 1 & 2	(3) Tier3	(4) All	(5) Tier 1 & 2	(6) Tier3	(7) All	(8) Tier 1 & 2	(9) Tier3
Variable	Debt/GDP 2021			Debt/GDP 2020			Debt/GDP 2019		
Average real estate investment ratio 2000-20	0.922***	1.173	0.857***						
	(0.226)	(0.795)	(0.262)						
Average real estate investment ratio 2000-19				0.786***	1.260	0.661***			
				(0.202)	(0.773)	(0.245)			
Average real estate investment ratio 2000-18							0.782***	1.491**	0.611***
							(0.177)	(0.713)	(0.185)
Cumulative GDP growth 2000-20	0.006	-0.003	0.007						
	(0.004)	(0.006)	(0.004)						
Cumulative GDP growth 2000-19				0.005	-0.002	0.006			
				(0.003)	(0.007)	(0.004)			
Cumulative GDP growth 2000-18							0.005*	-0.001	0.005*
							(0.002)	(0.007)	(0.003)
Cumulative population growth 2000-20	-0.151***	-0.131**	-0.151***						
	(0.042)	(0.061)	(0.052)						
Cumulative population growth 2000-19				-0.135***	-0.130**	-0.129***			
				(0.037)	(0.056)	(0.045)			
Cumulative population growth 2000-18							-0.120***	-0.121**	-0.116***
							(0.033)	(0.054)	(0.040)
Average urbanization rate 2000-20	-0.073	0.056	-0.117						
	(0.071)	(0.208)	(0.084)						
Average urbanization rate 2000-19				-0.057	0.019	-0.093			
				(0.064)	(0.186)	(0.078)			
Average urbanization rate 2000-18							-0.050	0.021	-0.083
							(0.058)	(0.164)	(0.070)
Constant	0.363***	0.330*	0.375***	0.340***	0.328*	0.349***	0.290***	0.240	0.302***
	(0.033)	(0.191)	(0.042)	(0.033)	(0.185)	(0.042)	(0.032)	(0.163)	(0.039)
Number of observations	251	34	217	251	34	217	251	34	217
R2	0.090	0.268	0.084	0.090	0.279	0.081	0.105	0.315	0.093

Note: * p<0.1, ** p<0.05, *** p<0.01

To explore how real estate investment affects growth, we estimate the following model:

$$\sum_{T}^{T+m} g_{i,t} = \beta_1 + \beta_2 * \ \bar{X}_{i,t} + \mathrm{B} * \sum_{T-n}^{T} R_{i,t} + \varepsilon_{i,t} \qquad (4)$$

where $\sum_{t+1}^{t+m} g_{i,t}$ stands for cumulative GDP growth of city i from year t to year $t+m$, and m=1, 2, 3. $\bar{X}_{i,t}$ refers to the average ratio of real estate investment over GDP from year 2000 to year t. $R_{i,t}$ is a vector of control variables, including population, urbanization rate, and past GDP growth. $\varepsilon_{i,t}$ is the error term. Similarly, we correct for heteroskedasticity by using robust standard errors.

Table 3. Real Estate and Growth

	(1) All	(2) Tier 1 & 2	(3) Tier3	(4) All	(5) Tier 1 & 2	(6) Tier3
Variable	Growth 2020-21			Growth 2019-21		
Average real estate investment ratio 2000-20	-0.483**	-0.207	-0.485**			
	(0.191)	(0.177)	(0.212)			
Average real estate investment ratio 2000-19				-0.285**	-0.034	-0.299*
				(0.143)	(0.212)	(0.164)
Cumulative GDP growth 2000-20	0.005***	0.003*	0.006***			
	(0.001)	(0.002)	(0.001)			
Cumulative GDP growth 2000-19				0.005***	0.002	0.005***
				(0.001)	(0.003)	(0.001)
Cumulative population growth 2000-20	0.019	-0.014	0.033**			
	(0.012)	(0.020)	(0.013)			
Cumulative population growth 2000-19				0.051**	0.042	0.071**
				(0.024)	(0.098)	(0.030)
Average urbanization rate 2000-20	0.028	0.103	0.037			
	(0.025)	(0.066)	(0.028)			
Average urbanization rate 2000-19				-0.069*	-0.039	-0.063
				(0.036)	(0.098)	(0.040)
Constant	1.064***	1.046***	1.044***	1.085***	1.093***	1.070***
	(0.016)	(0.049)	(0.020)	(0.021)	(0.072)	(0.027)
Number of observations	279	35	244	279	35	244
R2	0.183	0.137	0.205	0.132	0.149	0.138

Note: * p<0.1, ** p<0.05, *** p<0.01

Table 3 indicates real estate investment was associated with negative GDP growth in the period of 2019-2021 (Column 1, Column 4). The negative growth impact was primarily driven by tier 3 cities (Column 3, Column 6), whereas the effect was insignificant in other city groups (Column 2, Column 5).

To examine how the relationship between real estate construction and GDP growth evolves over time, we rerun Equation (4). Real estate was helpful for growth following the 2008 Global Financial Crisis, as suggested by the positive coefficients on real estate investment in Table 4.[28] However, starting from 2019, its growth effect has turned negative, especially in tier 3 cities, as we have shown in Table 3. The findings are consistent with our hypothesis that although real

[28] The results are extremely robust to what year we choose for cutoff.

estate had been a key contributor to China's impressive growth in the past two decades, as it approaches a gigantic size, the risks loom large and have started to weigh on the economy.

Table 4. Real Estate and Growth – Historical

	(1) All	(2) Tier 1 & 2	(3) Tier3	(4) All	(5) Tier 1 & 2	(6) Tier3
Variable	Growth 2016-2019			Growth 2008-2011		
Average real estate investment ratio 2000-16	1.023**	1.010*	0.944**			
	(0.394)	(1.022)	(0.425)			
Average real estate investment ratio 2000-08				1.352***	1.717*	1.339***
				(0.417)	(0.980)	(0.486)
Cumulative GDP growth 2000-16	-0.015***	-0.019	-0.014**			
	(0.006)	(0.011)	(0.006)			
Cumulative GDP growth 2000-08				0.034***	0.055*	0.031***
				(0.008)	(0.030)	(0.009)
Cumulative population growth 2000-16	0.282***	0.351**	0.253***			
	(0.063)	(0.141)	(0.071)			
Cumulative population growth 2000-08				-0.213**	0.147	-0.225**
				(0.088)	(0.223)	(0.096)
Average urbanization rate 2000-16	-0.471***	-0.070	-0.515***			
	(0.095)	(0.301)	(0.111)			
Average urbanization rate 2000-08				-0.194***	-0.582***	-0.152*
				(0.066)	(0.182)	(0.078)
Constant	1.228***	0.801**	1.273***	1.085***	1.469***	1.751***
	(0.057)	(0.318)	(0.075)	(0.021)	(0.202)	(0.094)
Number of observations	279	35	244	279	35	244
R2	0.169	0.415	0.159	0.104	0.504	0.080

Note: * p<0.1, ** p<0.05, *** p<0.01

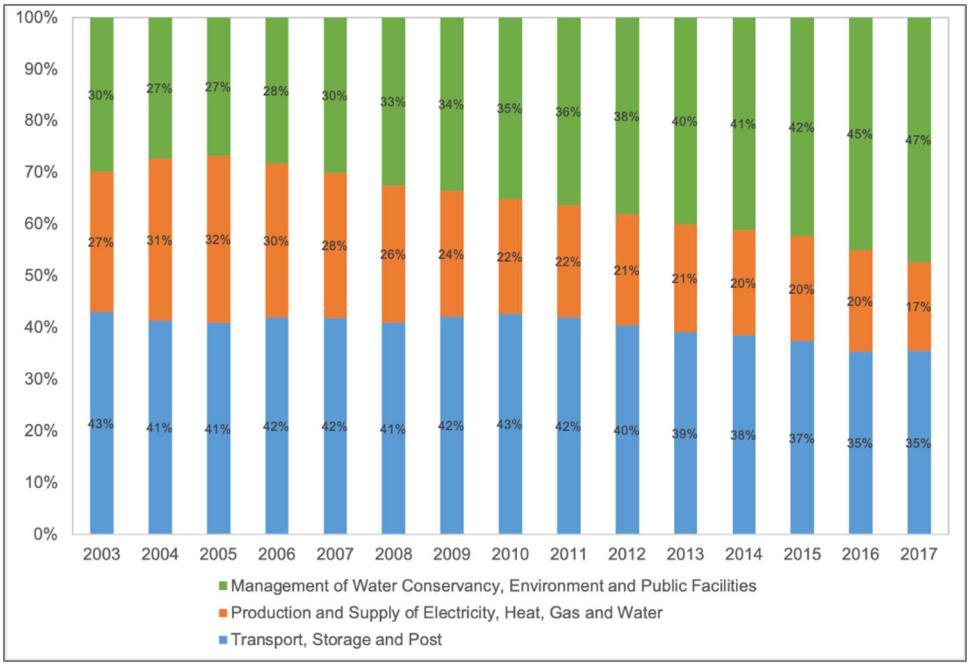
V. Infrastructure Development

Similar to housing, China is building vast quantities of infrastructure at a pace that is, if anything, even more rapid. Although not our main focus here, many of the issues are closely related, both in terms of whether China is running into diminishing returns as did Japan and many other Asian economies, and because large swathes of infrastructure closely correlate with real estate development.

5.1 Infrastructure Investment

China has continuously been investing in infrastructure, especially transportation facilities. From 2003–12, investment in transport, storage, and post accounts for over 40 percent of all fixed assets investment, representing the largest item of infrastructure construction projects, although in recent years it has been taken over by expenditures on environmental conservation (Figure 9).[29]

Figure 9. Breakdown of Infrastructure Investment



Sources: Official website of National Bureau of Statistics of China, China Statistical Yearbook 2018.
Note: Infrastructure investment includes three categories: transport, storage and post; production and supply of electricity, heat, gas, and water; and management of water conservancy, environment and public facilities.

A closer look at the statistics of different city tiers reveals that, at least for the transport and storage sector, a disproportionate scale of infrastructure construction occurred in tier 3 cities. Despite the fact that tier 3 cities account for roughly 60 percent of national GDP, they account for 88 percent of all roads and 92 percent of new road construction (Appendix Figures 15 and 16). Expressways, a subcategory of roads, tier 3 cities also take up a disproportionate share, whether in terms of stock or flow (Appendix Figures 17, 18 and 19). The same is true for pipelines, an important subcategory of supply of electricity, heat, gas and water in Figure 9.

Of course, an important argument for investing more heavily in lower income tier 3 city infrastructure is precisely to help reduce regional inequality, but the experience of many advanced economies is that Zipf's law is a powerful centripetal force.

5.2 The High-Speed Railways

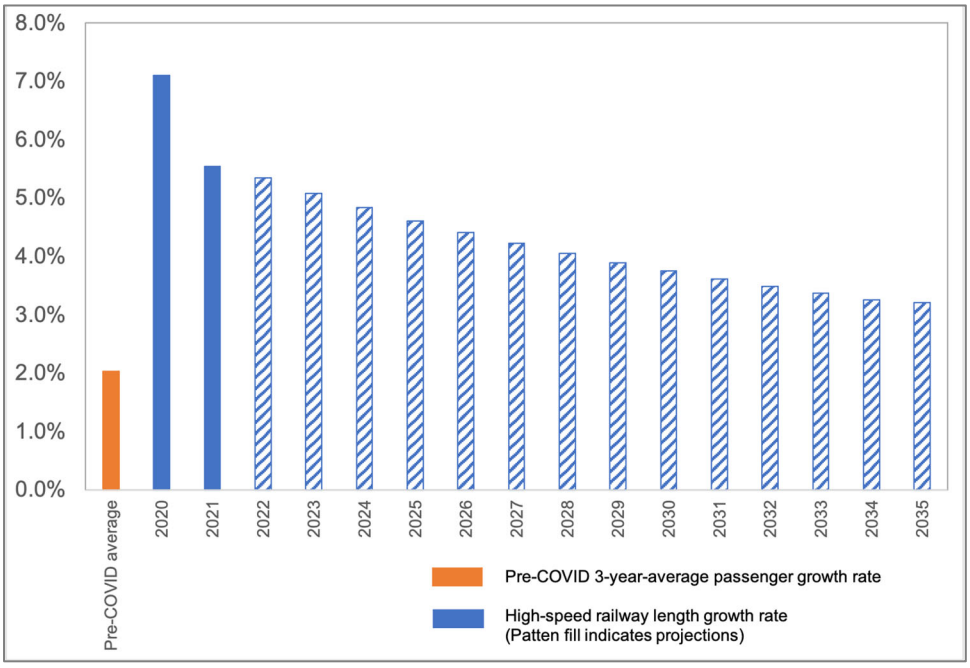
[29] Post refers to postal and courier activities. Storage refers to storage and warehousing industry.

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.[30] However, a careful examination unveils major problems.

To build the network, Chinese railway companies have borrowed substantially and taken on a large amount of debt. Interest expenses coupled with high operating and maintenance costs render China State Railway Group—the country's high-speed rail operator—in consecutive losses (Appendix Figure 20). When we look at individual routes, many, if not all, of the 142 high-speed railways are often unable to cover interest expenses, let alone operating and maintenance costs.

Despite excess capacity and heavy financial losses, China keeps expanding its high-speed railway network at a rate that far outpaces the growth rate of passengers (Figure 10).

Figure 10. 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.

Admittedly, high-speed rail is an important form of public goods and can generate considerable externalities (Cornes and Sandler, 1996), either through agglomeration and network effects (Wetwitoo and Kato, 2019), or by knowledge dissemination and technology spillovers (Huang and Wang, 2020; Bhatt and Kato, 2021).

However, such effects are conditional upon a set of other factors such as city size, industry structure, complementary amenities, distance from the urban center etc. While it makes sense to construct routes to connect heavily populated tier

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

1 cities, high speed railways have been disproportionately built in tier 3 cities.[31] The fact that such railways are running at relatively low capacity reflects the government's struggles to move people to less populated regions.

5.3 The New Infrastructure Push in Response to COVID-19

China's infrastructure investment surged by 7.1 percent in the first half of 2022 and is estimated to increase by 8 percent in the whole year, sharply higher than the 0.4 percent increase seen in 2021, with the aim of lifting the economy out of COVID-19 recession.[32]

However, the marginal growth contribution of investment is already in decline. Projects in transportation, energy and water conservancy, which the government again called for, are already in excess (Liu and Yang, 2020). Investing in infrastructure for supercomputing, cloud computing and artificial intelligence could be cost-effective, but the already high debt load limits the policy space to embark on large-scale public works.

More importantly, production of steel, cement and other materials generate the lion's share of China's CO2 emissions. These industries, much needed for the new infrastructure push, will have to shrink much more rather than expand for China to hit its target of capping carbon emissions by 2030.

[31] Manual collection of news on the launch of newly-constructed high-speed railway stations.

[32] https://www.ndrc.gov.cn/fgsj/tjsj/ssjj/202207/t20220727_1331796.html

VI. Conclusion

For years, reports of China's large housing inventory and empty buildings have suggested imbalances between supply and demand for housing stock and risk of correction, but most of the evidence has been quite limited to a few prominent examples highlighted by journalists. In this paper, we focused on the current housing stock, future housing demand, and various dimensions of housing sector risks in tier 3 cities, which have been relatively neglected in the literature, yet account for roughly 60 percent of GDP and an even larger share of real estate construction. Prices did not soar in tier 3 cities as in the much more written about tier 1 cities, and now they are falling faster. Our estimates of the stock of housing show the sector is very likely going to be demand constrained for a long time to come, and because of the outsized reliance of tier 3 cities on housing for fiscal budget, wealth and employment, the adjustment could be a challenging one. We also argue that much the same issues apply to infrastructure, which has also become overbuilt, particularly in tier 3 cities. Our analysis, including empirical regression across 298 cities, suggests that the growth effects of real estate investment have faded, but the effects on local government indebtedness and therefore financial vulnerability, continue to grow, especially for tier 3 cities.

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Complete listing of data reference is in Appendix IV.

Appendix I. Size of China's Real Estate Activity

We can use the exact same method as used in Table 1 of the text 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 2021.

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 II. Projections of Urban Housing Demand from 2022–35

Given the extraordinary size of China's housing sector, documented in Table 1, and the large stock of real estate already constructed, as shown by the estimates in Figure 3, a salient question is how long demand can sustain the current pace of production, and if it falls, how the burden will be distributed. There are two sources of future demand, first future household formation, and second replacing older substandard housing with newer units. Necessarily, the calculations here are crude estimates of future trends, but nevertheless the evidence seems to strongly underscore a disconnect between the overhang of existing units, the continuing rapid construction of new units, and imputed projections for significant aging and outmigration from tier 3 cities.

In this section, we assess China's housing sector demand in 2022–35. To estimate housing sector demand growth, we strip away the influences from short-term factors such credit conditions, interest rate fluctuations etc. and look instead at various long-term demand factors. While short-term policy loosening can temporarily relieve the credit constraints, we believe that long-term demand factors play a central role in shaping China's housing dynamics. We note that our analysis does not take into account the significant possibility of rising global real interest rates, which will put pressure on housing as an investment vehicle, and could impact demand through household liquidity constraints (that is, at higher interest rates, a great share of households will run into financing constraints.)

As noted in the introduction, given that there are no official estimates for population growth in tier 3 cities, but there do exist estimates at the national level and for tier 1 and 2 cities, we combine sources to obtain coherent estimates.

1. Methodology

We consider four driving forces of long-term housing demand—population growth, urbanization, home improvement needs and replacement needs. Housing demand, measured by total residential floor space, can thus be decomposed into

$$\begin{aligned} &Housing\ Demand \\ &\quad = (Total\ Population \times Urbanization\ Rate) \times (Existing\ Per\ Capita\ Residential\ Floor\ Space \\ &\quad + Home\ Improvement\ Needs + Replacement\ Needs) \end{aligned}$$

We illustrate in the following subsections how each factor evolves over the period 2022-2035.

2. Population Growth

China's population growth has slowed considerably, falling behind the trend in the most pessimistic scenario of UN population projections (Appendix Figure 11). In 2021, China added only 2 million new births. Its population was reported at 1.413 billion, up by 0.034 percent from end 2020, which was the slowest natural growth rate in six decades.

In the current study, population projections are made on a case-by-case basis for each tier 1 and tier 2 city, using estimates published by local authorities in these cities. We set the projection year to 2035 because the country's long-

range economic and social objectives are made through the year 2035. In the city-level development plans, most cities outline their population objective.

For example, according to *Beijing Overall Urban Planning (2016-2035)*, the capital city aims to limit its population to 23 million in 2030. Beijing's population reached 21.9 million in 2021, suggesting considerable need to control population growth and decentralize administrative functions. Shanghai, with 24.9 million residents in 2020, sets its 2030 population target at 25 million. Guangzhou plans to increase its population from 18.8 million in 2021 to 20 million in 2035, implying an average annual growth rate of 0.4 percent. With an annual population growth rate of over 5 percent in the past decade, Shenzhen is one of the fastest growing cities in China, thanks to a thriving tech industry and one of the loosest residency rules in the country. However, it sets its population target at 19 million in 2035, up from 17.6 million in 2020. To achieve this target, Shenzhen will have to significantly tighten its residency rules.

For tier 2 cities, 23 out of 31 have an official population target. We use the authorities' population target as their projected population in 2035. We then project the average population growth during 2022–35 of this group, and apply the projected growth rate to 8 other tier 2 cities which do not publish an explicit population target.

After calculating the projected populations in tier 1 and tier 2 cities, we deduct them from total population to obtain the populations in tier 3 cities. Total population is projected based on UN's medium variant scenario. Despite the fact that China's population is growing more slowly than in UN's most pessimistic (or low variant) scenario, we opt for a more optimistic projection, taking into account the possibility that the authorities could impose various policy measures to boost birth rate, the recent movement to replace two-child policy with three-child policy being one of them.

Based on the UN's medium variant scenario, China's population will peak in 2031. Geographic mobility will lead to a continuous decline in lower-tier cities, and a moderate increase in tier 1 and tier 2 cities.

3. Urbanization

In addition to a population target, most Chinese development plans also contain an urbanization target. Overall, China aims to achieve an 80 percent urbanization rate at the national level in 2050. Given a moderating urbanization drive, we assume that China's urbanization rate will reach 75 percent in 2035, which is consistent with the consensus projection (Qiao et al., 2018; United Nations, 2018; Li and Sun, 2020).

We then turn to city-level statistics. Shenzhen's urbanization rate already reached 100 percent in 2010, according to Shenzhen's 2010 Population Census. In Beijing, Shanghai, and Guangzhou, urban populations accounted for 88 percent, 89 percent, and 86 percent, respectively. In tier 2 cities as a whole, the average urbanization rate was 79 percent in 2021.

For tier 1 and tier 2 cities, we make reference to each city's development plans for their respective urbanization target. For cities without an official urbanization target, we assume their urbanization rate follows current pace of growth. To project the urbanization rate in tier 3 cities, we subtract projected urban populations in tier 1 and tier 2 cities from total urban population, and use the outcome to divide total population in tier 3 cities.

The results in Appendix Figure 12 suggest that tier 1 and tier 2 cities will converge to 90 percent urbanization over the next 10–15 years, whereas tier 3 cities will reach around 66 percent urbanization rate in 2035. National average urbanization rate by then is projected at 75 percent.

4. Home Improvement Needs

As we have discussed in the text, China's per capita residential floor space appears comparable to that of most advanced economies. However, there exists a unique feature characterizing homes sold by Chinese property developers—that of shared area,[33] which complicates the calculation.

Depending on the design, the proportion of shared area could be as high as 30 percent. Normally, the more complicated the building structure, the higher the proportion of shared area. The shared area in multi-story apartments (4 to 8 stories) ranges from 8 percent to 15 percent of residential floor space. In high-rise buildings, the ratio rises to 10–30 percent. Thus, accounting for the shared area, the actual residential floor space that is available for use could continue to improve before reaching the level of advanced economies.

Depending on the floor space discount, we assume that per capital residential floor space will continue to expand to 40-50 square meters across all city tiers and then stabilize at this level, in which case the actual residential floor space will reach approximately 40 square meters, comparable to that of most rich countries.[34]

5. Replacement Needs

Massive construction over the past three decades has led to a substantial upgrade of Chinese homes. The majority of Chinese homes were built around or after the 2000s (Appendix Figure 13), relatively new compared to homes in the U.S.

However, there remains a stock of substandard housing in urban areas without a kitchen or a toilet, as suggested by the 2010 Census. These residences, which were mostly built before the 2000s, are usually not counted as proper homes by U.S. standards. We assume that they will depreciate faster and be replaced more quickly than homes built after the 2000s. Based on the current construction standards, we assign a 50-year depreciation to such residences.

6. Projected Housing Demand in 2022–35

Taking into account all the aforementioned factors and plugging them into equation in Section 1, we estimate that the demand for new urban housing had peaked in China, projected to fall from an average of 183 billion square feet in the 2010s to 168 billion square feet by 2035 (Appendix Table 2). At the aggregate level, annual new construction may decline by approximately 3 percent starting from 2022. However, due to divergent housing and migration policies, tier 1 and tier 2 cities may experience a modest increase in housing construction, whereas tier 3 cities may see an annual decline of roughly 6 percent.

Since the actual population growth may overshoot the predetermined population target. We consider an additional scenario (Appendix Table 3) where tier 1 cities implement a less strict population control than what was stated in the National Planning.

[33] Shared area refers to the construction area of a building's common parts, which include elevator shafts, pipeline wells, stairwells, garbage passages, substation rooms, equipment rooms, public halls, corridors, patrol rooms, public rooms, management rooms, the dividing wall between the housing and the public building, as well as the floor area of half of the horizontal projected area of the external wall and the gable. Such area is shared by the property owners and counted toward their residential floor space.

[34] Of course, the ratio of units owned to units rented differs across countries (for example, in some Chinese cities, a significant fraction of units are held for investment purposes); however, the unit must ultimately still be occupied so owner versus rent issue is distinct from the question of living space per capita.

Appendix Table 2. Population Grows Following Development Plans

	Tier1	Tier2	Tier3	Total
Total demand (Billion ft2)				
2010-2021	7.8	41.7	133.4	182.8
2022-2035E	8.3	58.1	107.2	173.5
New demand composition				
Population growth	11%	33%	-6%	8%
Urbanization drive	5%	22%	26%	24%
Home improvement	13%	2%	10%	8%
Replacement needs	72%	43%	70%	61%
Average annual demand				
2010-2021	0.7	3.8	12.1	16.6
2022-2035E	0.6	4.1	7.7	12.4
Annualized percentage change				
2010-2021	4.0%	6.2%	6.2%	6.1%
2022-2035E	-1.3%	0.9%	-4.5%	-3.0%

Appendix Table 3. Population Increases at Trend Growth Rate

	Tier1	Tier2	Tier3	Total
Total demand (Billion ft2)				
2010-2021	7.8	41.7	133.4	182.8
2022-2035E	12.6	71.0	84.5	168.0
New demand composition				
Population growth	7%	27%	-8%	8%
Urbanization drive	34%	35%	9%	22%
Home improvement	8%	2%	13%	8%
Replacement needs	50%	36%	86%	62%
Average annual demand				
2010-2021	0.7	3.8	12.1	16.6
2022-2035E	0.9	5.1	6.0	12.0
Annualized percentage change				
2010-2021	4.0%	6.2%	6.2%	6.1%
2022-2035E	1.7%	2.4%	-6.1%	-3.2%

The results in Appendix Tables 2 and 3 illustrate a delicate trade-off between expanding tier 1 cities and developing tier 3 cities. Obviously, if China lets population balloon in the country's largest cities, resources and services will come under pressure, and less developed tier 3 cities will wither. However, if the government chooses to instead restrict the size of large tier 1 cities, it would be fighting the Zipf's law, which is hard, if not impossible.

Appendix III. List of Tier 1 and Tier 2 Cities

City Name	Tier

Beijing	1
Shanghai	1
Guangzhou	1
Shenzhen	1
Tianjin	2
Shijiazhuang	2
Taiyuan	2
Hohhot	2
Shenyang	2
Dalian	2
Changchun	2
Harbin	2
Nanjing	2
Hangzhou	2
Ningbo	2
Hefei	2
Fuzhou	2
Xiamen	2
Nanchang	2
Jinan	2
Qingdao	2
Zhengzhou	2
Wuhan	2
Changsha	2
Nanning	2
Haikou	2
Chongqing	2
Chengdu	2
Guiyang	2
Kunming	2
Xi’an	2
Lanzhou	2
Xining	2
Yinchuan	2
Urumqi	2

Appendix IV. List of Data Sources

Title	Category
2020 Chinese National Census	National
2010 Chinese National Census	National
2000 Chinese National Census	National
2021 Beijing Statistical Communiqué	Provincial
2021 Tianjin Statistical Communiqué	Provincial
2021 Shanghai Statistical Communiqué	Provincial
2021 Chongqing Statistical Communiqué	Provincial
2020 Beijing Census Communiqué	Provincial
2020 Tianjin Census Communiqué	Provincial
2020 Shanghai Census Communiqué	Provincial
2020 Chongqing Census Communiqué	Provincial
2010 Beijing Census	Provincial
2010 Tianjin Census	Provincial
2010 Shanghai Census	Provincial
2010 Chongqing Census	Provincial
2010 Hebei Census	Provincial
2010 Shanxi Census	Provincial
2010 Inner Mongolia Census	Provincial
2010 Liaoning Census	Provincial
2010 Jilin Census	Provincial
2010 Heilongjiang Census	Provincial
2010 Jiangsu Census	Provincial
2010 Suzhou Census	Provincial
2010 Anhui Census	Provincial
2010 Fujian Census	Provincial
2010 Jiangxi Census	Provincial
2010 Shandong Census	Provincial
2010 Henan Census	Provincial
2010 Hubei Census	Provincial
2010 Hunan Census	Provincial
2010 Guangdong Census	Provincial
2010 Guangxi Census	Provincial
2010 Hainan Census	Provincial
2010 Sichuan Census	Provincial

2010 Guizhou Census	Provincial
2010 Yunnan Census	Provincial
2010 Shaanxi Census	Provincial
2010 Gansu Census	Provincial
2010 Qinghai Census	Provincial
2010 Ningxia Census	Provincial
2010 Xinjiang Census	Provincial
2010 Yinchuan Census	City
2010 Urumqi Census	City
2021 Shijiazhuang Statistical Communiqué	City
2021 Taiyuan Statistical Communiqué	City
2021 Hohhot Statistical Communiqué	City
2021 Shenyang Statistical Communiqué	City
2021 Dalian Statistical Communiqué	City
2021 Changchun Statistical Communiqué	City
2021 Harbin Statistical Communiqué	City
2021 Nanjing Statistical Communiqué	City
2021 Hangzhou Statistical Communiqué	City
2021 Ningbo Statistical Communiqué	City
2021 Hefei Statistical Communiqué	City
2021 Fuzhou Statistical Communiqué	City
2021 Xiamen Statistical Communiqué	City
2021 Nanchang Statistical Communiqué	City
2021 Jinan Statistical Communiqué	City
2021 Qingdao Statistical Communiqué	City
2021 Zhengzhou Statistical Communiqué	City
2021 Wuhan Statistical Communiqué	City
2021 Changsha Statistical Communiqué	City
2021 Guangzhou Statistical Communiqué	City
2021 Shenzhen Statistical Communiqué	City
2021 Nanning Statistical Communiqué	City
2021 Haikou Statistical Communiqué	City
2021 Chengdu Statistical Communiqué	City
2021 Guiyang Statistical Communiqué	City
2021 Kunming Statistical Communiqué	City
2021 Xian Statistical Communiqué	City
2021 Lanzhou Statistical Communiqué	City
2021 Xining Statistical Communiqué	City

2021 Lanzhou Statistical Communiqué	City
2021 Yinchuan Statistical Communiqué	City
2021 Urumqi Statistical Communiqué	City
2020 Shijiazhuang Census Communiqué	City
2020 Taiyuan Census Communiqué	City
2020 Hohhot Census Communiqué	City
2020 Shenyang Census Communiqué	City
2020 Dalian Census Communiqué	City
2020 Changchun Census Communiqué	City
2020 Harbin Census Communiqué	City
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2020 Yinchuan Census Communiqué	City
2020 Urumqi Census Communiqué	City
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2010 Taiyuan Census	City
2010 Hohhot Census	City

2010 Shenyang Census	City
2010 Dalian Census	City
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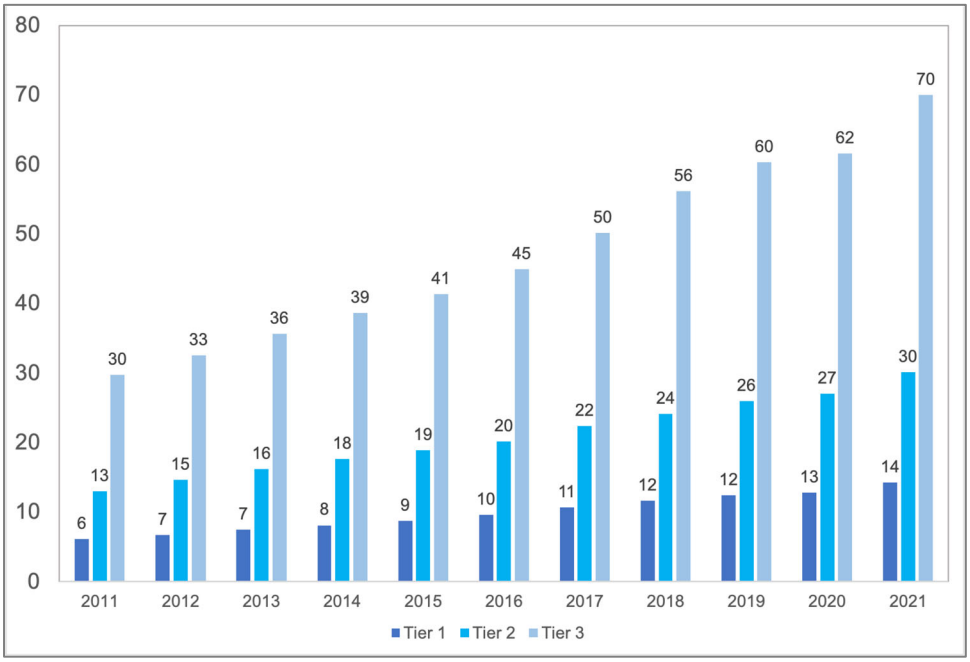
2010 Haikou Census	City
2010 Chengdu Census	City
2010 Guiyang Census	City
2010 Kunming Census	City
2010 Xian Census	City
2010 Lanzhou Census	City
2010 Xining Census	City
2010 Lanzhou Census	City
2010 Yinchuan Census	City
2010 Urumqi Census	City

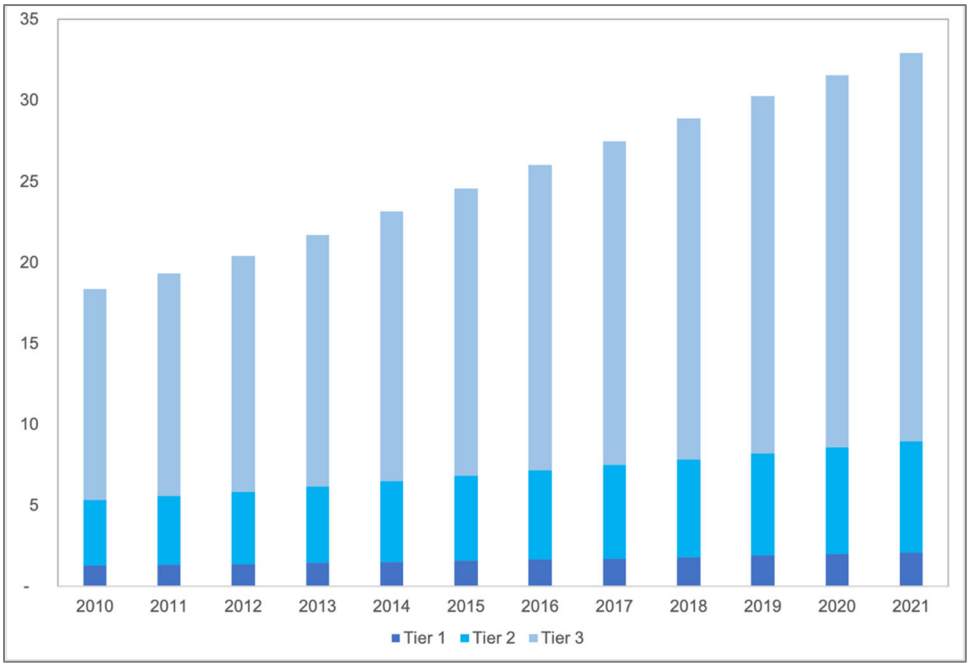
Appendix IV. Additional Figures

Appendix Figure 1. GDP by City Tier (trillion yuan)



Sources: National and city-level Statistical Communiqué of the People's Republic of China on the 2021 National Economic and Social Development; China Statistical Yearbooks from 2011–21, Provincial-level Statistical Yearbooks from 2011–21.

Appendix Figure 2. Urban Housing Stock by City Tier (billion square meters)

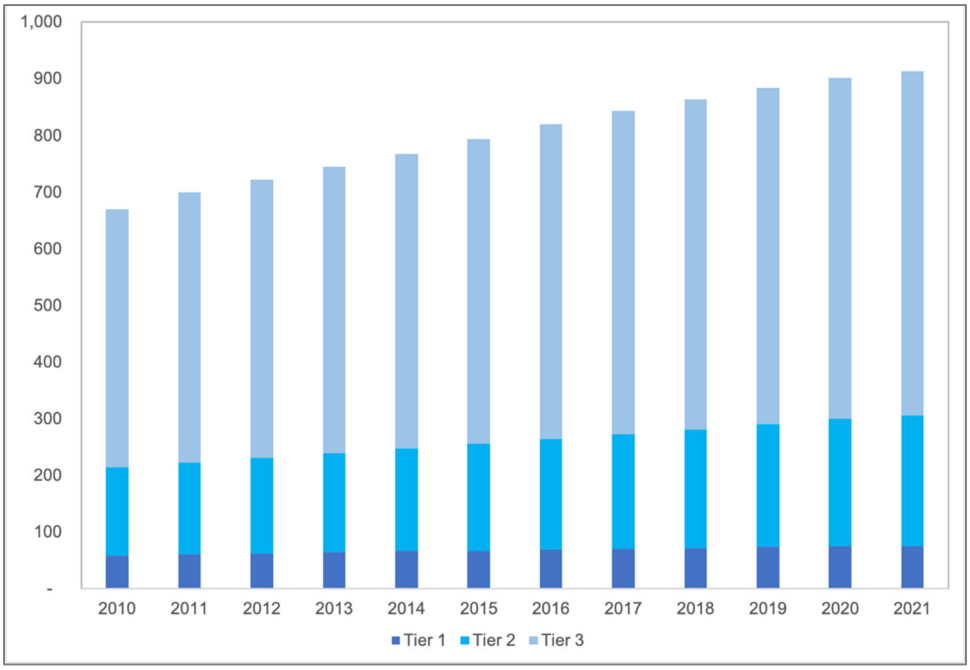


Sources: Official website of National Bureau of Statistics of China; China Statistical Yearbooks from 2011 to 2021; 2000, 2010, 2020 Chinese National Censuses; 2000, 2010 Chinese Provincial Censuses.

Notes: 1. There is no clear evidence of how much residential floor space is added each year in urban regions. Fixed assets investment residential housing completed series had the urban/rural classification, but the series was discontinued in 2016. In years where the series was available, we find the proportion of urban residential housing completed similar to China's urbanization rate.

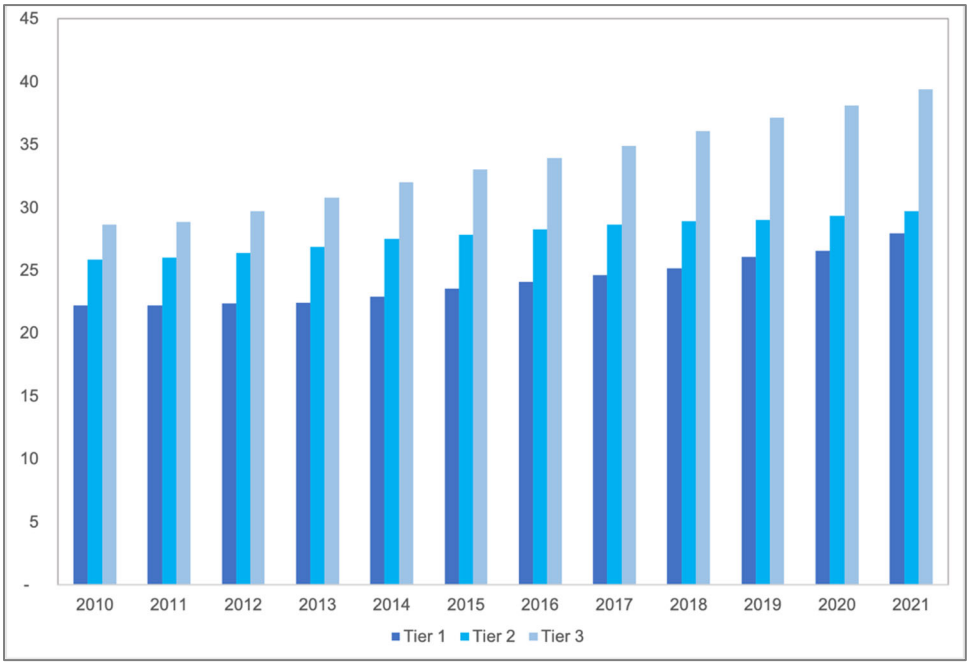
2. China urbanizes not only by building new dwellings in urban regions, but also by expanding the city frontiers and transforming existing rural dwellings into urban ones. In calculating urban housing stock, we estimate the scale of such urban transformation without new construction based on data from the 2000 and 2010 national censuses. The scale is estimated at 300 billion square meters per year.

Appendix Figure 3. Urban Population by City Tier (million people)



Sources: National and city-level Statistical Communiqués on the 2021 National Economic and Social Development; 2000, 2010 and 2020 Chinese National Censuses; City-level Communiqués on the 2020 Chinese Census, City-level Communiqués on the 2010 Chinese Census.
Notes: Up to the time we write this paper, urban population data of four tier 2 cities—Dalian, Harbin, Changsha, Haikou, and Urumqi—have not been published. We extend the series by using the 2020 urban population growth rate.

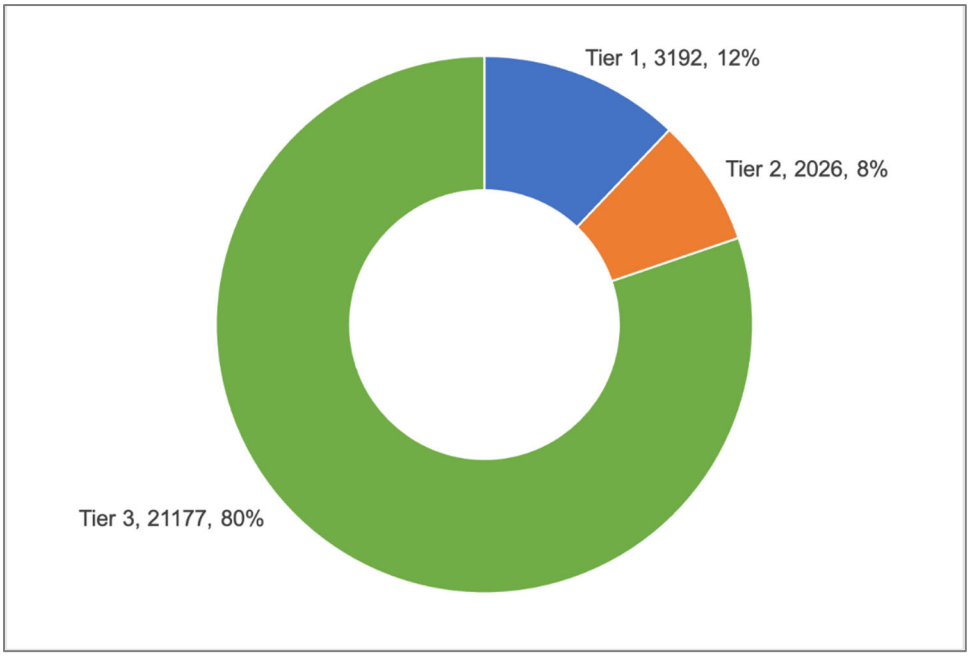
Appendix Figure 4. Urban Per Capita Living Space by City Tier (square meters)



Sources: Official website of National Bureau of Statistics of China; China Statistical Yearbooks from 2011 to 2021; 2000, 2010, 2020 Chinese National Censuses; 2000, 2010 Chinese Provincial Censuses; national and city-level Statistical Communiqués on the 2021 National Economic and Social Development; city-level Communiqués on the 2020 Chinese Census; city-level Communiqués on the 2010 Chinese Census.

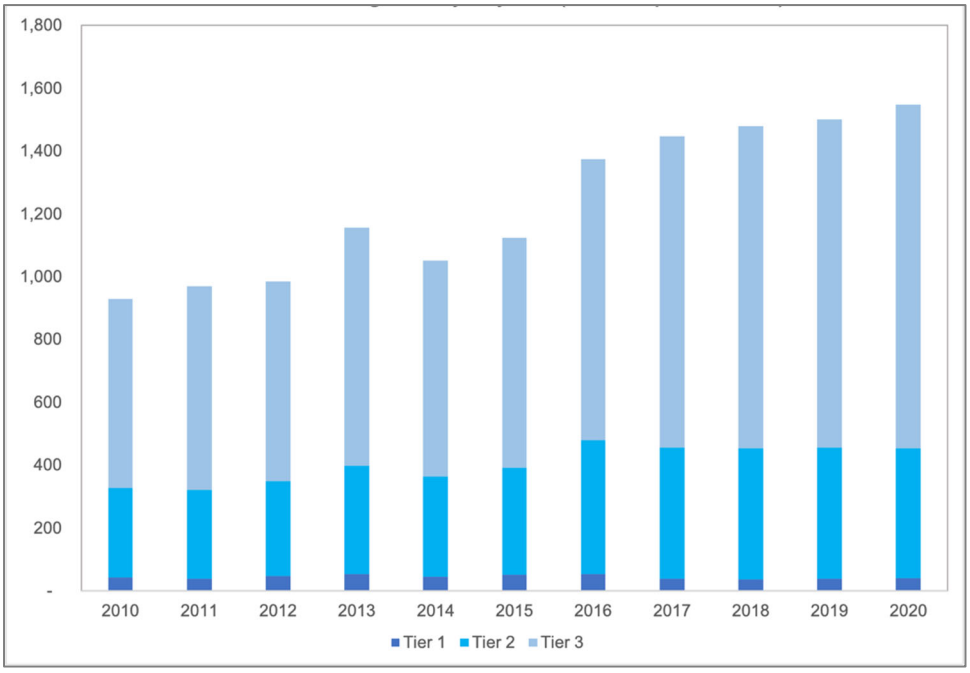
Notes: For each city tier, urban per capita living space is calculated by dividing urban housing stock by urban population.

Appendix Figure 5. Construction Production by City Tier in 2020 (billion yuan)



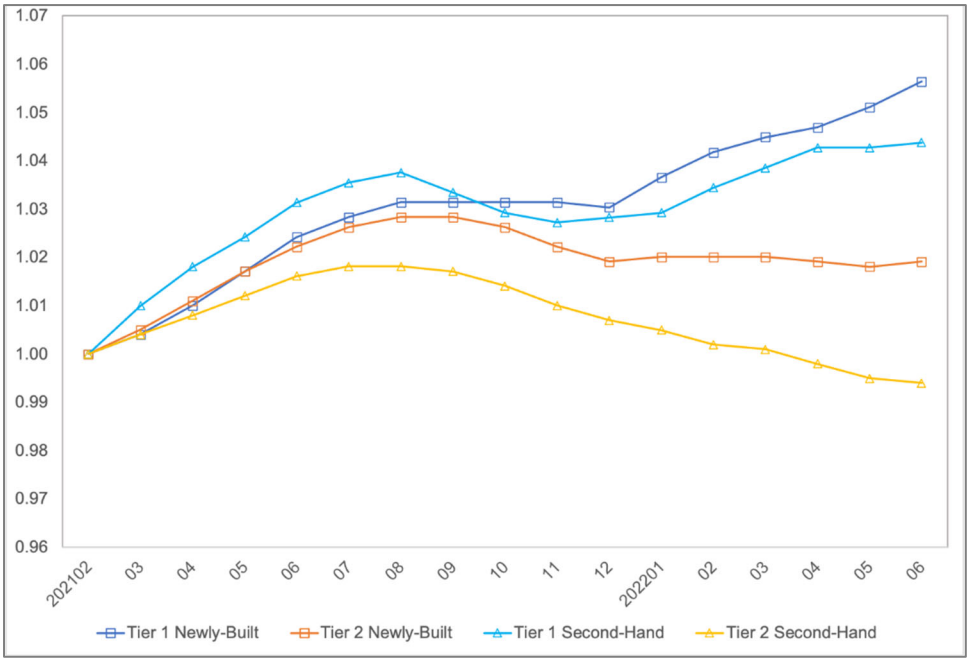
Sources: National and city-level 2021 Statistical Yearbooks.

Appendix Figure 6. Residential Housing Sales by City Tier (million square meters)



Source: Official website of the National Bureau of Statistics of China.

Appendix Figure 7. Price Changes of Newly-Built and Second-Hand Dwellings

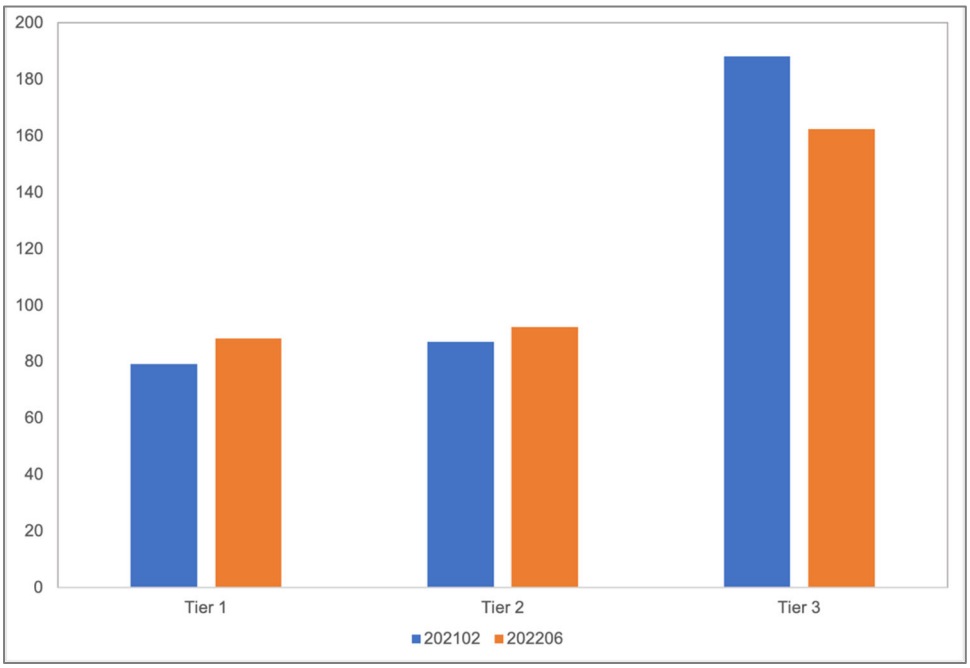


Source: Official website of the National Bureau of Statistics of China.

Notes: 1. Unit is one.

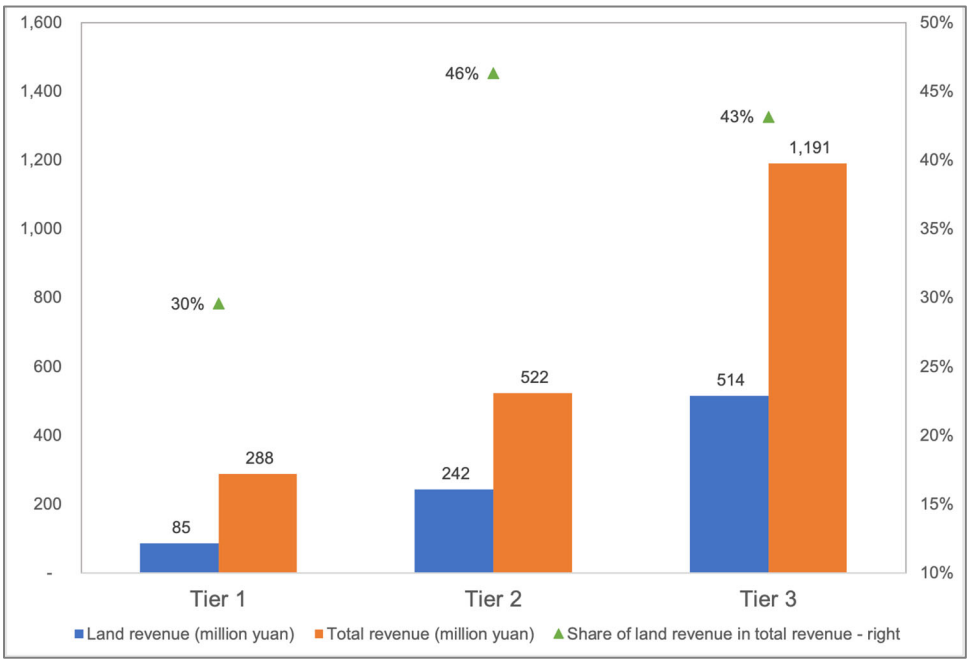
2. The month of February 2021 is used as the base month and the indices measure cumulative change relative to the base month.

Appendix Figure 8. Housing Market Valuation by City Tier (trillion yuan)



Sources: Official website of National Bureau of Statistics of China, China Statistical Yearbook, 2010 Chinese National Census, 2020 Chinese National Census, 2010 Chinese Provincial Censuses.
Notes: Market valuation is defined as housing price multiplied by housing stock.

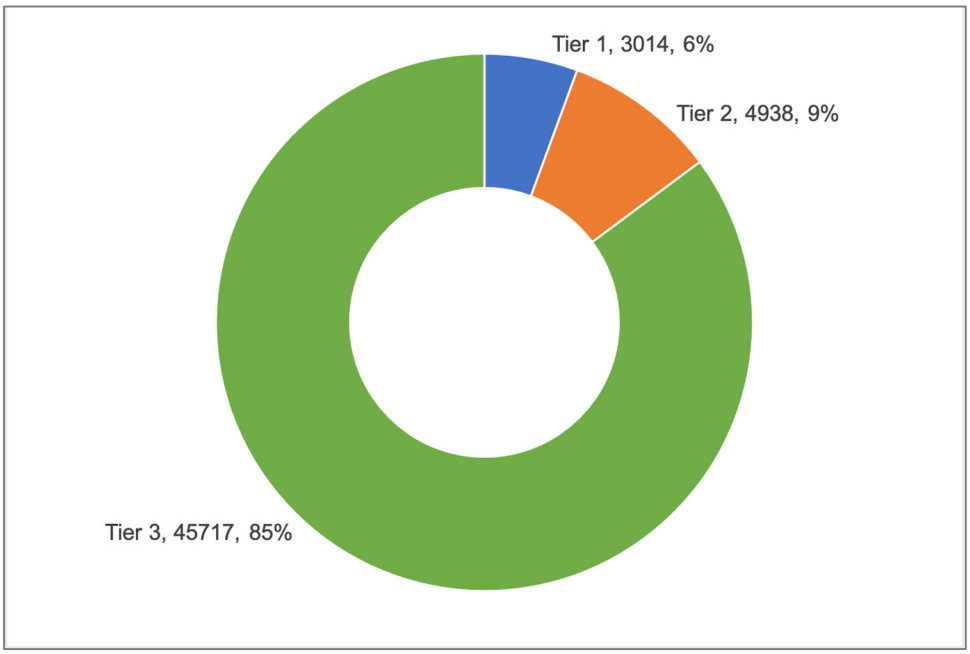
Appendix Figure 9. Land Revenue and Total Fiscal Revenue in 2020[35]



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

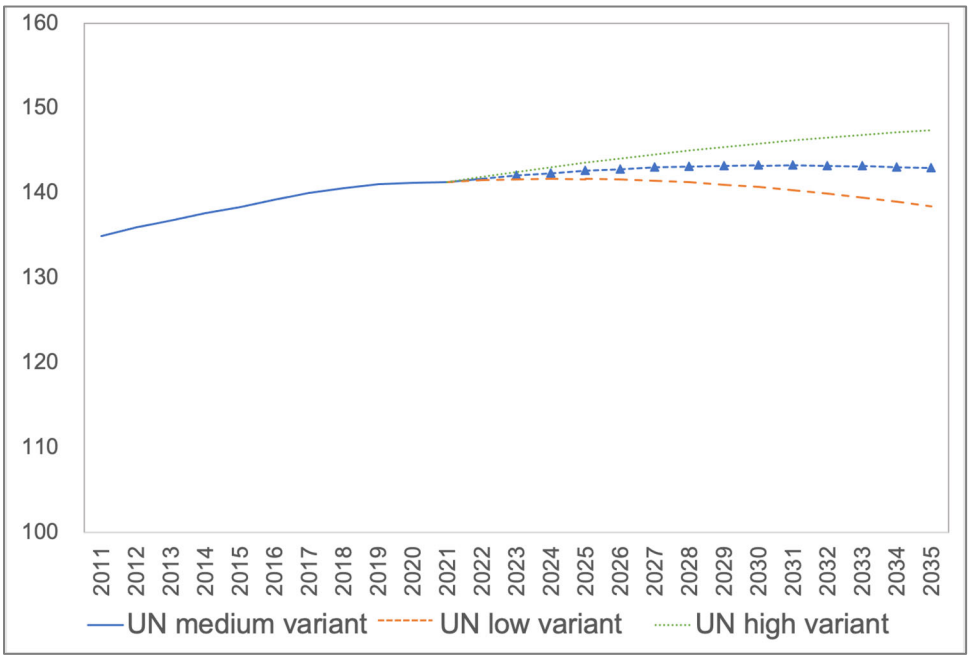
[35] Fiscal revenues at the local level comprise four components: general public budgetary revenues, government fund revenues, state-owned capital operating revenues, and social security fund revenues. General public budgetary revenues are primarily composed of tax revenues and transfer payments from 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.

Appendix Figure 10. Construction Sector Employees by City Tier (thousand people)



Sources: City-level 2021 Statistical Yearbooks.

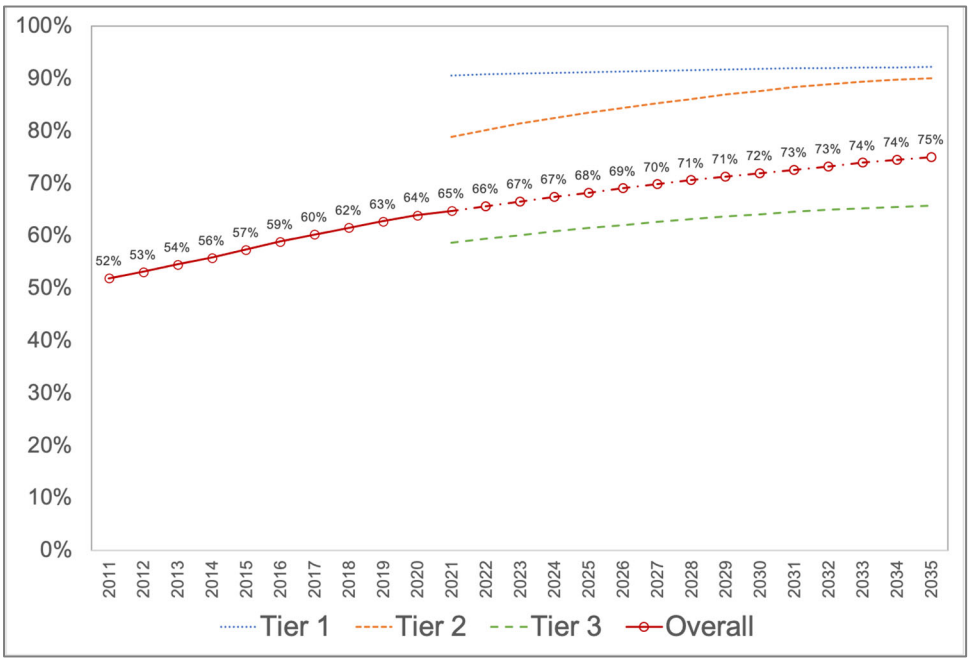
Appendix Figure 11. Population Projections



Sources: 2022 Revision of World Population Prospects by the United Nations, official website of the National Bureau of Statistics of China.

Notes: China's population growth has slowed considerably, falling behind the trend in the most pessimistic scenario of UN population projections. In 2021, China added only 2 million new births. Its population was reported at 1.413 billion, up by 0.034 percent from end 2020, which was the slowest natural growth rate in six decades.

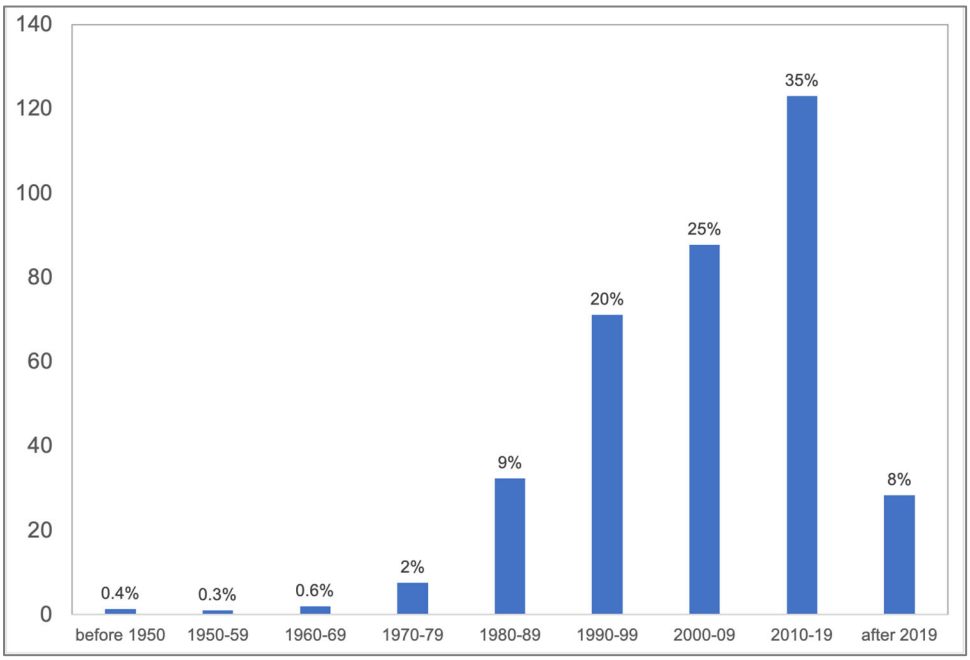
Appendix Figure 12. Urbanization Rate Projections



Sources: Official website of the National Bureau of Statistics of China, city-level Development Plans 2016–35.

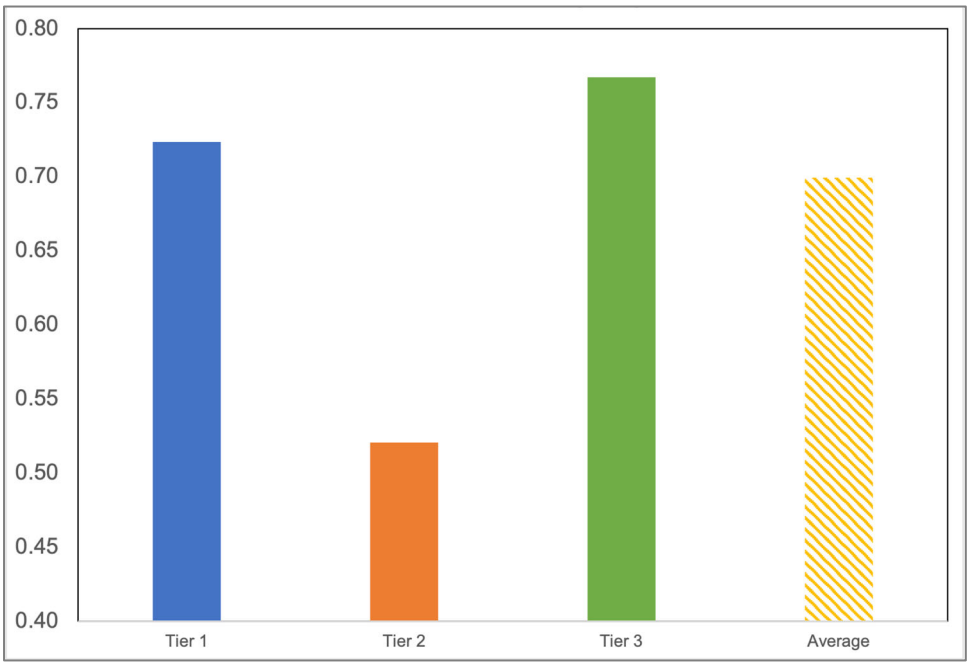
Notes: Overall, China aims to achieve an 80 percent urbanization rate at the national level in 2050. Given a moderating urbanization drive, we assume that China's urbanization rate will reach 75 percent in 2035, which is consistent with the consensus projection (Qiao et al., 2018; United Nations, 2018; Li and Sun, 2020).

Appendix Figure 13. Residential Space by Construction Year



Sources: 2020 Chinese National Census, official website of the National Bureau of Statistics.
Notes: Massive construction over the past three decades have led to a substantial upgrade of Chinese homes, The majority of Chinese homes were built around or after the 2000s, relatively new compared to homes in the U.S. However, there remains a stock of substandard housing in urban areas without a kitchen or a toilet, as suggested by the 2010 Census. These residences, which were mostly built before the 2000s, are usually not counted as proper homes by U.S. standards. We assume that they will depreciate faster and be replaced more quickly than homes built after the 2000s. Based on the current construction standards, we assign a 30-year depreciation to residences built before the 2000s, and a 50-year depreciation to residences built after the 2000s. Replacement needs account for over 60 percent of housing demand over the next 14 years.

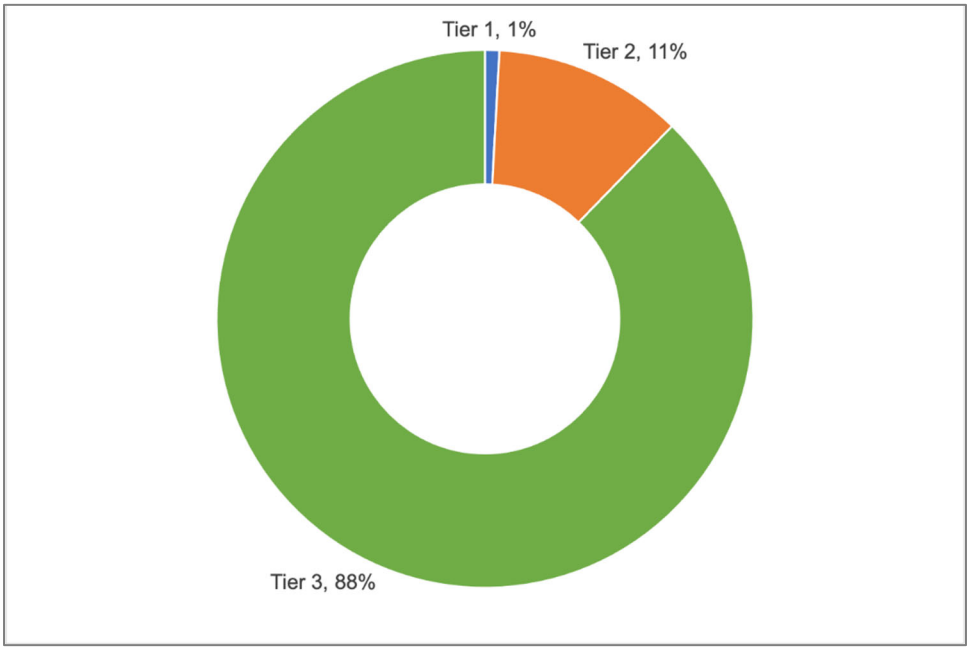
Appendix Figure 14. Construction Sector Debt Ratio by City Tier



Sources: City-level 2021 Statistical Yearbooks.

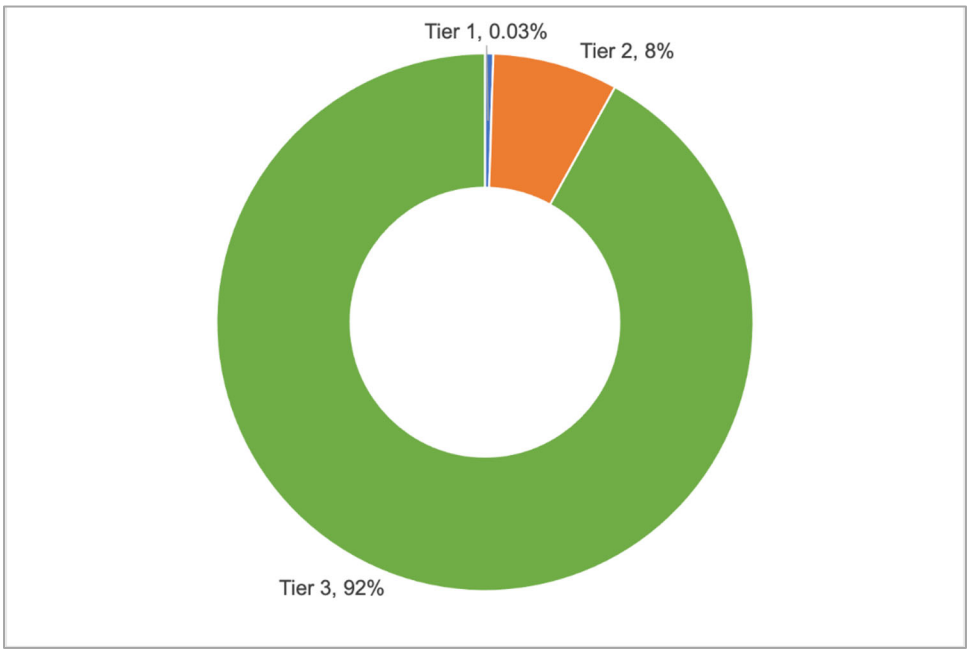
Notes: Debt ratio is defined as total debt over total assets. Total assets include current assets, fixed assets, and projects under construction.

Appendix Figure 15. Length of Roads by City Tier



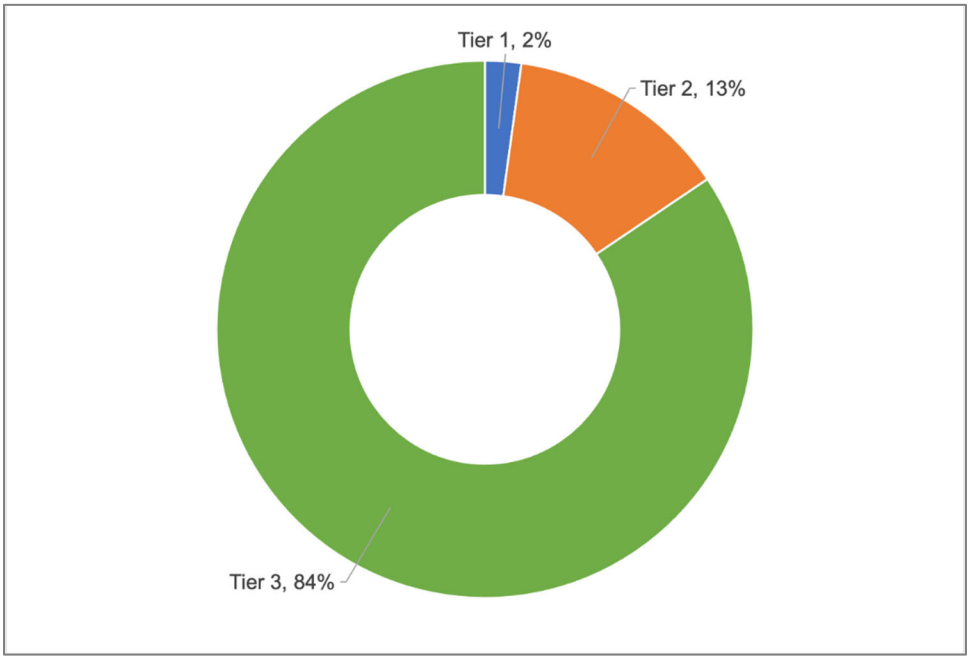
Sources: China City Statistical Yearbook 2021 and author calculations.

Appendix Figure 16. New Road Construction by City Tier



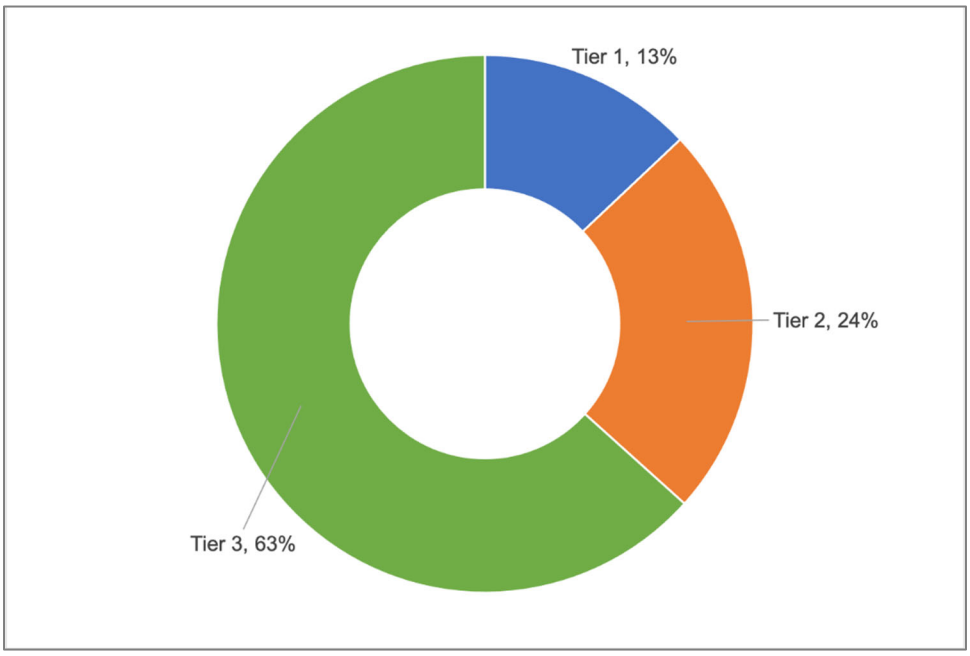
Sources: China City Statistical Yearbook 2021, CEIC, and author calculations.

Appendix Figure 17. Length of Expressways by City Tier



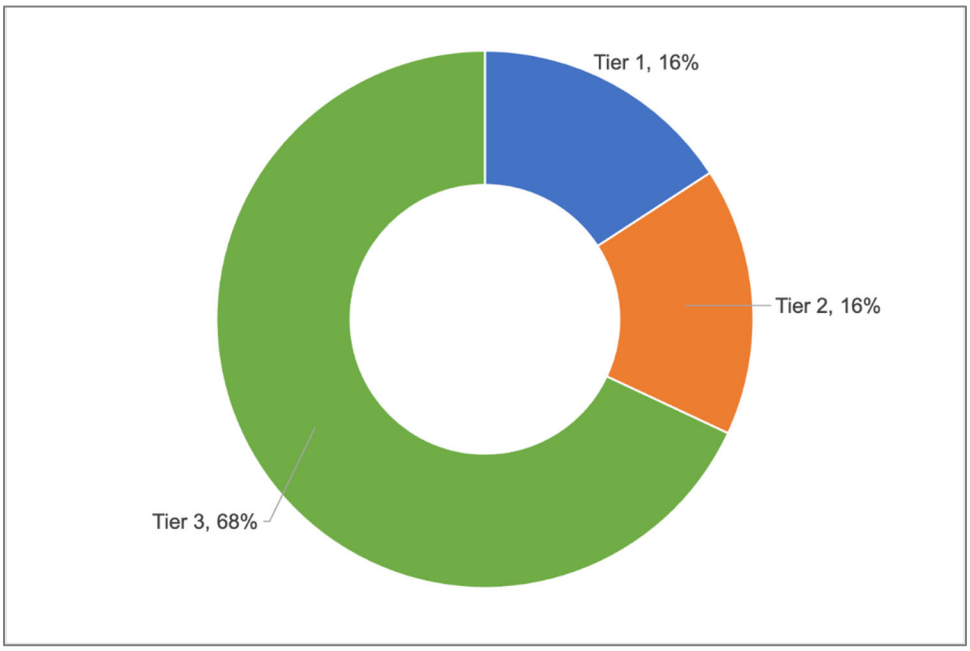
Sources: China City Statistical Yearbook 2021 and author calculations.

Appendix Figure 18. Length of Sewage Pipes by City Tier



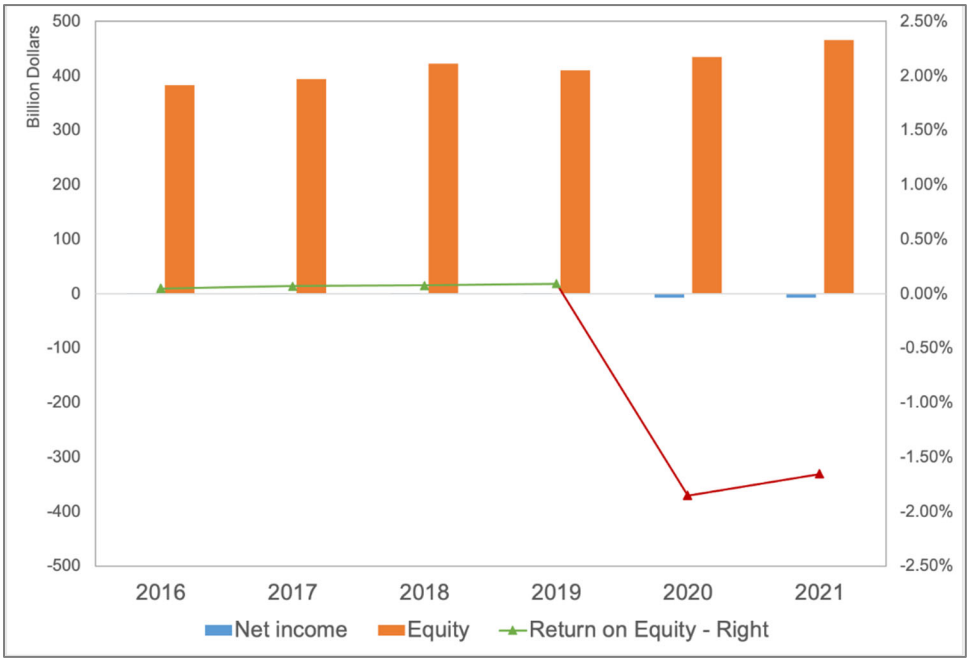
Sources: China City Statistical Yearbook 2021 and author calculations.

Appendix Figure 19. New Sewage Pipe Construction by City Tier



Sources: China City Statistical Yearbook 2021, CEIC, and author calculations.

Appendix Figure 20. Financial Analysis of China State Railway Group



Sources: 2016–21 Financial Statements of the China State Railway