RESERVE BANK
OF AUSTRALIA

Research Discussion Paper

Chinese Urban Residential Construction to 2040

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RDP 2012-04

ISSN 1320-7229 (Print)

ISSN 1448-5109 (Online)

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Research Discussion Paper
2012-04

September 2012

Economic Group
Reserve Bank of Australia

The authors thank colleagues for their input, especially Anthony Rush who was integral to the initial stages of this project, and Stephen Elias for alerting us to the Taiwanese data. Danan Gu and Alan Heston were very helpful when we had queries about the World Urbanization Prospects and Penn World Tables databases. The views in this paper are those of the authors and do not necessarily reflect those of the Reserve Bank of Australia. The authors are solely responsible for any errors.

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Abstract

This paper projects Chinese urban residential construction out to 2040. The paper argues that the extraordinary growth of recent years will not continue, but that construction will stabilise at a high level. This augurs well for steel demand, especially as steel intensity is expected to increase. These projections are subject to upside and downside risks, which are discussed. In addition, this paper argues that official figures understate the extent of urban residential construction.

JEL Classification Numbers: E22, R31

Keywords: China, residential construction

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1. Introduction

In 2011, 1.9 billion square metres of residential floor space was built in China.[1] This volume is more floor space than the entire residential building stock in Australia. The scale of construction is necessary, in part, to house the 20 million annual increase in the urban population. Residential construction is a key driver of Chinese economic growth and, given its use of steel, construction is an important determinant of the demand for iron ore, which is one of Australia's most significant exports.

This paper assesses the medium-term prospects for the Chinese urban residential construction boom, using projections of urbanisation rates, building size and construction quality. Chinese urban residential construction is expected to remain at elevated levels for the next couple of decades, but growth will undoubtedly slow. As the urbanisation process winds down and as improvements in building quality become more incremental, construction is expected to peak in 2017 and fall back below current levels some time around 2030.

This projection is dependent upon a number of assumptions, and we consider the sensitivity of our projections to these assumptions. If urbanisation advances at a slower pace than envisaged, then the peak of residential construction could be close to hand. However, there are upside risks as well. The evolution of floor space per capita is quite uncertain; should this advance at a faster pace than the relatively conservative view in the baseline scenario, the high-growth phase of Chinese residential construction could continue for several more years.

Fundamentally, the construction boom is the result of extraordinary economic growth and urbanisation, which are intertwined in complex ways (Spence, Annez and Buckley 2008). Other countries, for example Korea, have experienced similar,

1 Unless otherwise specified, data in this paper are drawn from CEIC. The 2011 figure includes all construction in rural and urban areas, whereas the most commonly cited figures refer to 'commodity buildings' – which can loosely be defined as housing for sale in the private market – in urban areas.

or even more rapid, increases in the proportion of residents living in urban areas. Yet no country can compare to China in terms of the sheer scale of its urbanisation. China's urbanisation process has other distinct features. The *hukou* system, which determines individuals' residency status and welfare entitlements, limits labour mobility to a degree that could be responsible for a large gap in wages between urban and rural areas (Henderson 2009). There is also evidence suggesting that Chinese cities are undersized compared to some optimal level, suggesting scope for further expansion in city sizes (Fujita *et al* 2004; Au and Henderson 2006). This paper does not take account of these features explicitly in the analysis, but they are likely to have only minor implications relative to the influence of China's overall growth.

Construction requires steel, which in turn requires iron ore, of which Australia is a significant producer. We estimate that residential construction uses about 14 per cent of China's crude steel output. More intense use of steel, due to taller buildings and other amenities such as underground car parks, means that steel use by residential construction will grow at a faster rate than the volume of floor space built. Indeed, we project that steel used in residential construction will peak around 2024, at a level that is 30 per cent higher than in 2011.

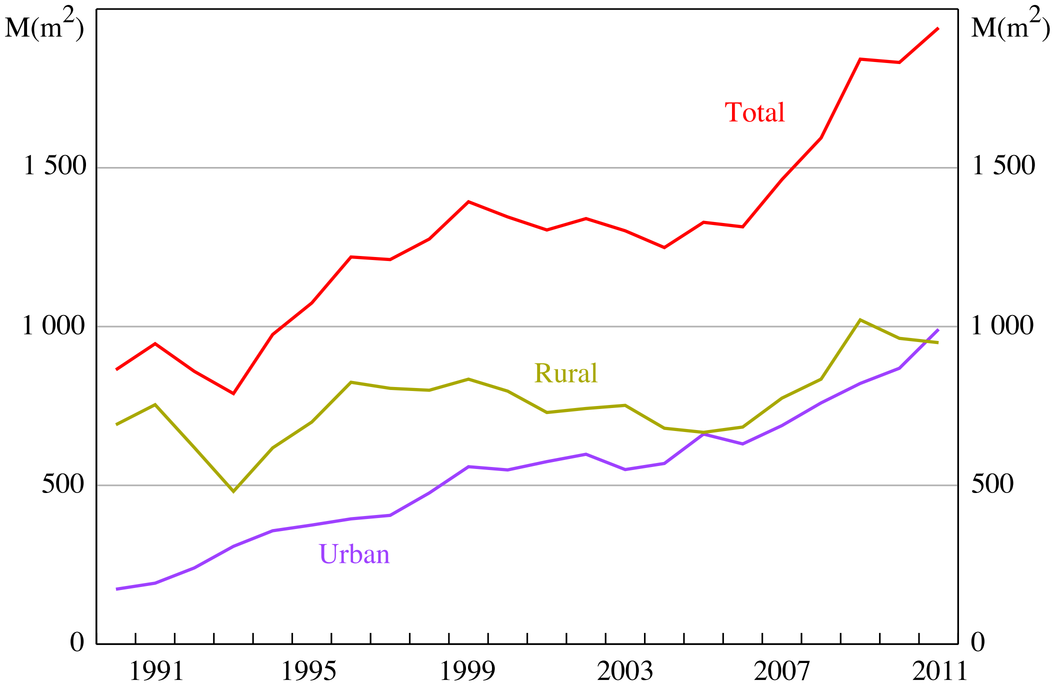
This paper also touches on the structure of the Chinese economy and its evolution. As is well known, Chinese nominal investment as a share of GDP is high. We estimate that the residential construction share of GDP has risen from 5½ per cent in 2004 to 9 per cent in 2011. The extent of this increase is somewhat higher than suggested by the volume of floor space constructed. Quality improvements and higher materials prices could account for this.

The paper progresses as follows. Section 2 discusses past residential construction, and argues that official data understate true urban residential construction. Section 3 outlines the methodology used for our projections, and Section 4 presents those projections. Section 5 discusses the sensitivity analysis and Section 6 concludes.

2. Past Urban Residential Construction

According to official figures, urban residential construction first overtook rural residential construction in 2011 (Figure 1). However, it seems odd that urban construction did not exceed rural construction much earlier than the official statistics suggest. After all, the Chinese urbanisation rate is over 50 per cent, the urban population of China has been increasing by over 2 per cent per year and the rural population has been declining since 1995. We contend that much of the official estimate of rural construction is occurring on land classified as rural during the construction phase that is then reclassified as urban after a critical mass of people move in.

Figure 1: Official Residential Floor Space Completed



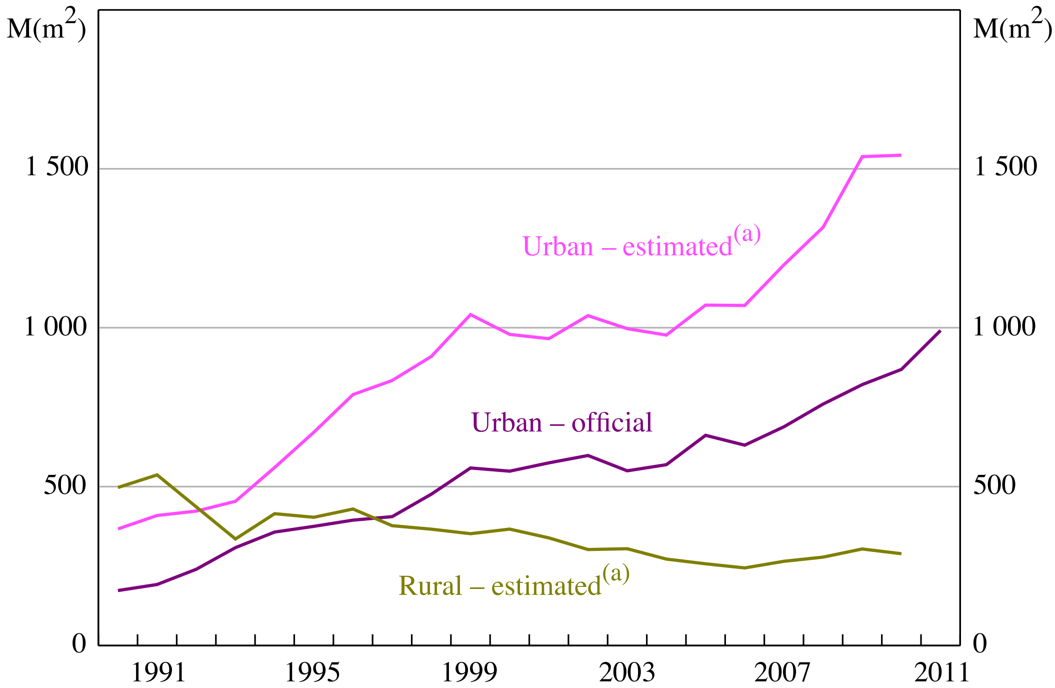
Source: National Bureau of Statistics of China

Other data support this assertion. In 1990, less than one-third of all rural floor space completed had a steel-reinforced concrete structure, but that share has more than doubled over the past 20 years. Since reinforced concrete structures are typically found in high density apartments and are not required for low-rise buildings, it is not likely that this represents construction in a true rural environment. We therefore derive a measure of urban construction that assumes all rural reinforced concrete residential floor space is *de facto* urban construction (Figure 2).[2] This measure overtook estimated rural construction – the officially classified rural construction that did not consist of a reinforced concrete structure – in 1993, which seems more plausible. The estimated measure of urban residential

2 This estimate is provided only up to 2010, when the most recent data on the type of rural construction are available.

construction has grown by an average of 7 per cent per year since 1990 and by 9 per cent per year since 2006. Section 3.5 shows that this profile is consistent with published housing stock data.

Figure 2: Residential Floor Space Completed



Note: (a) Urban floor space completed plus rural floor space completed with construction that uses a 'reinforced concrete structure'; rural is total minus estimated urban

Sources: National Bureau of Statistics of China; authors' calculations

Is this new measure consistent with land classification practices in China? The National Bureau of Statistics of China (NBS) now provides the land classification of all sub-districts in China – areas that could range from an urban block to a small rural village and its hinterland. We studied Hailing County in Jiangsu Province in detail, which has a population of half a million people. The satellite image in Appendix A identifies urban areas in yellow, and rural areas in red. The boundaries are approximate and it is difficult to classify large segments of land. Nonetheless, the exercise shows that there are areas classified as rural that are close to the built-up fringe, so it seems plausible that construction in areas of this kind could explain the large amount of construction that is classified as 'rural' but uses reinforced concrete. These areas presumably would be reclassified as urban once population levels reached some threshold. Moreover, we contend that when new cities are built over razed rural villages, the construction is also classified as rural in the official statistics until the city is inhabited.

3. Methodology and Components

To better understand the prospects for urban residential construction, this section of the paper attempts to model the construction process.

3.1 Methodology

To begin, we note that urban construction is the change in the stock of urban residential floor space plus demolitions:[3]

$$\begin{aligned} Construction_t &= Floor\ Space\ Stock_t - Floor\ Space\ Stock_{t-1} \\ &\quad + Demolitions_t \end{aligned} \tag{1}$$

The stock of urban floor space is the product of urban residential floor space per capita and urban population:

$$Floor\ Space\ Stock_t = Urban\ Population_t \times Floor\ Space\ per\ Capita_t \tag{2}$$

Therefore, the path of construction is determined by the following factors:

- urban population;
- floor space per capita; and
- demolitions.

Each of these factors is considered below.

3.2 Urban Population

The Chinese urbanisation rate has been rising rapidly over the past two decades and we expect it to continue to do so for some time (Figure 3). In 1990, just over one quarter of the Chinese population lived in urban areas, today over a half do. Large flows of rural immigrants to urban areas and large scale land

3 Demolitions are broadly defined as any floor space that is destroyed, whether it be through intent or neglect.

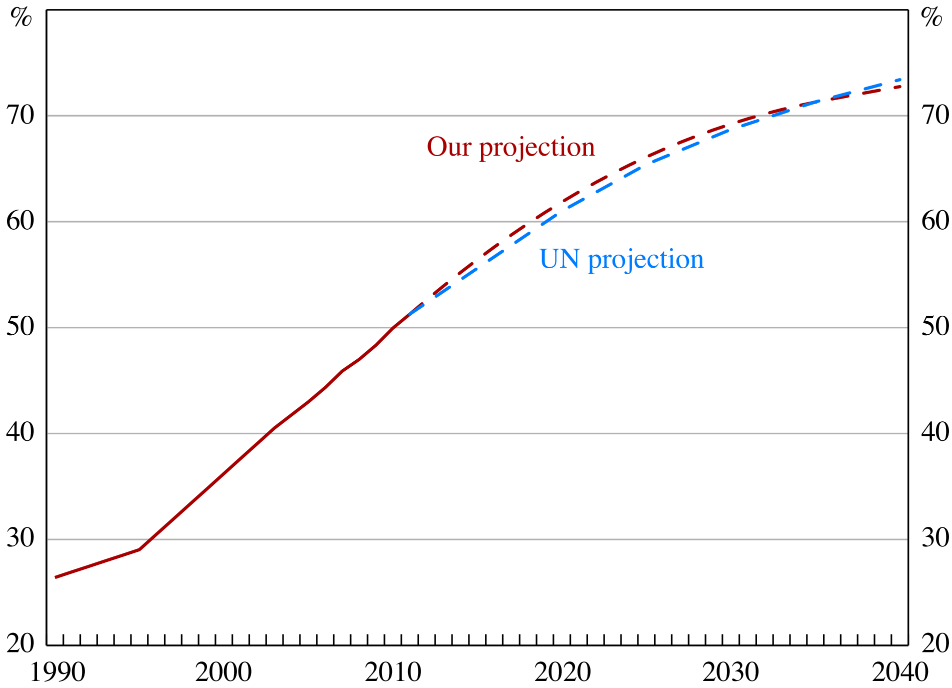
reclassification have driven this trend (Woeztel *et al* 2009; Henderson 2011). Our urban population projections are calculated using a similar methodology to the United Nations' (UN) World Urbanization Prospects and, as Figure 3 shows, the the projections are close to the UN's.[4] We project an urbanisation rate of almost 70 per cent by 2030 and around 73 per cent by 2040.

Our projected path is not unprecedented. Figure 4 shows the urbanisation path followed by Korea, Japan and China. All paths are centred at the point where the urbanisation rate reached 50 per cent, the date of which is indicated in parentheses for each country. Korea experienced an even more rapid urbanisation than we are projecting for China. Japan's was slower, but not significantly so; 10 years after reaching 50 per cent, Japan's urbanisation rate stood at 58 per cent, while we are projecting that China's urbanisation rate will reach 62 per cent at a similar point. Moreover, Japan's urbanisation rate was increasing at a much slower pace than China's as it approached 50 per cent.

Aside from the UN, other institutions have also made projections of China's urbanisation rate for 2030. Table 1 shows some of these estimates, which vary substantially, and the assumptions behind the differences are not entirely clear. Our projections are in line with the median projection.

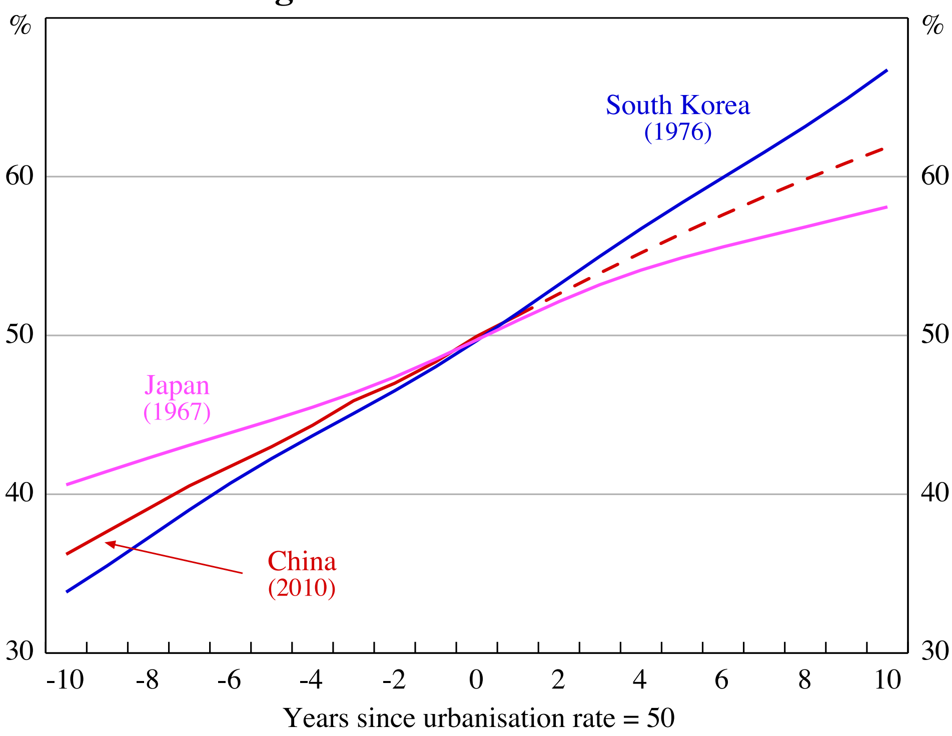
4 World Urbanization Prospects is available at http://esa.un.org/unpd/wup/index.htm. Like the UN, we project the ratio of the urban to rural population using the weighted sum of two growth rates. The first growth rate is the growth of the ratio of the urban to rural population over the recent past (rur_{past}). The second growth rate is a 'hypothetical' growth rate ($hrur_t$) calculated on the basis of cross-country regressions in United Nations (2012) and follows $hrur_t = 0.033 - 0.025PU_t$, where PU is the proportion of the urban population in the total. The UN keeps $hrur$ constant at its current value, i.e. $hrur_t = hrur_{2011}$ for $t > 2011$, whereas we allow $hrur_t$ to change over time with the urbanisation rate. The weighted average of the growth rate follows $rur_t = W_t rur_{past} + (1 - W_t)hrur_t$ where $W_t = 1$ for the first year of the projection. W_t then declines linearly by 0.04 each year until $W_t = 0$, from which point it is constant. Our projections start from the the most recent NBS statistics and begin with $rur_{past} = 0.055$ and $hrur_{2011} = 0.019$. rur_{past} is calculated from 2005 to 2011 and $PU_{2011} = 0.51$.

Figure 3: Urbanisation Rate



Sources: United Nations; authors' calculations

Figure 4: Urbanisation Paths



Sources: United Nations; authors' calculations

Table 1: Urbanisation Projections for 2030
Share of population living in urban regions – per cent

CASS	CSMC	UN	Berkelmans and Wang	REICO	CCIEE	DRC
65	65	69	69	70	70	80

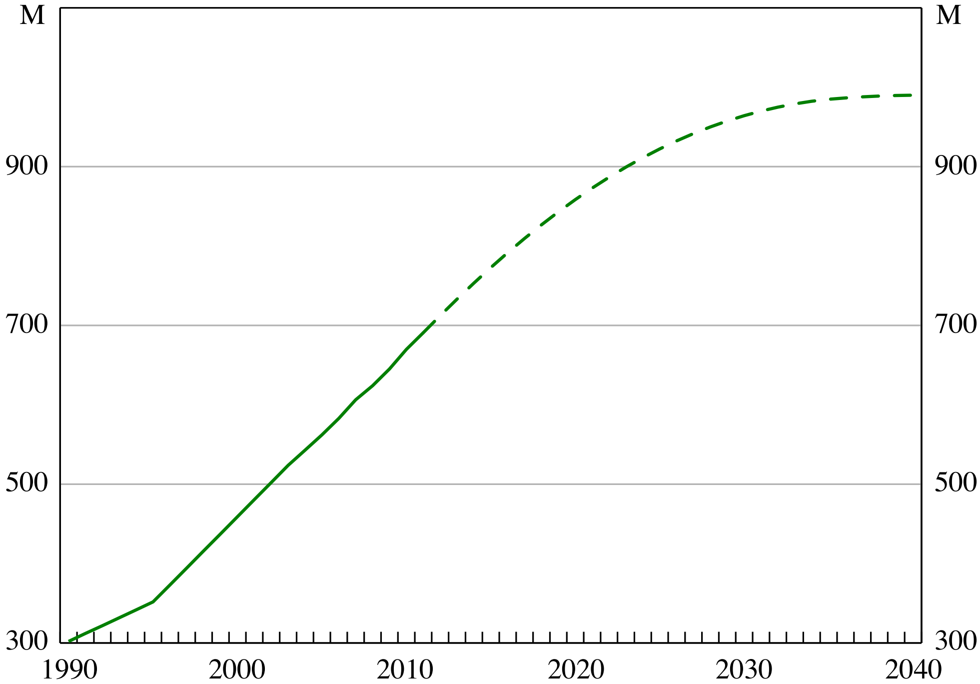
Sources: China Academy of Social Sciences (CASS); China Center for International Economic Exchanges (CCIEE); China Small Medium Cities (CSMC); Development Research Center of the State Council (DRC); REICO Studio (REICO); United Nations (UN); authors' calculations

There are fundamental reasons for the relatively rapid increase in the urbanisation rate. The wage gap between rural and urban areas is large, which should attract workers to cities (Harris and Todaro 1970; Henderson 2009). Also, the Chinese rural population is relatively well educated given China's stage of development, which may increase their mobility (Henderson 2009). While the *hukou* system acts as a barrier to migrant flows, the system has evolved gradually over recent years and further reform bodes well for improving population mobility.

We calculate the urban population path using the projections for the urbanisation rate along with 'medium variant' population projections from the UN's World Population Prospects database (Figure 5).[5] Accordingly, we project the urban population will reach almost one billion by 2030 from its current level of 691 million, and then stabilise. Our projected rate of increase gradually recedes over the projection horizon: compared to the current 20 million annual increase in urban population, the rate of increase is projected to fall to 7½ million per year by 2030 and to just over 1 million per year by 2040.

5 World Population Prospects can be found at http://esa.un.org/unpd/wpp/index.htm. This database provides data at 5-year intervals, and we generate annual data using a cubic spline interpolation.

Figure 5: Urban Population Projection



Sources: CEIC; United Nations; authors' calculations

3.3 Floor Space per Capita

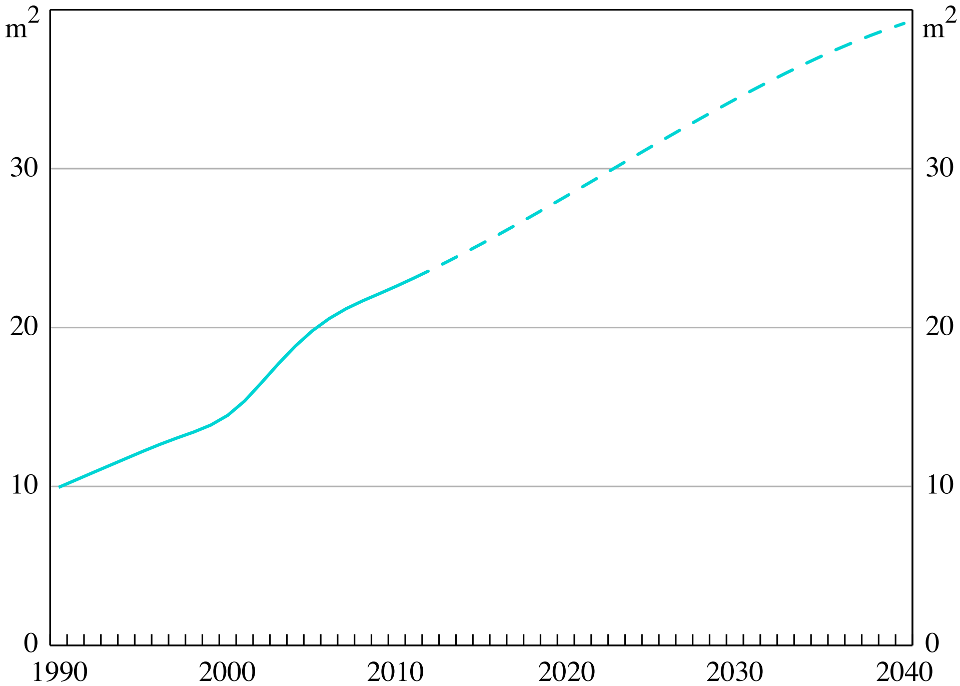
When considering Chinese urban per capita residential floor space, we use data from the NBS *China Statistical Yearbooks*. However, we believe the official figures overstate the actual urban floor space per capita as they are calculated using an understated population base. Instead of using actual urban population as the denominator, the official data appear to be calculated by dividing the total residential housing stock by the non-agricultural *hukou* population, which does not account for the migrants from rural areas who still hold an agricultural *hukou* (Beijing Municipal Bureau of Statistics 2006).[6] We correct for this by multiplying the original data by the ratio of the non-agricultural *hukou* population to actual urban population.[7] Floor space per capita data prior to 2002 are not published

6 Also, the reported increments to per capita floor space in Table 10-36 of the 2011 *China Statistical Yearbook* are more closely aligned with the construction numbers in Table 10-35 divided by the *hukou* population rather than the actual population.

7 All data are from the NBS. *Hukou* data are only available for 1990 and after 1997. We therefore omit data before 1990 and the urban *hukou* population is linearly interpolated between 1990 and 1997.

in the latest *Yearbook*, but these data are available in earlier *Yearbooks*. The data exhibit a large jump in 2002, which suggests that there is a break in the series. But because the pre-2002 data carry information, we do not discard them. Instead, we smooth the full dataset using a Hodrick-Prescott filter with a parameter of 6.25 to extract the trend, which delivers the historical path shown in Figure 6. The aim of extracting the trend is to obtain a realistic path that reflects the data, but smooths through any aberrant movements.

Figure 6: Floor Space per Capita Projection



Sources: CEIC; authors' calculations

We base our projections of floor space per capita on estimated international relationships between income and residential floor space. While the regressions generally focus on total floor space per capita rather than urban floor space per capita, they are nonetheless informative; the regressions generally cover highly urbanised countries, so the overall relationship is a reasonable proxy for the urban relationship in the datasets. Like Isaac and van Vuuren (2009), we find the following equation generally fits the data better than a linear alternative.

$$Floor\ Space\ per\ Capita_t = \alpha + \beta \ln(Real\ Income\ per\ Capita_t) + \varepsilon_t \qquad (3)$$

We estimate this equation on three datasets. First, we use Taiwanese regional panel data from Directorate-General of Budget, Accounting and Statistics (2011). The original income data are nominal and so we deflate income by the consumer price index to obtain real income.[8]

The second dataset consists of international panel data. The floor space data are sourced from International Energy Agency (2004) and GDP per capita data are sourced from the Penn World Tables, version 7.0.[9] These floor space data cover 13 industrialised countries from 1973 to 1998.[10] While a linear regression fits the IEA data better, we still use Equation 3 to be consistent with the models estimated using other data.

Finally, we also estimate Equation 3 on Chinese nationwide floor space data from 1990 to 2010. GDP per capita numbers are once again taken from the Penn World Tables.

The estimated value of the income coefficient, β, ranges from 6.6 to 25.7 (Table 2). The panel data give lower coefficients when controlling for fixed – regional or country effects – and year effects.[11] This might be because technology improvements – which would allow more floor space to be constructed for given inputs – are picked up by the income variable when year effects are omitted. Despite this, the Chinese coefficients, which are estimated without year effects, are lower than other estimates, especially in recent years. *Prima facie*, this could be due to the type of accommodation rural migrants inhabit and the increased share of floor space they occupy. Small dormitories for workers are a common image associated with those who move from the countryside. However, this issue

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8 The Taiwanese GDP deflator has been declining for a number of years, reflecting falling export prices. As exports are not purchased by households, using this deflator is arguably a misleading basis for our real income calculations.

9 As mentioned in Isaac and van Vuuren (2009), International Energy Agency (2007) contains more recent data that ‘due to changes in the methodology are not consistent with data from the earlier publication’. From the Penn World Tables, we use the ‘rgdpl2’ measure of PPP-adjusted GDP per capita, which is the ‘new, preferred growth rate series’ (Heston, Summers and Aten 2011).

10 The countries are Australia, Canada, Denmark, Finland, France, Germany, West Germany, Italy, Japan, Norway, Sweden, the United Kingdom and the United States. Germany and West Germany have separate fixed effects.

11 All our estimates of β are larger than the estimate of 6.3 from Isaac and van Vuuren (2009).

may not be a significant concern, as less than 25 per cent of migrants live on construction and manufacturing sites (National Population and Family Planning Commission of China 2011; NBS 2012). Alternatively, it may be that the supply of housing in China is not adjusting to income in the 'usual' way, given the rapid growth in income. If floor space per capita were to have increased according to the long-run estimated relationship, then residential construction as a share of GDP would be above its current high level. The lower income coefficient estimated may also reflect an increase in the cost of building materials, which may have held back the rate of construction during this period.

Table 2: Regressions of Floor Space per Capita on $\ln(y)$[(a)]

Data	Taiwan	Taiwan	IEA	IEA	China	China
β	19.3	9.2	25.7	13.6	9.2	6.6
Fixed effects	Y	Y	Y	Y	na	na
Year effects	N	Y	N	Y	na	na
Data range	1998–2010	1998–2010	1973–1998	1973–1998	1990–2010	2003–2010
Within R^2	0.07	0.05	0.93	0.19	0.97	0.94

Note: (a) For Taiwan y is our measure of real household income, for IEA and Chinese data, y is real GDP per capita.

To be consistent with the Chinese historical experience, and also within the range found in other contexts, we choose a conservative value of 10 for China's long-run income coefficient. This choice suggests that a one per cent increase in real income, on average, would lead to a 0.1 square metre increase in urban floor space per capita. However, this value is larger than the coefficient estimated using more recent data, i.e. 6.6, so a projection of China's floor space per capita based on the value of 10 would induce a large immediate level shift in urban residential construction. To avoid this, we project floor space per capita in the following way. First, we assume floor space per capita increases in line with our long-run income coefficient of 10 by the end of the projection period.[12] Second, we interpolate all years from the present to the end of the projection period using a cubic spline, which ensures that there is no large change in the rate at which floor space per capita increases. This implies an income coefficient below 10 in the short-run that subsequently goes above 10 to allow catch-up to the estimated long-run level by the end of the projection period. Alternative assumptions for this coefficient are considered in the sensitivity analysis below.

12 This projection is used for both 2039 and 2040. This is to ensure, within the spline framework, that the slope at the end of the projection is consistent with the slope of the long-run path.

To complete the projection of floor space per capita, we base our projection of per capita GDP growth on GDP projections from World Bank and Development Research Center (2012) and the UN population projections discussed in Section 3.2. This projection gives an annual GDP per capita growth rate that gradually falls from 9.1 per cent in 2011 to 3.6 per cent in 2040. This implies a level of PPP-adjusted GDP per capita of a touch over US$40 000 at 2005 prices by 2040.[13] The resulting projection for floor space per capita increases from 22.6 square metres per capita in 2010 to almost 40 square metres per capita in 2040 (Figure 6).

3.4 Demolitions

Between 2008 and 2010, around 1.8 billion square metres of floor space was demolished to reduce the number of dilapidated buildings in China (State-Owned Assets Supervision and Administration Commission of the State Council 2011). These demolitions imply an annual demolition rate of at least 4½ per cent, based on our estimates of the stock of floor space.[14]

It is unlikely, however, that China will sustain such a high demolition rate, because the stock of dilapidated residential buildings will gradually decline. As these buildings are replaced with higher-quality construction, the average life-span of a building will increase. Also, the legal system has moved to enforce property rights for citizens, which will add cost to the expropriation process and reduce the rate of demolition. Hence, we assume the demolition rate will gradually fall to 3 per cent by 2020 and to 2 per cent by 2030 (Figure 7). The 2 per cent demolition rate is in line with the depreciation rate from the Chinese national accounts, which implies an average building life span of 50 years (Lardy 2012). The depreciation profile is smoothed using a cubic spline interpolation.

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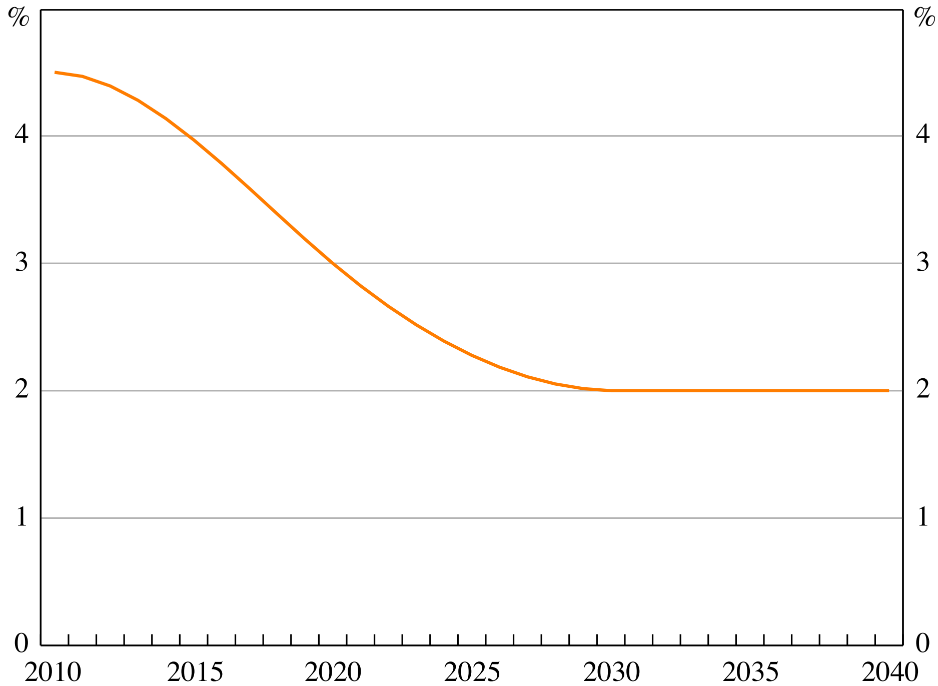
13 The current level of GDP per capita, which is used as the base, is taken from the Penn World Tables. A cubic spline is used to extrapolate growth from 2030, the final projection year for World Bank and Development Research Center (2012), to 2040.

14 These demolished buildings arose from relocation, so they were arguably predominately in urban areas, making way for improved facilities.

Figure 7: Urban Residential Building Demolition Rate



Source: authors' calculations

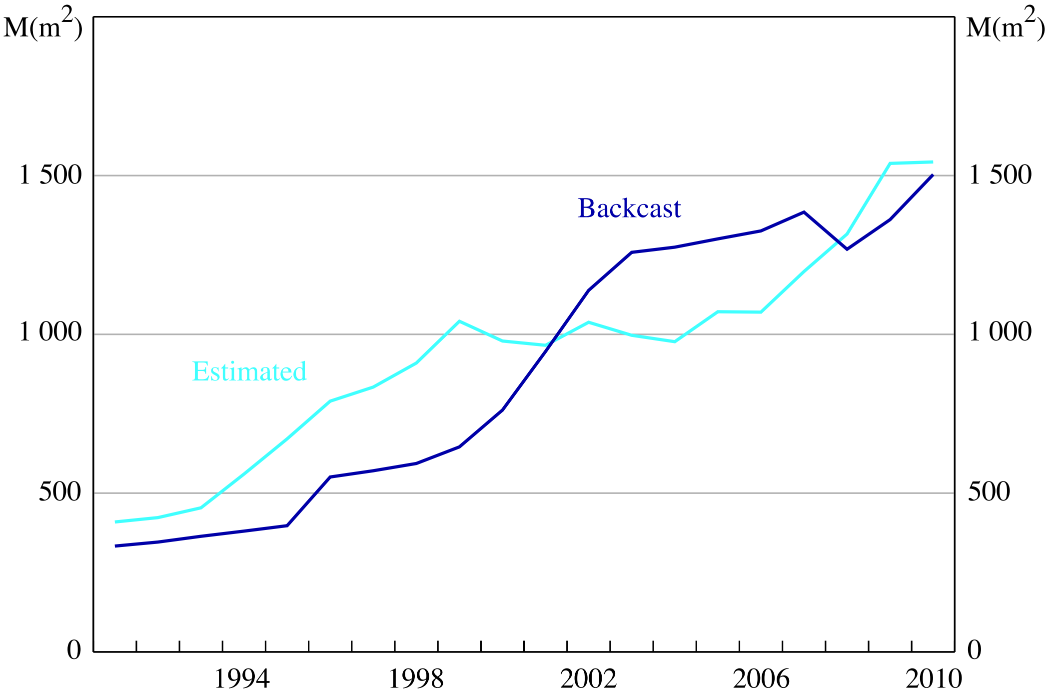
3.5 Backcast Testing the Validity of Our Approach

We can gauge the validity of our approach by comparing two series. The first is the estimated history of urban residential construction from Section 2. The second series is a backcast using the modelling approach described in Section 3.1 and applying it to actual data for each of the various components in Equations (1), (2) and (3).[15] Figure 8 shows that, despite the different methodologies and data sources, the paths are quite similar. Both series suggest that about 1.5 billion square metres of urban residential floor space was constructed in 2010 from a level of about 400 million square metres in 1991. Integrating over the 20 year period leads to approximately the same cumulative floor space construction. The alignment of these series supports our hypothesis about the reclassification of land from rural to urban discussed in Section 2, namely that rural reinforced concrete floor space should be treated as urban floor space. The two series do appear to have different cyclical properties, but there could be many reasons for this. For example, the stock of floor space per capita would depend upon the timing of

15 Demolitions are assumed to start at 3 per cent of the housing stock in 1990 and are interpolated using a cubic spline.

land reclassification, which would affect our backcast series, but not our estimated series.

Figure 8: Urban Residential Construction



Sources: CEIC; National Bureau of Statistics of China; authors' calculations

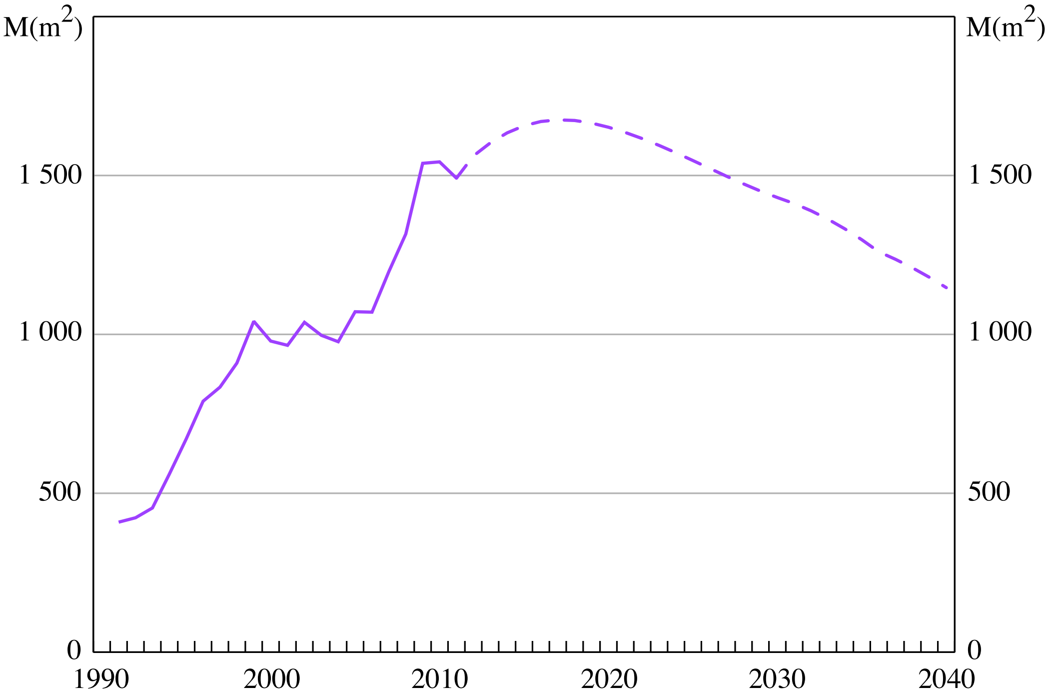
4. Projections

Turning to the future, our methods suggest that the level of urban residential construction is projected to peak in 2017 at a level almost 12 per cent higher than 2011 levels (Figure 9).[16] This marks a moderation of the strong growth we have seen over the past few years. Nonetheless, the outlook is positive. Chinese urban residential construction is expected to stabilise at a high level, and to remain above current levels for almost 20 years. Further out, urban residential construction is projected to taper off slowly.

An alternative projection is offered in Woetzel *et al* (2009), where much stronger growth is forecast. We project lower growth rates partly due to our higher starting point, arising from our conjectures in Section 2. Nonetheless, our projected volumes remain above those in Woetzel *et al* because we project faster growth

16 Even though the line in Figure 9 is solid up to 2011, the 2011 figure is, in effect, a projection because the data are not yet available to allow us to derive our estimated measure.

Figure 9: Urban Residential Construction



Sources: CEIC; authors' calculations

in floor space per capita. Hu *et al* (2010) also provide projections; our projections are higher than theirs, which appears to be due in part to their assumption of lower rates of demolition.

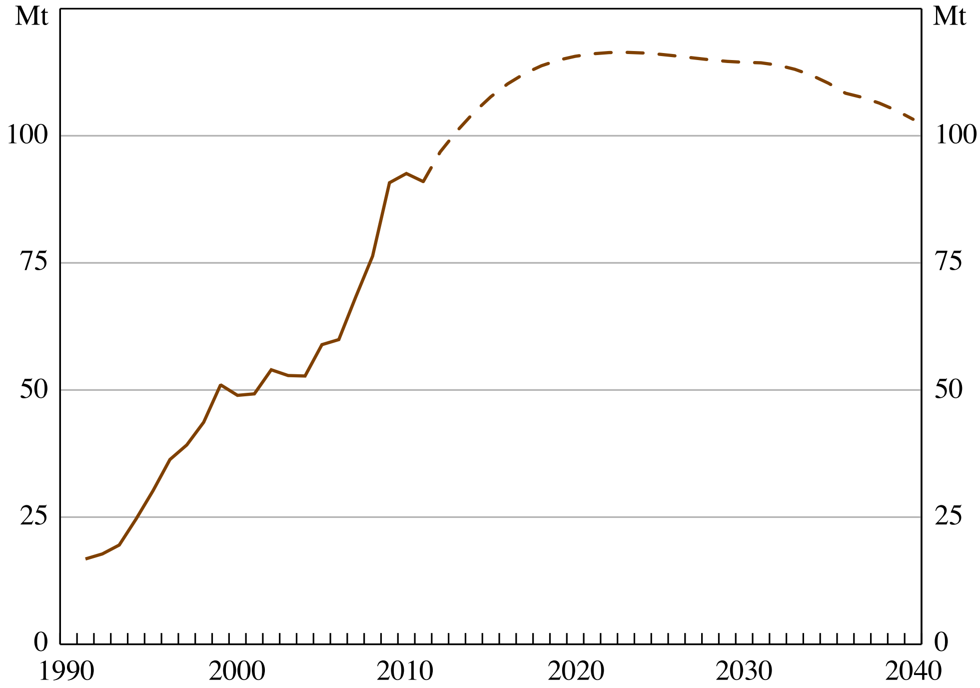
We now turn to consider the implications of our projections of urban residential construction for steel demand and the structure of the Chinese economy.

4.1 Steel

Steel intensity is defined as the weight of steel used per square metre of floor space constructed. In this paper, we do not account for steel found in internal furnishing and appliances, such as refrigerators. Average steel intensity in construction depends upon a range of factors. For example, while most modern apartments are constructed with reinforced concrete, steel intensity can vary based on the building's design and legislation requires a higher steel content for buildings in earthquake-prone regions. A key consideration is that steel input varies with the height of the building. Estimates by Walsh (2011) suggest low-rise apartment construction requires, on average, around 40–50 kg of steel per square metre of floor space, whereas around 60–100 kg of steel per square metre is required for a 30-storey building. Basements also increase a building's average steel intensity substantially.

We begin by assuming that the average steel intensity for newly constructed apartments in China was 60 kg per square metre in 2010. This is in line with Woetzel *et al* (2009, p 373) and Walsh (2011). Given that approximately 1.54 billion square metres of residential floor space was constructed with reinforced concrete in 2010, this implies steel use of about 93 million tonnes – about 14 per cent of China's 2010 crude steel production (Figure 10). Some estimates suggest that total building construction – i.e. residential and non-residential – accounts for about 30 per cent of steel use (KPMG China 2011; Wu 2009). This appears to be consistent with Chinese residential building accounting for about 60 per cent of construction as commercial building should be more steel intensive than residential construction.

Figure 10: Projection of Steel Use from Urban Residential Construction



Sources: CEIC; authors' calculations

We also assume that average steel intensity for newly constructed apartment buildings will increase linearly by 1 kg per square metre per year to reflect improved quality and higher buildings.[17] Moreover, the projected increase in

17 This is consistent with the rate of increase in Hu *et al* (2010).

incomes is likely to see higher car ownership and demand for underground car parking, which suggests that this is a conservative assumption. If this rate of increase is assumed over the course of the past few years, 19 per cent of steel production for 2004 would have been used in residential construction, which is identical to the share estimated by Hu *et al* (2010).

Under these assumptions, and our earlier projections for residential construction, steel use in residential construction is likely to continue to grow rapidly for a few more years. Beyond the middle of this decade, growth is projected to moderate, with steel use reaching its peak in 2023, at a level that is 30 per cent higher than consumption in 2011.

4.2 Implications for the Structure of the Economy

Since 2004 residential construction has increased rapidly as a share of GDP (Figure 11).[18] We estimate the current share to be around 9 per cent of GDP, which is high by international standards. Australia's share is 5 per cent and, at the peak of the building boom around 2005, the share in the United States reached over 6 per cent.[19]

From 2004 to 2011, China's real GDP more than doubled. Annual floor space completed, which includes both rural and urban buildings, increased by only 41 per cent. Our measure of urban construction increased by 57 per cent. If relative prices remained constant, then these growth rates imply that dwelling investment would have accounted for a declining share of nominal GDP. However, relative price changes, perhaps indicative of quality improvements or changes in the price

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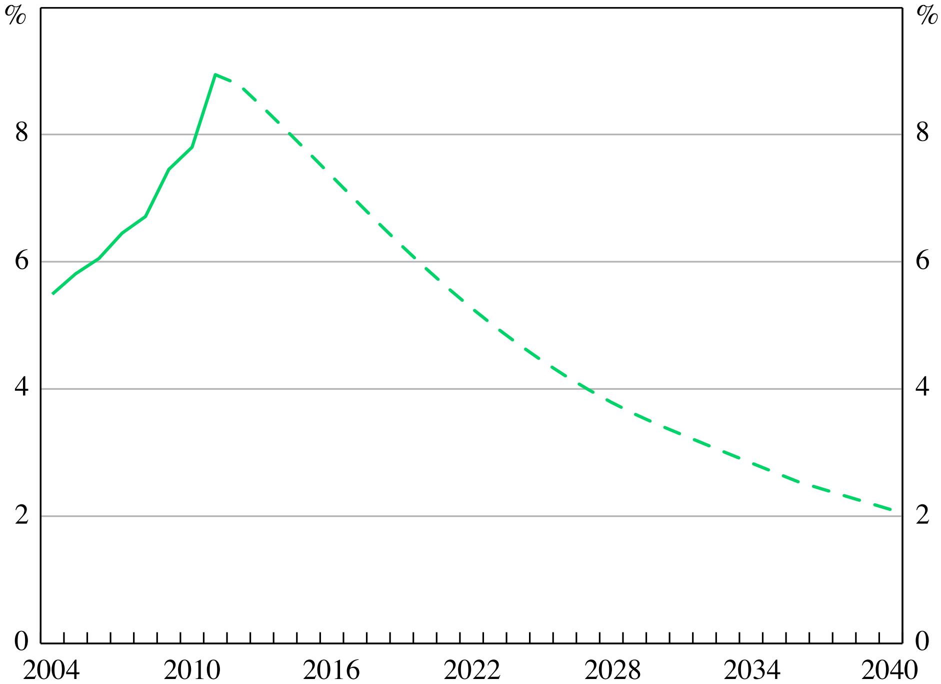
18 To calculate this share, we first deduct land investment (CEIC DX Identifier: CRKARPN) from real estate investment (CEIC DX Identifier: CECA), and then multiply this value by the share of residential building (CEIC DX Identifier: CECAA) in real estate investment, to get an approximate series for residential building investment less land. Because fixed asset investment (FAI) data better represent what is calculated in the national accounts, we multiply our approximate series by the ratio of residential building FAI (CEIC DX Identifier: COBDJW) to residential building investment. We then divide the resultant series by nominal GDP to get the share in Figure 11.

19 Australian figures are for total dwelling investment, which include alterations and additions: Australian Bureau of Statistics Cat No 5204.0, Table 2. Figures for the United States are from the Bureau of Economic Activity.

Figure 11: Share of Residential Construction in GDP



Sources: CEIC; authors' calculations

of materials, are likely to have been important.[20] Steel intensity is arguably a good proxy for quality improvements, in which case overall growth in steel use reflects growth in real construction. The estimated steel use in residential construction grew by over 70 per cent from 2004 to 2011. While this increase is not enough to account for the rising share of GDP if all other relative prices remained constant, it is an improvement upon the raw floor space numbers. On the basis that other factors that may have previously affected the share – for example, increasing materials prices – are not sustained, but that quality improvements continue, the share of residential construction will begin to fall over the projection horizon, but not rapidly (Figure 11). We project residential construction's share to decline to 6 per cent in 2020, and by 2040 it will be down to around 2 per cent of GDP.

20 Another potential explanation is that there has been a bulge of construction that is yet to be completed, which would affect GDP calculations but would not yet show up in completion numbers. However, this seems unlikely to be the full explanation given that it typically takes one to two years for a large building to be built in the United States, and possibly less time in China (US Census Bureau 2012).

5. Sensitivity Analysis

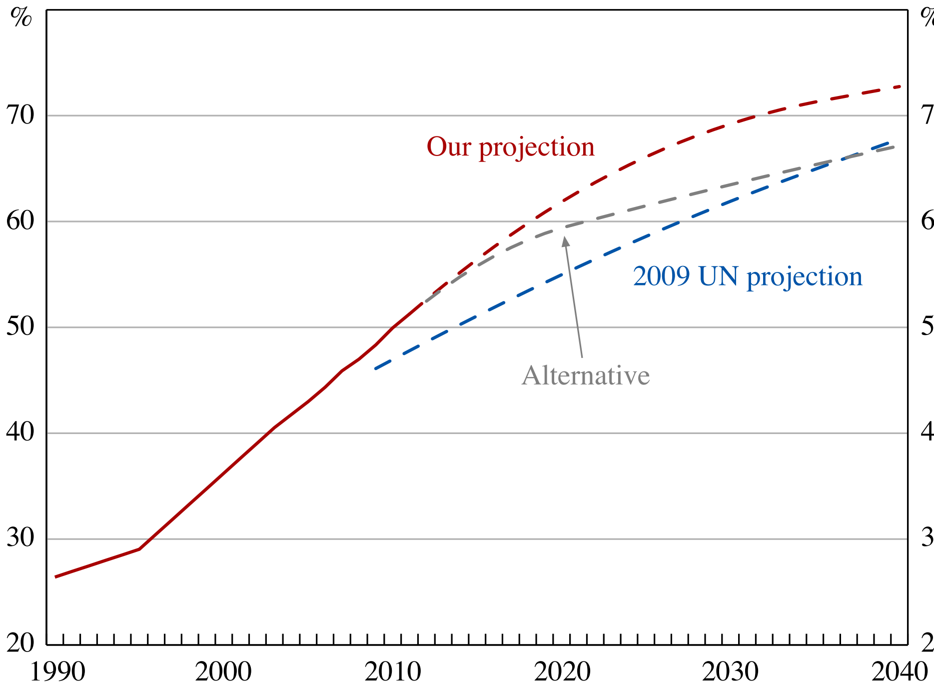
This section evaluates the sensitivity of the baseline projection for urban residential construction to different assumptions. We evaluate these assumptions in isolation, but it is certainly possible that they could be correlated. For example, a more rapid increase in the urbanisation rate than projected may be accompanied by higher than projected GDP growth. The implications of these different assumptions for steel use are presented in Appendix B.

5.1 Urbanisation Assumptions

While our urbanisation projections are close to the current UN projections, they differ substantially to the projections the UN offered in 2009 (Figure 12). This difference primarily reflects data updates over the past two years, which have shown an unexpectedly strong increase in the urbanisation rate. Under the UN methodology this recent rapid growth has a persistent effect, so that the gap between the two projections reaches 7½ percentage points by 2025. There is some chance that the recent data are anomalous, and that the UN's 2009 extended projections better capture the prospects for urbanisation. Therefore, we consider an alternative where the urbanisation rate approaches the UN's 2009 numbers by 2040.[21] Under this alternative path, floor space construction does not exhibit any appreciable growth from here on in and it begins to fall in 2014 (Figure 13). The downward trajectory arises because the growth of the urban population slows rapidly.

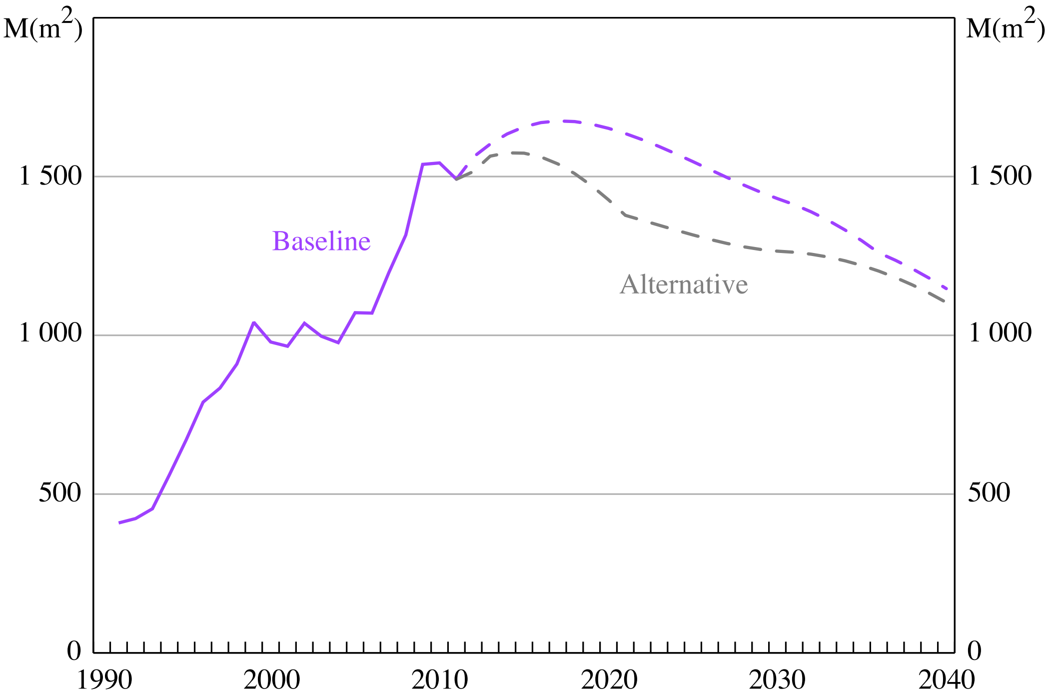
21 To do this, we assume that the rapid growth over the past 2 years only influences the projection for the next 10 years rather than the next 25 as specified in footnote 4, i.e. W_t declines by 0.1 each year rather than by 0.04.

Figure 12: Alternative Urbanisation Path



Sources: CEIC; authors' calculations

Figure 13: Urban Residential Construction under Alternative Urbanisation Path



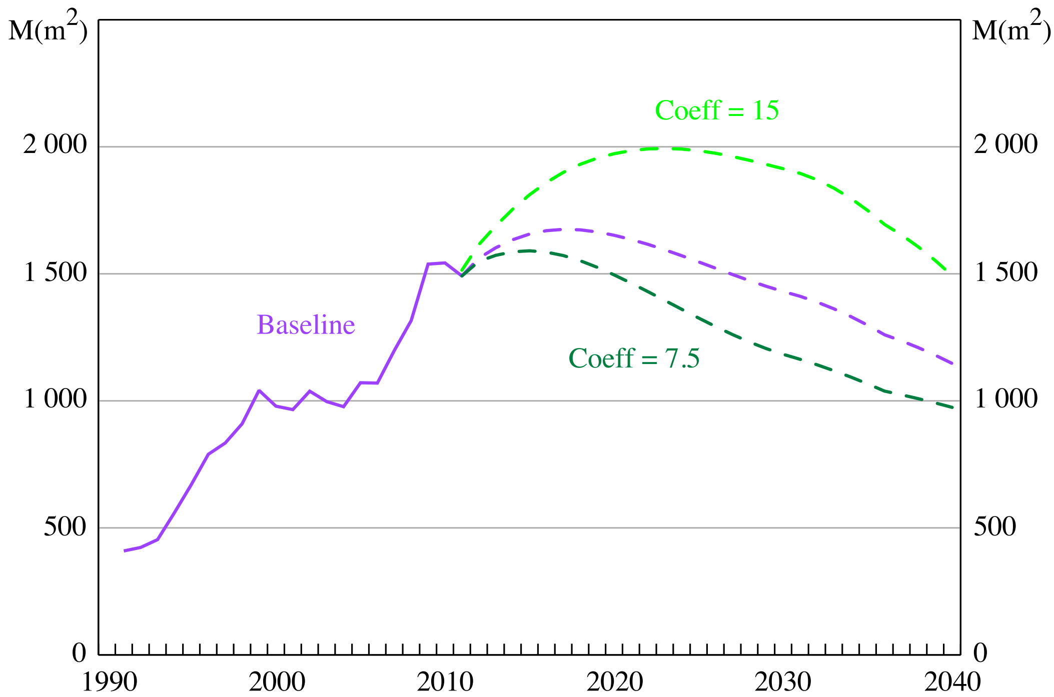
Sources: CEIC; authors' calculations

5.2 Floor Space per Capita Assumptions

The estimates of the relationship between floor space per capita and income are imprecise. We consider a higher and lower alternative. On the upside we impose a coefficient of 15 on the log of GDP per capita in its long-run relationship with floor space per capita, as opposed to 10 in the baseline. This is at the lower end of the coefficients found from IEA data, but at the upper end of those found from the Taiwanese data (Table 2). We use a coefficient of 7.5 as a downside alternative, which is closer to the relationship found in China after 2003.

The resulting paths tell quite different stories (Figure 14). The upside projection sees the growth of the past decade taper off quite slowly, with construction peaking in 2023, 30 per cent above the recent levels. Alternatively, if floor space is less responsive to income, construction remains roughly flat for the next five years before declining.

Figure 14: Urban Residential Construction under Alternative Floor Space Assumptions



Sources: CEIC; authors' calculations

5.3 GDP Growth Assumptions

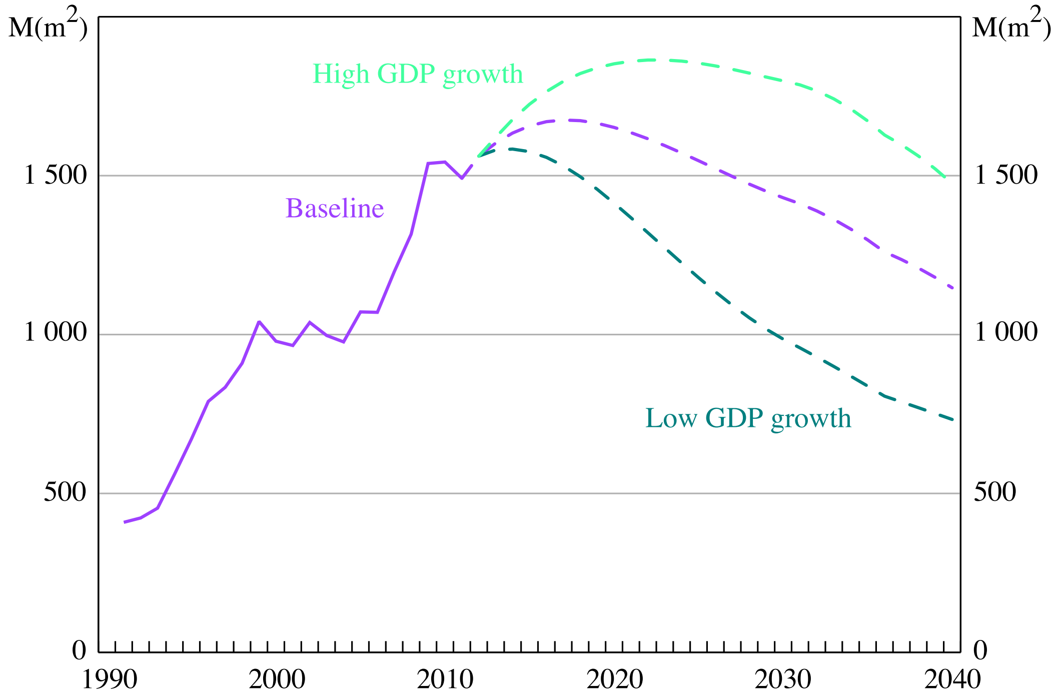
Given uncertainty about China's trend rate of growth, we consider two possibilities: a high-growth and a low-growth alternative.

- First we assume that the Chinese GDP per capita grows at 8 per cent per annum for the next 20 years, rather than around 6 per cent in the baseline. Lin (2011) suggests that China has the potential to do so considering China's stage of development relative to that of the United States, and the growth performance of Japan, Taiwan and Korea when they were at a similar stage of development. In this case we project that China's growth rate will follow the same deceleration after 2032 as the growth rate from World Bank and Development Research Center (World Bank and Development Research Center of the State Council, the People's Republic of China) (2012). Accordingly, China's PPP-adjusted GDP per capita reaches almost US$80 000 by 2040 (at 2005 prices), compared to around US$40 000 in the baseline projection.
- In the low-growth alternative we assume that GDP per capita growth is 2.7 percentage points lower than the baseline growth rate. This difference is equivalent to one standard deviation of the distribution of growth rates experienced in China between 2000 and 2009.[22] In this case, China's PPP-adjusted GDP per capita reaches US$20 000 by 2040 (at 2005 prices).

Under the high-growth assumption, floor space construction peaks in 2023, 25 per cent above recent levels, and remains above current levels for all but the last couple of years of the projection period (Figure 15). Under the low-growth assumption, construction is effectively at its peak now and will be almost 40 per cent below the baseline by the end of the projection period.

22 This standard deviation is calculated from growth rates from the Penn World Tables.

Figure 15: Urban Residential Construction under Alternative GDP Assumptions



Sources: CEIC; authors' calculations

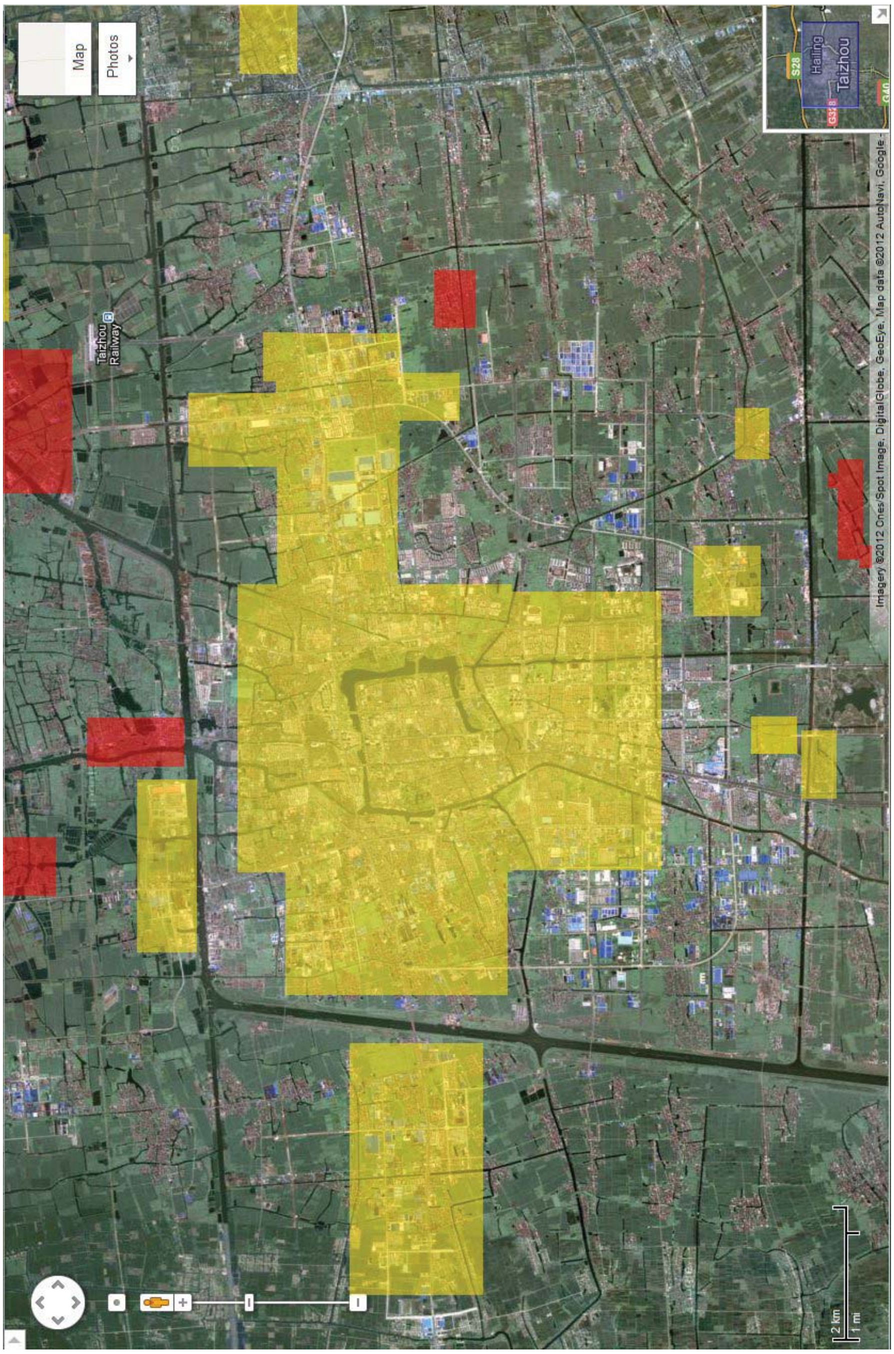
6. Conclusion

The medium- to long-term outlook for residential construction remains relatively strong in China. While growth in urban residential construction is expected to slow, the level of construction is nevertheless expected to remain high for a prolonged period of time. The prospects for steel used in residential construction are stronger still. We project that steel use in residential construction will grow for more than 10 years, reflecting improvements in building quality.

The prospective demand for primary resources associated with steel production is somewhat complicated by the matter of recycled materials. As China's steel structures age, they will be demolished, and the resultant scrap can be used as a substitute for newly smelted steel. In the past, there has been limited scope for steel recycling, as demolished buildings contained little steel. In the future, the availability of scrap will work to offset the demand for iron ore somewhat.

While residential construction accounts for around 9 per cent of GDP and 14 per cent of steel use, it has broader implications for steel demand. Appliances are required to fill the new homes. Commercial buildings and infrastructure are needed to service the new urbanites. These products and amenities will be positively correlated with residential construction, and so our projections for residential construction may be useful for analyses of these other activities.

Appendix A: Map of Hailing County, Taizhou Prefecture, Jiangsu Province

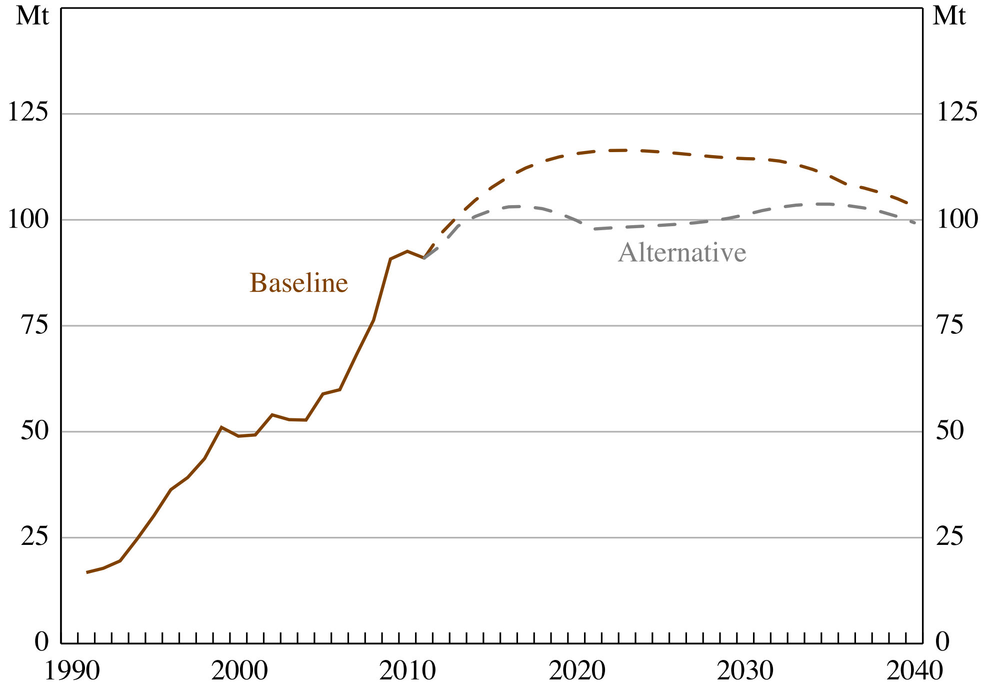


Notes: Yellow areas approximately correspond to urban areas. Red areas approximately correspond to rural areas. We were not able to classify unrendered areas.

Sources: Google Maps; National Bureau of Statistics of China; authors' calculations

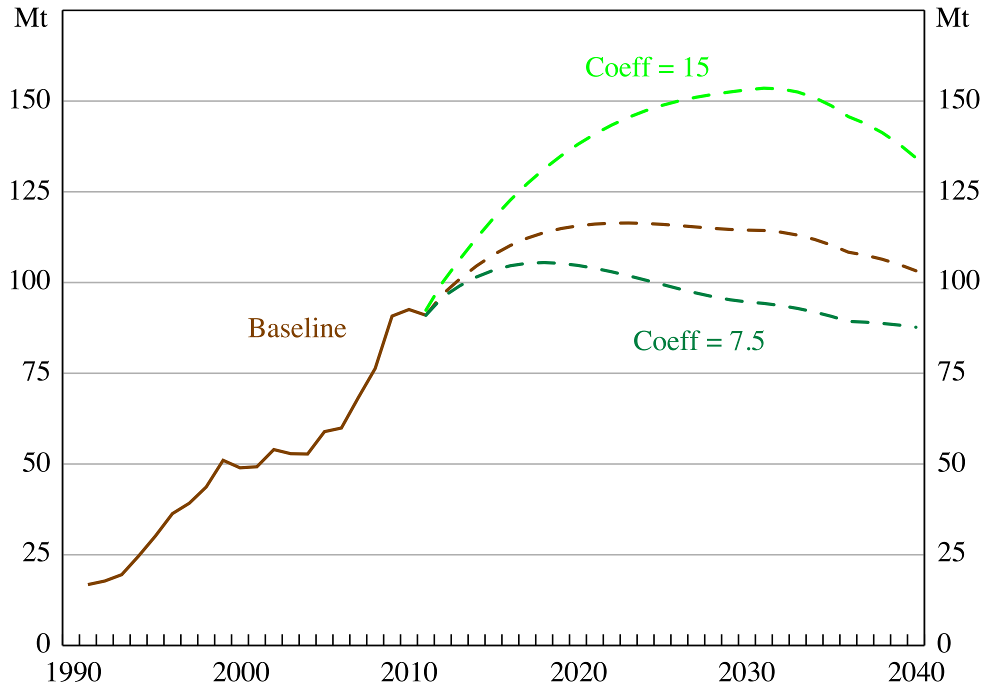
Appendix B: Steel Use under Alternative Assumptions

Figure B1: Steel Use under United Nations' 2009 Urbanisation Assumptions



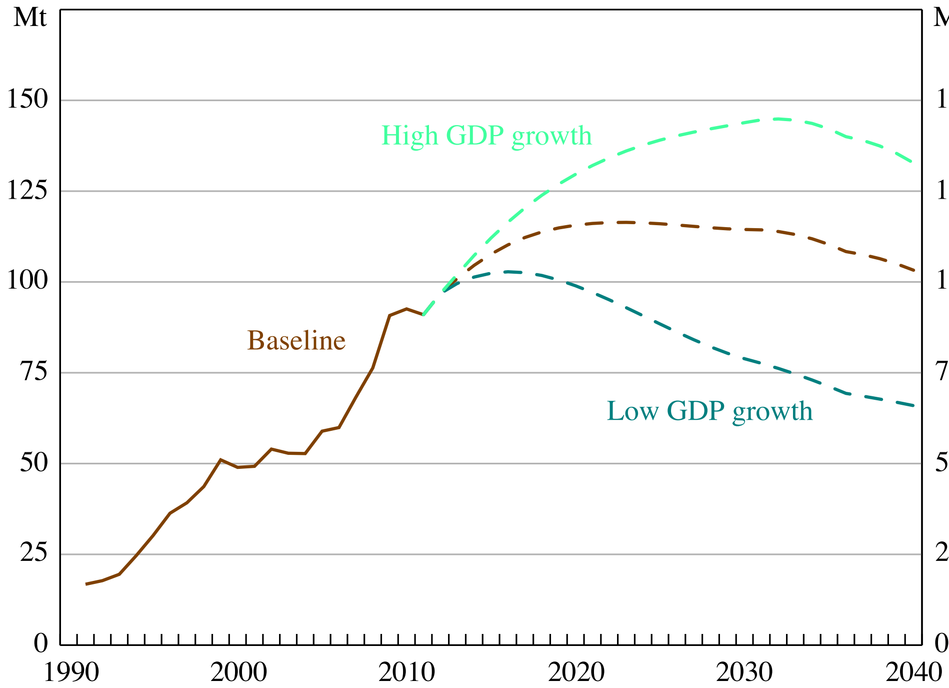
Sources: CEIC; United Nations, authors' calculations

Figure B2: Steel Use under Alternative Floor Space per Capita Assumptions



Sources: CEIC; authors' calculations

Figure B3: Steel Use under Alternative Growth Assumptions



Sources: CEIC; authors' calculations

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