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Rise in house prices and industrial growth: evidence from city-level data of China

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ABSTRACT

Employing city-level data from China over the period 2005 to 2017, this article examines how changes in house prices influence the growth of industrial output. Econometric results show that rising house prices have a negative and significant effect on industrial growth. However, this effect holds only in the boom periods and is higher for under-developed cities than for better-developed cities in China. The findings add to our understanding of effects of house price changes on the wider economy and carries important policy implications.

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1. Introduction

The boom and bust of housing markets has characterised the economy of many countries over the last two decades. China is not an exception. Market-oriented economic reforms and housing policy changes in the country since 1978 have led to a buoyant housing market (Cao & Keivani, 2014). Yet, the Chinese housing market exhibited significant volatility with a trend of ever-increasing house prices in all cities of the country over the past few years. While a rapid rise in house price produces wealth and a store of value for households (Munro, 2018; Ortalo-Magné & Rady, 2004) and gives property owners ‘money illusion’ (Munro, 2018), it may also have negative consequences for the wider economy (Munro, 2018; Wang et al., 2018).

Previous studies on this subject have provided conflicting empirical evidence about the impact of a buoyant housing market on the wider economy (Miao & Maclennan, 2017; Wang et al., 2018). Some find that a rapid and persistent rise in house prices is harmful for the wider economy because it threatens the stability of the financial system (Senhadji & Collins, 2002), suppresses labour force participation rate (Laamanen, 2013), and increases firms’ production cost and hinders their innovation

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(Fu et al., 2016; Rong et al., 2016). Others, however, show that a rapid and consistent rise in house prices increases the wealth of households (Munro, 2018), increases consumer spending (Ciarlone, 2011; Dong et al., 2017), and eases firms' financial constraints and stimulates their investment (Giuliodori, 2005; Kiyotaki & Moore, 1997). At the centre of the debate is the relationship between house price changes and economic growth. While most previous studies focus on how house price fluctuations respond to economic growth as a demand side factor (Stepanyan et al., 2010), little is known about the effects of house price changes on growth. Among the limited studies on the latter topic, several studies show that a decline in house prices adversely influences G.D.P. growth (Iacoviello & Neri, 2008; Madsen, 2012). Research on China shows a similar finding (Cao et al., 2018; Wu et al., 2012). While this stream of research provides valuable insights into the effects of house price changes on economic growth, we know very little about how rapid increases in house prices influence China's industrial growth – a key element of G.D.P. growth. This is surprising given the importance of manufacturing to China's economic growth over the last three decades. The question is highly pertinent to the debate about the link between house price increases and economic growth in China, particularly given that the country has been facing a continuous house price bubble and a trend of declining economic growth. The whole economy will likely be affected negatively and experience a decline in growth if house price inflation impedes the growth of industrial output.

This study therefore seeks to understand whether and how house price changes influence the growth of industrial output in Chinese cities. Industrial production refers to the activity of production from the industry, with the objective of selling the final production. The findings show that rising house prices have an overall negative impact on industrial growth in Chinese cities. This effect is more pronounced in boom periods than in non-boom periods and in under-developed cities than in better-developed cities.

The study makes two contributions. First, previous studies find that house price influence economic growth positively or negatively. Yet it remains unclear through what channels this effect occurs. Some studies show that house price affects consumption through the wealth effect, corroborating Friedman's permanent income hypothesis (Kishor, 2007). Yet consumption is merely a component of output and it is output data that helps better understand the transmission channel of house price changes (Demary, 2009). Further, while a few studies have examined the effects of house price on economic growth (Iacoviello & Neri, 2008; Madsen, 2012), to the best of our knowledge, none of these has considered industrial growth. By examining the effects of house prices on industrial growth, the study provides novel academic insights that complement the literature on the link between house price changes and their consequences for consumption and economic growth.

Second, previous studies on the effect of house price on consumption (Kishor, 2007) and economic growth (Miller et al., 2011) are based on national level data that hide substantial variations across subnational regions within a country in terms of, for example, housing policies, economic development and socio-economic conditions (Yi & Huang, 2014). These variations shape localised housing markets and

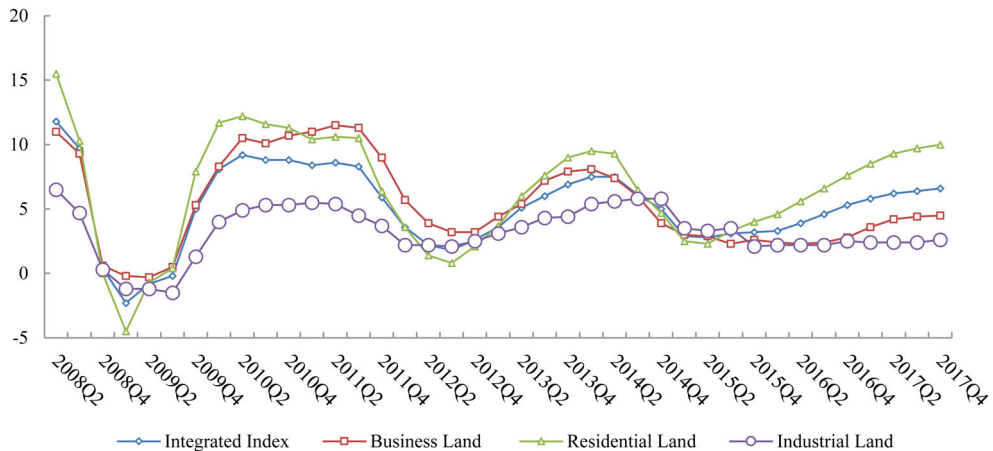


Figure 1. Quarter-on-quarter changes in the price of land for different usage in 105 cities (%).
 Source: "Report of Land Price Changes in the Fourth Quarter of 2017", Ministry of Land and Resources of China.

substantiate the heterogeneity of the focal relationship between house price changes and economic growth. By demonstrating the heterogeneous effects of the house price changes on industrial growth across different subnational regions within China and different times (in boom periods versus in non-boom periods), this study provides a characterisation of the effects of housing prices at a deeper level and hence enriches the literature on the impact of real estate sector on economic growth of a country.

2. Theory and hypothesis

Rising house prices can fuel industrial growth by increasing the value of collateral lending and by allowing firms to borrow and invest more following the increases in the value of their assets (Peek & Rosengren, 2000). Rising house prices may also encourage real estate investment that stimulates industrial growth by producing a multiplier effect through increasing fixed assets investment and consumption (Gauger & Snyder, 2003; Ofori & Sun, 2003). Despite the arguments for these positive effects, the dominant view is that a rapid and persistent rise in house prices has a negative effect on the wider economy. We suggest that through three channels, namely, production cost, resource misallocation and financing 'crowd-out', house price increases negatively affect industrial growth in Chinese cities.

The first is production cost channel. Local governments in China are land suppliers and an important source of their revenue comes from land leasing for residential and commercial purposes. This motivates them to increase land price which adds production cost for industrial firms and constrains their growth. Figure 1 shows that the increase in residential land price is always paired with the increase in industrial land price. Rises in house prices also increase the living costs of workers of industrial firms (Liang et al., 2016) because they have to pay more to purchase or rent a property.

The second is the resource misallocation channel. Fast increases in house prices lead profit margins to be higher in the real estate development sector than in the

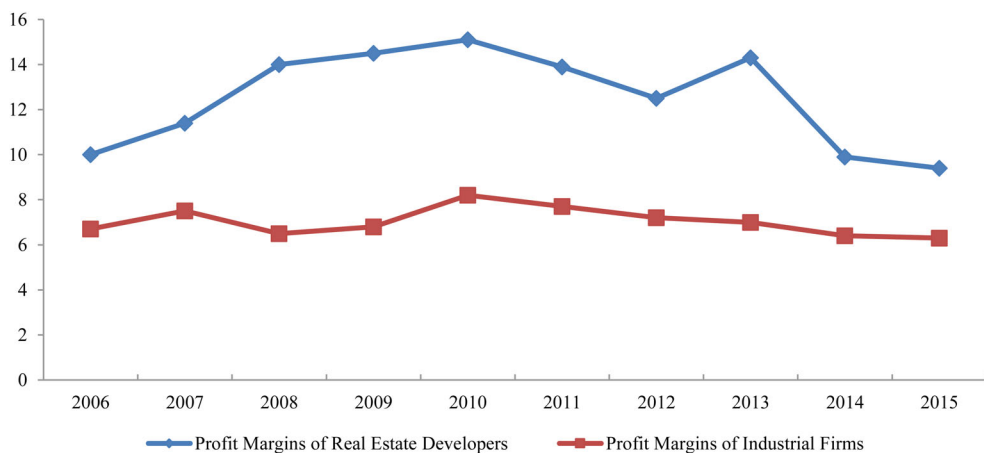


Figure 2. Profit margins of real estate developers and industrial firms (%).

Source: National Bureau of Statistics of China.

industrial sector in China. [Figure 2](#) shows that profit margins were higher in the real estate sector than in industrial sector of China over the period of 2006 and 2015. The higher profitability in the real estate sector stimulates outflow of capital from the industrial sector into the housing sector. This in turn reduces capital investment by industrial firms, hampers their investment and output growth. Reinforcing this view, [Rong et al. \(2016\)](#) provided evidence, showing that rapid rises in house prices decreases investment in R&D which leads to reduced number of patents in Chinese firms.

The third is the financing ‘crowd-out’ channel. This channel operates through affecting both credit demand and supply. When house prices rise, banks lend more to real estate developers than to industrial firms for higher profitability ([Chakraborty et al., 2018](#)). Data from [Figure 3](#) corroborates this view, showing that loan balance in industrial and service sectors increased at lower rates than in real estate sector in China after 2010. The channelling of lending to the real estate sector reduces industrial firms’ access to capital for production expansion. Although industrial firms can get access to shadow banking services, such as banks’ financing products, these come at higher prices which increase the cost of financing and constrains output growth.

We recognise that the mechanisms through which house price changes influence industrial growth are complex, making it difficult to isolate the effect of each individual channels. Moreover, the general trend of increasing house prices in China may have formed adaptive expectations from consumers and investors including industrial firms. In anticipation of increases in house prices, industrial firms will make adjustments to investment earlier, hence the effect of house price changes on increasing production costs, resource miss-allocation and financing ‘crowd-out’ lessen. Furthermore, the different channels of the impact are not necessarily exclusive to each other. For example, resource misallocation to real estate sector reduces capital investment in industrial firms which serve as suppliers or customers of other firms. As a result, firms that produce final products have to either manufacture intermediate products ‘in house’ or turn to inferior suppliers, both of which may increase

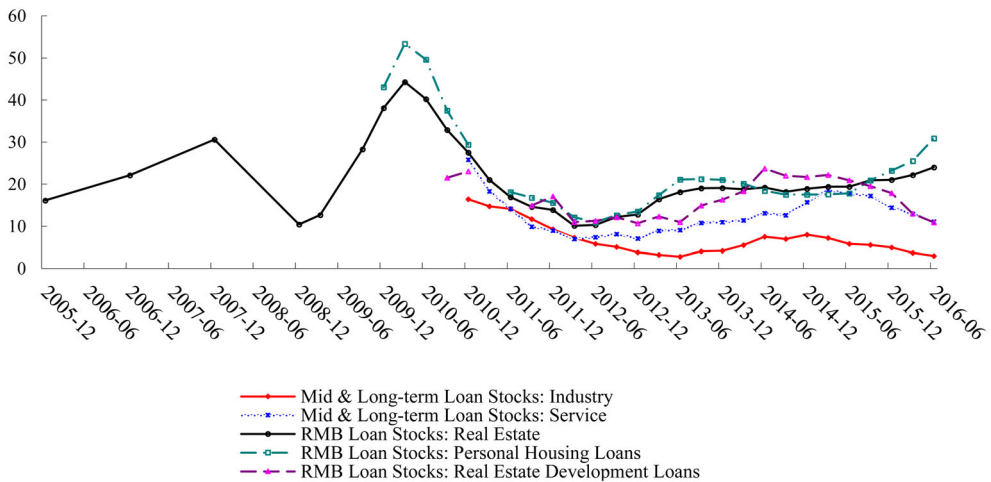


Figure 3. Quarter-on-quarter changes of loan balance in real estate, industrial and service sectors (%). Source: Wind Info.

production cost and reduce the quality of the end product. Despite these arguments, however, we suggest that the identification of these three channels helps us understand the mechanisms through which house price inflation influences industrial growth. The above discussion leads to:

Hypothesis 1: The rise of house prices has a negative effect on the growth of industry output.

Hypothesis 1 argues for a general negative effect of house price inflation on industrial growth, ignoring the cyclical nature of house price movement. Driven by the cyclical components of the real estate sector and the regular adjustments of government policies, house prices tend to be boom and bust cyclically in China, with a general upwards trend (Figure 4).

Based on this observation, we further argue that the negative effect proposed in Hypothesis 1 is more pronounced in boom periods than in non-boom periods. In terms of the production cost channel, during a period of housing boom, high house prices induces local governments to lease more land for residential and commercial purposes, which increases the production costs of industrial firms. The wage cost of industrial firms will also increase more rapidly during this period as workers have to pay more for housing. As the real estate sector is highly profitable in this period, industrial firms will invest more into this sector, squeezing their investment in the industrial projects. Similarly, during the boom period, financial institutions tend to provide more lending to the real estate sector than to the industrial sector. This makes it more difficult or costly for industrial firms to raise capital for investment. All these factors make the production cost of industrial firms higher in the boom periods, which can depress their output growth. By contrast, the above effects will be less pronounced in times of lower or stable house price inflation. Hence, we propose:

Hypothesis 2: The negative effect of the rise in house prices on the growth of industrial output is more pronounced in boom periods than in non-boom periods.

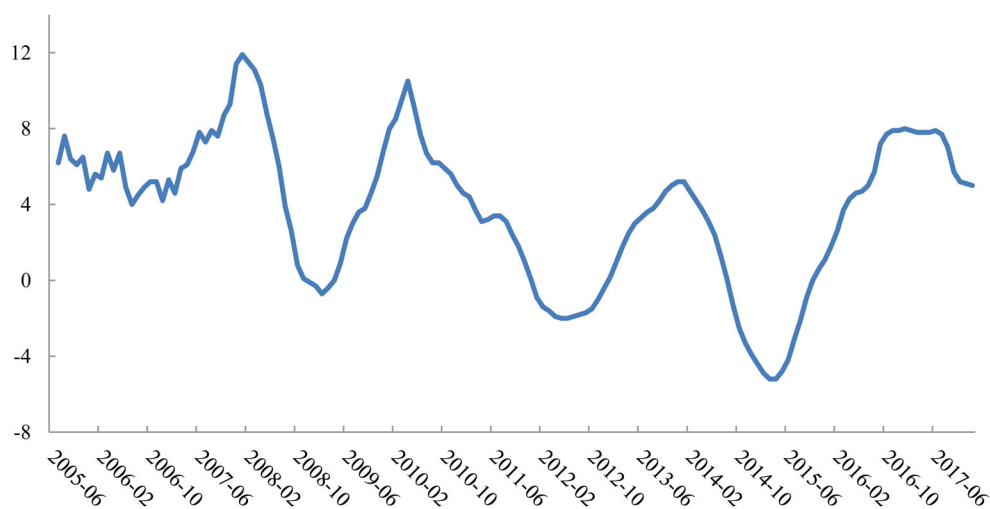


Figure 4. Movements of second-hand house price growth (year-on-year, %) in 70 large- and medium-sized cities in China.

Source: Wind Info.

We further propose that the negative effect asserted in Hypothesis 1 is stronger in under-developed cities than in better-developed cities of China. We define under-developed and better-developed cities in terms of the level of economic development. Despite rapid economic growth, different regions in China vary in the levels of economic development and income. Some regions in eastern China have entered the post-industrialisation phase, while most regions in central and western China are still undergoing industrialization. The economic structure also differs between under-developed and better-developed cities. Whilst the economy in better-developed cities is dominated by service sector, under-developed cities feature the dominance of low-end manufacturing. These differences influence the ways through which house price affects industrial growth and lead to differential effects in the two groups of cities.

We first consider the production cost channel. Because firms in better-developed cities focus on service sector and high-end manufacturing which have higher profit margins, land leasing is relatively a small component of the total cost for these firms. As such, the rise of house prices will not significantly increase their production cost, hence its negative effect on industrial growth. In contrast, the economy in under-developed cities focuses on low-end manufacturing, the cost of land leasing is a more important component of their total cost. As house price inflation increases the price of land leasing, it will significantly increase the production cost of these firms and hence will constrain their output growth.

Second, we turn to the resource misallocation channel. Although high profit margins in real estate development may attract Chinese manufacturing firms entered into this sector, the capital transfer effect is less pronounced in better-developed cities than in under-developed cities. Because manufacturing firms in better-developed cities have more opportunities to generate profits from the service industry and from industrial sectors that are characterised with higher value-addition and higher profit margin, they are less motivated to transfer capital to the real estate sector. This leaves them with sufficient capital for investment which increases industrial output.

Finally, we consider the financing ‘crowd-out’ channel. Better-developed cities feature mature financial markets, providing more opportunities for manufacturing firms to raise capital for investment and growth. Therefore, even if banks in these cities move away from commercial lending into real estate lending, firms in these cities can still access other channels of finance. By contrast, firms in under-developed cities have fewer other sources of financing due to the under-developed financial market and have to rely on banks to raise capital. As banks lend more money to the real estate sector, industrial firms in these cities have to borrow at a higher cost to raise capital for investment. Therefore, the financial ‘crowd-out’ effect is more pronounced in under-developed cities than in better-developed cities.

Hypothesis 3: The negative effect of the rise in house prices on the growth of industrial output is stronger in under-developed cities than in better-developed cities.

3. Empirical model and data description

3.1. Empirical model

We set the following econometric model to study the impact of house price changes on the growth of industrial output:

$$Y_{i,t} = \alpha + \psi Y_{i,t-1} + \beta HP_{i,t} + \sum \gamma_j X_{j,t} + \mu_i + \phi_t + \varepsilon_{i,t} \quad (1)$$

$Y_{i,t}$ and $Y_{i,t-1}$ is the year-on-year growth of industrial output in city i at period t and $t-1$ respectively. The core explanatory variable is $HP_{i,t}$, which is defined as the year-on-year growth of second-hand house prices in city i at period t , $X_{j,t}$ represents a set of control variables, μ_i is city-specific effects, ϕ_t is period-specific effects, and $\varepsilon_{i,t}$ is error term.

We use the year-on-year growth of second-hand house price (e.g., house prices in January 2018 over house prices in January 2017) to operationalise our predictor variable (HP_{it}). Compared with yearly or quarterly data, year-on-year house price growth removes seasonal effects. Because Chinese house prices changed very frequently over the sample period, yearly or quarterly data are less appropriate. Moreover, the data on year-on-year house price growth of Chinese cities are the only monthly data that are publicly available (Xu & Chen, 2012) and these data are used by most recent studies (Guo & Qu, 2019; Yang et al., 2018). We can only use prices of second-hand houses because Chinese government policies such as restrictions of purchasing new houses and setting a price ceiling for new houses distort house prices.

We introduce two groups of control variables. The first group concerns various characteristics of cities that are considered to influence industrial growth¹:

1. $Invest_{i,t}$: year-on-year growth rate of investment in industrial fixed assets. We suggest that investment in fixed assets is positively associated with industrial growth.
2. $Export_{i,t}$: year-on-year growth rate of total export. It measures changes in the external demand of city i . Export growth increases external demand and acts as an important driver of industrial growth.

The second group of controls consists of macroeconomic variables, accounting for the role of the macroeconomic environment in affecting industrial growth:

1. $M2_t$: year-on-year growth of M2 in China. M2 growth is always used as an important intermediary tool of monetary policy in China. According to Christiano et al. (1997), the manufacturing sector is more responsive to a monetary policy shock than economy-wide measures of output are.
2. $Interest_t$: the benchmark lending rate of medium and long-term loans. It measures the financial cost of firms and therefore the role of monetary and financial environment in which industrial firms operate.
3. $LnEPU_t$: natural logarithms of economic policy uncertainty (EPU) index. We use the EPU index of China constructed by Baker et al. (2016) to define EPU. High EPU may result in a pessimistic expectation of firms and consumers about economic prospect and lead them to take a ‘wait and see’ approach that depresses investment and output growth (Baker et al., 2016).
4. $LnMECI_t$: natural logarithms of economic sentiment indicator. We use the national macroeconomic prosperity index provided by National Bureau of Statistics of China as a proxy to reflect the market expectation on macroeconomic prospect and entrepreneurs’ confidence in the economy.

House price changes take a certain amount of time for their effect on the growth of industrial output to show up. The time lag effect of house price changes on industrial growth varies substantially across different industrial sectors. Moreover, house price changes influence industrial growth through many channels which interact with each other, making the length of the time lag effect of house price changes difficult to determine. For all these considerations, instead of predicting an appropriate lag structure, we experiment with different lags (1–4 months) to ascertain the time lag effects.² We similarly use lagged control variables such as $Invest_{it}$, $Export_{it}$, $LnEPU_t$ and $LnMECI_t$. Informed by literature in monetary economics (Gruen et al., 1999) and official documents of some central banks, which assume a typical lag of 2–3 quarters between monetary policy actions and their impact on economy including output (Walsh, 2010), we use the 6 lagged value of M2 and medium- and long-term interest rate. Because of the inertia of year-on-year industrial output growth, it is also appropriate to add lagged dependent variable into the regression. After adding these lags for variables, the regression equation (1) is specified as:

$$Y_{i,t} = \alpha + \psi Y_{i,t-1} + \beta HPI_{i,t-1} + \gamma_1 Invest_{i,t-1} + \gamma_2 Export_{i,t-1} + \gamma_3 M2_{t-6} + \gamma_4 Interest_{t-6} + \gamma_5 LnEPU_{t-1} + \gamma_6 LnMECI_{t-1} + \mu_i + \phi_t + \varepsilon_{i,t} \quad (2)$$

3.2. Data and statistical description

We obtained monthly data of house prices from the National Bureau of Statistics of China which publishes year-on-year growth rate of house prices in 70 large- and medium-sized cities in the country. These cities vary in terms of the level of

Table 1. Descriptive statistics of variables.

Variable	Mean	Minimum	Maximum	Standard deviation	Observed Value
$Y_{i,t}$	13.31%	-19.70%	59.50%	8.455%	6285
$HP_{i,t}$	3.26%	-18.70%	60.50%	5.991%	10420
$Invest_{i,t}$	18.20%	-92.40%	1024.00%	34.04%	3780
$Export_{i,t}$	17.69%	-91.40%	556.00%	36.33%	6135
$M2_t$	15.90%	8.80%	29.74%	4.31%	168
$Interest_t$	6.04%	4.75%	7.75%	0.81%	168
$LnEPU_t$	4.862	3.264	6.544	0.673	168
$LnMECI_t$	4.594	4.531	4.644	0.034	168

Data sources: (1) Wind Info; (2) Monthly Statistical Reports for Cities of China; (3) www.policyuncertainty.com.

economic development, the ratio of industrial output in GDP, and house price growth, thus well representing the population of Chinese cities. Furthermore, all previous studies at city-level focus only on large- and medium-sized Chinese cities (Chen & Wen, 2017; Liu & Xiong, 2019). Our decision to focus on this tier of cities allows us to compare our findings with those of other studies. We agree that the house prices in certain cities may be under-estimated by this data source (Yang, et. al., 2018). However, we checked all other data sources and found that it is the only monthly data set on house price changes that are available to researchers (Xu & Chen, 2012) and it matches the data on industrial output (which is also published in a year-on-year growth manner) perfectly. Therefore, despite concerns about under-estimation of house price growth, the most recent studies on Chinese house prices use the same data set (Guo & Qu, 2019; Yang et al., 2018). Our sample covers 70 large and medium cities in China for the period of July 2005 to December 2017 because data on year-on-year growth of second-hand house prices were only published since July 2005. We chose the period 2005–2017 because this period saw significant price appreciation and it is a period when Chinese cities experienced different episodes of price adjustments (Liu & Xiong, 2019). Data on EPU index were obtained from the website of www.policyuncertainty.com. Data on all other variables are obtained from WIND database and monthly statistical reports provided by the cities in our sample³. In theory, the sample should have 10,420 city-month observations in total. However, some data on industrial growth, investment growth and export growth were missing for certain cities. This reduced the number of cities to 43 and led to our use of an unbalanced panel data set and the number of observations in different models to vary. Table 1 shows statistical descriptions of variables.

3.3. Estimation method

Given that our panel is an unbalanced with missing observations for some variables, the estimation of Equation (2) will result in an excessive loss of sample information. This is because one missing original observation will lead to two losses of adjacent first order differencing observations. Roodman (2009) suggests using orthogonal deviations to transform the data to alleviate such concerns. Instead of differencing therefore, we derived a new series of observations for each variable before

estimating the regression by subtracting the average of all future observations from each variable.

We adopt a System Generalized Method of Moments (GMM) method (Blundell & Bond, 1998) to estimate Equation 2 for two reasons. First, although our model includes several macro-level variables and city-level variables to isolate the effects of house prices, some variables may still be missing in our model. The System GMM helps to address endogeneity associated with the issue of missing variables by instrumenting the lagged dependent variable and/or any other endogenous variables which are thought to be uncorrelated with the fixed effects. The System GMM is more efficient with an additional assumption that the first differenced instruments are uncorrelated with the fixed effects. This in turn allows the inclusion of more instruments (Roodman, 2009) and thus help to avoid the problems associated with the absence of information about the focal variables. Second, the lagged depended variable may have a high correlation with the error term. The System GMM yields consistent and efficient parameter estimates for such regressions (Roodman, 2009). Finally, the GMM estimator is efficient when heteroskedasticity is present. We conducted the Wald test to examine the existence of group wise heteroskedasticity (Greene, 2018). The result shows $\lambda^2(43) = 1091.26$, where 43 represents the number of cities in the sample, and $P = 0.0000$, confirming the appropriateness of using system GMM method.

4. Empirical results

4.1. Baseline regression results

Because the System GMM method requires that all variables are $I(0)$, we need to test stationarity of the variables before estimating Equation (2). We conducted an ADF-Fisher unit root test, showing that all variables are $I(0)$, indicating that they are stationary without any differencing⁴. Table 2 show the results estimated from Equation 2. Results from Arellano-Bond test for serial correlation indicates that the null hypothesis of no autocorrelation could be rejected for AR (1), but it could not be rejected for AR (2). Results from the Hansen test show that the null hypothesis (that the over-identifying restrictions are valid) could not be rejected. Therefore, the use of system GMM model is justifiable and effective.

The coefficients of the lagged housing price variable in all models are negative and statistically significant. Interestingly, these results do not change qualitatively with the length of the lag (1, 2, 3, or 4 months), illustrating that the number of months to be lagged is indeed not important for reasons such as adaptive expectations from consumers or investors, as explained in the section 3.1. These results support our conjecture that the rapid rise of house prices impedes industrial growth in Chinese cities, corroborating Hypothesis 1. The results are also in line with the changes in house prices and industrial growth over the sample period. Our data show that the average house price in the 70 cities increased by 10.9% annually over the sample period, whilst the average annual growth rate of industrial output was 6.6% only over the same period. Although the Chinese government implemented policies to restrict speculative demand and control house price growth by, for example, increasing

Table 2. Baseline regression results.

	(1)	(2)	(3)	(4)	(5)
$HP_{i,t-1}$	-0.017** (-2.04)	-0.034** (-2.14)			
$HP_{i,t-2}$			-0.032** (-2.28)		
$HP_{i,t-3}$				-0.025** (-2.31)	
$HP_{i,t-4}$					-0.021** (-2.32)
$Y_{i,t-1}$	0.927*** (45.17)	0.931*** (35.22)	0.931*** (35.85)	0.930*** (36.01)	0.930*** (36.14)
$Invest_{i,t-1}$	0.005*** (2.65)	0.004* (1.74)	0.004* (1.87)	0.004* (1.94)	0.004** (2.00)
$Export_{i,t-1}$	0.000 (0.24)	-0.001 (-0.91)	-0.001 (-0.86)	-0.001 (-0.60)	-0.001 (-0.46)
$M2_{t-6}$	0.047*** (2.68)	0.025* (1.88)	0.026* (1.85)	0.025* (1.75)	0.024* (1.70)
$Interest_{t-6}$	0.038 (0.36)	-0.137 (-0.88)	-0.083 (-0.51)	-0.046 (-0.34)	-0.022 (-0.18)
$LnEPU_{t-1}$		-0.022 (-0.29)	-0.005 (-0.05)	-0.013 (-0.13)	-0.017 (-0.18)
$LnMECI_{t-1}$		12.413** (2.25)	11.573** (2.26)	10.942** (2.26)	10.496** (2.25)
Constant	5.543 (1.33)	-48.865** (-2.08)	-45.388** (-2.12)	-42.717** (-2.11)	-40.822** (-2.09)
Time Fixed Effect	YES	YES	YES	YES	YES
City Fixed Effect	YES	YES	YES	YES	YES
$AR(1)_p$	0.035	0.036	0.036	0.036	0.036
$AR(2)_p$	0.456	0.454	0.451	0.454	0.454
Hansen Test	0.528	0.544	0.559	0.548	0.571
Observations	2628	2628	2607	2586	2565

Note: t values are in parentheses. ***, **, and * indicate significance at 1%, 5% and 10%, respectively; number of cities: 43.

Data sources: (1) Wind Info; (2) Monthly Statistical Reports for Cities of China; (3) www.policyuncertainty.com.

mortgage rates for buying a second house, the upward house price trend did not change. One of reasons could be the lack of alignment between different prudential tools, which reduces the effectiveness of the policies aimed at reining house price growth. For example, the effectiveness of Chinese government's prudential policies to remove house price bubbles was, to a large extent, cancelled out by the loosening of monetary policies to stimulate economic growth in 2008 when the global financial crisis struck. As discussed in section 2, the fast increase in house price over the sample period channelled more resources away from the industrial sector into the real estate sector and thus significantly hampered industrial growth.

Turning to the results pertaining to control variables, the coefficients of $Invest_{i,t-1}$ and $LnMECI_{t-1}$ are positive and significant. These results indicate that investment growth in fixed assets and sound economic sentiment enhances industrial growth. The coefficient of $M2_{t-6}$ is significant when $LnMECI_{t-1}$ is not added in the regression, but it becomes insignificant when the effect of $LnMECI_{t-1}$ is controlled for. This result implies that loosening monetary policies facilitate industrial growth. The coefficient of $Export_{i,t-1}$ is insignificant. A possible explanation is that many inland cities in our sample have a lower export-to-GDP ratio and export is not a key driver of industrial growth. The coefficient of $Interest_{t-6}$ is insignificant. This occurs perhaps because firms pay more attention to loan balance rather than lending rate. The coefficient

Table 3. Division of house boom periods and non-boom periods.

Boom periods	Non-boom periods
March 2007 to December 2007	July 2005 to February 2007
January 2009 to April 2010	January 2008 to December 2008
June 2012 to December 2013	May 2010 to May 2012
April 2015 to September 2016	January 2014 to March 2015
	October 2016 to December 2017

Source: Authors' calculations.

Data sources: Monthly Statistical Reports for Cities of China.

of $\ln EPU_{t-1}$ is not significant either. It is possible that part of the effect of EPU is reflected in the economic prosperity indicator.

4.2. Boom periods and non-boom periods

To further identify the asymmetric effects of house price growth on industrial growth and test Hypothesis 2, we divide the sample into two periods: boom period and non-boom period. We follow previous studies (Claessens et al., 2012; Harding & Pagan, 2002) and apply the 'classical' method of judging business cycle to distinguish the two periods. Although this method was developed to judge business cycles, house prices show similar cyclical feature of fluctuation. This method has been widely adopted to determine the business cycles of the U.S. and Euro Zone by the National Bureau of Economic Research (NBER) and the Center for Economic Policy Research (CEPR). Some studies define business cycles by using the so-called BB algorithm (Harding & Pagan, 2002) or by analysing how economic activity or asset price deviates around a trend (Stock & Watson, 1999). Compared with these methods, the classic method has two advantages. First, it avoids trend-cycle dichotomy and thus the subjectivity of the determination of turning points (Claessens et al., 2012). Second, the turning points this method identifies are robust to the inclusion of newly available data; by contrast, in other methods, adding new data may affect the estimated trend and thus the identification of cycles (Canova, 1998).

Specifically, we extend the BB algorithm of Bry and Boschan (1971) to identify the turning points in a series.⁵ We define the minimum cycle length (trough to trough or peak to peak) to be at least six months and ensure that troughs and peaks have to alternate. The highest (lowest) value is chosen when there are consecutive troughs (peaks). Specifically, a peak in a monthly series y_t occurs at time t , if:

$$\left\{ [(y_t - y_{t-2}) > 0, (y_t - y_{t-1}) > 0] \text{ and } [(y_{t+2} - y_t) < 0, (y_{t+1} - y_t) < 0] \right\} \quad (3)$$

and a trough in a monthly series of y_t occurs at time t , if:

$$\left\{ [(y_t - y_{t-2}) < 0, (y_t - y_{t-1}) < 0] \text{ and } [(y_{t+2} - y_t) > 0, (y_{t+1} - y_t) > 0] \right\} \quad (4)$$

where y_t represents year-on-year growth of second-hand house prices at time t . Table 3 displays the division of the two periods for our data.

Table 4. Regression results for house boom periods and non-boom periods.

	(1) Boom periods	(2) Non-boom periods	(3) Dummy variable method
$HP_{i,t-1}$	-0.035* (-1.92)	-0.003 (-0.18)	0.027 (0.51)
$Boomdummy_t$			-0.470** (2.03)
$HP_{i,t-1} * Boomdummy_t$			-0.068* (-1.86)
$Y_{i,t-1}$	0.933*** (27.38)	0.860*** (13.53)	0.889*** (17.97)
$Invest_{i,t-1}$	0.008*** (3.29)	0.003 (0.98)	0.006** (2.11)
$Export_{i,t-1}$	-0.001 (-0.93)	0.000 (0.49)	0.001 (0.17)
$M2_{t-6}$	0.014** (2.33)	0.004 (0.32)	0.001 (0.03)
$Interest_{t-6}$	-0.024 (-0.08)	-0.065 (0.58)	-0.101 (-1.11)
$LnEPU_{t-1}$	-0.020 (-0.26)	-0.116 (-1.07)	-0.083 (-0.34)
$LnMECI_{t-1}$	12.026** (2.09)	18.528*** (3.31)	14.829*** (2.76)
Constant	-43.601 (-0.90)	-86.980*** (-3.40)	-61.978*** (-2.58)
Time Fixed Effect	YES	YES	YES
City Fixed Effect	YES	YES	YES
$AR(1)_p$	0.040	0.040	0.038
$AR(2)_p$	0.512	0.377	0.426
Hansen Test	0.337	0.327	0.332
Observations	1437	1175	2612

Note: t values are in parentheses. ***, **, and * indicate significance at 1%, 5% and 10%, respectively; number of cities: 43.

Data sources: (1) Wind Info; (2) Monthly Statistical Reports for Cities of China; (3) www.policyuncertainty.com.

Table 4 shows a remarkable difference in the impact of house prices on industrial growth in the two different periods. The coefficient of the lagged housing price variable in the boom period model is negative and statistically significant, whilst it is negative but is statistically insignificant in the non-boom period model. Hypothesis 2 is corroborated. To check the robustness of this finding, we used a dummy variable approach in model (3). The coefficient of $HP_{i,t-1} * Boomdummy_t$ ($Boomdummy_t=1$ for boom period and 0 otherwise) is negative and statistically significant. Similar results are obtained when we interacted $Boomdummy_t$ with other lagged house prices including $HP_{i,t-2}$, $HP_{i,t-3}$ and $HP_{i,t-4}$. These results are highly consistent with those in models (1) and (2). Therefore, Hypothesis 2 is still supported.

4.3. Under-developed and better-developed cities

In order to test Hypothesis 3, we divided the sample into two groups based on the initial economic development level of each city in 2004: better-developed and under-developed groups. Cities with GDP per capita below the average (of all sampled cities) in 2004 fall into the 'under-developed' group, whilst cities with GDP per capita above the average in the same year fall into the 'better-developed' group.

Models 1 in Table 5 shows that the coefficient of the house price variable is negative but is significant at 10% level only, whilst it is negative and significant at

Table 5. Regression results for cities with different levels of development.

	(1) Better-developed cities	(2) Under-developed cities	(3) Tier 1 Cities	(4) Tier 2 Cities	(5) Tier 3 Cities
$HP_{i,t-1}$	-0.018* (-1.93)	-0.039** (-2.10)	-0.009 (-0.34)	-0.024* (-1.70)	-0.077** (-2.10)
$Y_{i,t-1}$	0.934*** (49.50)	0.750*** (7.50)	0.977*** (29.56)	0.943*** (23.49)	0.830*** (12.03)
$Invest_{i,t-1}$	0.006** (1.97)	0.003 (1.22)	0.002*** (4.79)	0.009** (1.97)	0.012 (1.24)
$Export_{i,t-1}$	-0.001 (-0.62)	0.001 (0.64)	-0.004 (-0.62)	-0.002 (-1.08)	-0.001 (-0.99)
$M2_{t-6}$	0.006 (0.48)	0.056 (0.75)	0.040*** (4.70)	0.015* (1.83)	0.056 (0.57)
$Interest_{t-6}$	-0.084 (-0.52)	-0.208 (-1.23)	-0.392** (-2.19)	-0.189* (-1.86)	-0.285* (-1.71)
$LnEPU_{t-1}$	-0.023 (-0.39)	-0.001 (-0.01)	-0.005 (-0.05)	-0.066 (-1.16)	-0.066 (-0.57)
$LnMECI_{t-1}$	8.560* (1.73)	21.936*** (3.50)	8.075*** (3.14)	10.960* (1.71)	31.831*** (3.96)
Constant	-32.514* (-1.73)	-99.667*** (-3.60)	-33.686*** (-3.03)	-42.781** (-2.22)	-139.965*** (-4.09)
Time Fixed Effect	YES	YES	YES	YES	YES
City Fixed Effect	YES	YES	YES	YES	YES
$AR(1)_p$	0.087	0.061	0.087	0.083	0.086
$AR(2)_p$	0.327	0.342	0.149	0.509	0.381
Hansen Test	0.796	0.344	0.450	0.356	0.355
Observations	1538	829	378	1579	655

Notes: (a) t values are in parentheses; (b) ***, **, and * indicate significance at 1%, 5% and 10% respectively. (c) number of cities: 43. (d) Tier 1 cities include Beijing, Shanghai, Guangzhou and Shenzhen (4 cities), Tier 2 cities include Chengdu, Hangzhou, Wuhan, Chongqing, Nanjing, Tianjin, Xi'an, Changsha, Shenyang, Qingdao, Zhengzhou, Dalian, Ningbo, Xiamen, Fuzhou, Hefei, Kunming, Harbin, Jinan, Changchun, Wenzhou, Shijiazhuang, Nanning, Quanzhou, Nanchang, Guiyang, Taiyuan, Yantai, Jinhua, Huizhou, Xuzhou, Haikou, Ürümqi and Lanzhou (36 cities) and Tier 3 cities include Hohhot, Xining, Yinchuan, Zhanjiang, Shaoguan, Tangshan, Qinhuangdao, Baotou, Dandong, Jinzhou, Jilin, Mudanjiang, Bengbu, Anqing, Jiujiang, Zhanzhou, Jining, Luoyang, Pingdingshan, Yichang, Xiangyang, Yueyang, Changde, Guilin, Beihai, Sanya, Luzhou, Nanchong, Zunyi and Dali (30 cities). As our data is non-balanced panel, the number of Tier 2 and Tier 3 cities in regression is smaller than 36 and 30 respectively.

Data sources: (1) Wind Info; (2) Monthly Statistical Reports for Cities of China; (3) www.policyuncertainty.com.

5% level in Model 2. These results support Hypothesis 3 and suggest that the negative effect of house price increases is stronger in under-developed cities than in better-developed cities.

We further break the cities into first-, second- and third-tier groups. We followed 'The List of the Most Commercially Charming Cities in China' published by Yicai Global (https://en.wikipedia.org/wiki/Chinese_city_tier_system?tdsourcetag=s_pcqq_aiomsg) to define the three groups. We used the same set of cities for tiers 1 and 2 in the list and considered all other cities in our sample as tier 3 cities. The results in Models (3)–(5) in Table 5 show that the coefficient of the house price variable is significant at 5% level for the third tier group, while it is marginally significantly at 10% level for second tier group and insignificant for the first tier group. These results are consistent with those in the models (1) and (2) and lend further support to Hypothesis 3.

House price growth, industrial growth and their relationship may also differ between cities depending on the share of manufacturing/services in the GDP of the city. We also break the sample into two groups of cities, namely, a group with

Table 6. Regression results for cities with different manufacturing GDP shares.

	(1) Higher manufacturing GDP share group	(2) Higher services GDP share group
$HP_{i,t-1}$	-0.049** (-2.49)	-0.014* (-1.78)
$Y_{i,t-1}$	0.937*** (22.46)	0.879*** (37.02)
$Invest_{i,t-1}$	0.007** (2.35)	0.005* (1.75)
$Export_{i,t-1}$	-0.003 (-0.35)	0.003 (0.97)
$M2_{t-6}$	0.032 (0.86)	0.020** (2.26)
$Interest_{t-6}$	-0.290 (-1.09)	-0.155 (-0.70)
$LnEPU_{t-1}$	-0.020 (-0.12)	-0.082 (-1.06)
$LnMECI_{t-1}$	15.915** (2.40)	10.855*** (2.84)
Constant	-70.275** (-2.44)	-36.171*** (-3.34)
Time Fixed Effect	YES	YES
City Fixed Effect	YES	YES
AR(1)_p	0.088	0.072
AR(2)_p	0.405	0.243
Hansen Test	0.767	0.486
Observations	1204	1285
Number of cities	26	17

Note: t values are in parentheses. ***, **, and * indicate significance at 1%, 5% and 10%, respectively.

Data sources: (1) Wind Info; (2) Monthly Statistical Reports for Cities of China; (3) www.policyuncertainty.com.

a higher share of manufacturing GDP (46 cities) and a group with a higher share services GDP (24 cities). The results from the estimation of model (2) for these two groups (Table 6) show that the house price variable is significant at 5% level for the group of cities with a higher share of manufacturing GDP, but it is insignificant for the other group at 5% level. Because manufacturing takes a higher share of GDP than services do in the third tier cities, these results are highly consistent with those concerning the three tiers of cities, providing additional support for Hypothesis 3.

5. Conclusion

Employing monthly data of 70 large- and medium-sized cities in China for the period of 2005 to 2017, this study has examined whether and how the rise in house prices influences the growth of industrial output. Overall, the results indicate that rapid rise in house price has a negative impact on industrial growth. This effect is more pronounced in the boom periods than in non-boom periods and in under-developed cities than in better-developed cities. These findings have not been advanced in the prior literature and add to our understanding of how house price inflation negatively affects the wider economy.

Our analysis demonstrates the importance of allowing for region- and time-specific heterogeneity (Głuszak et al., 2018) when examining the effects of house prices on industrial output. In this regard, previous analyses using aggregate data miss the sources of such variations. Our analysis reveals sub-relationships that up until now have

remained hidden in the aggregate national level analysis and, hence, help avoid a uniform type of policy intervention. Our approach represents a step forward in understanding the effects of house price changes on the wider economy and calls for future research to focus on the heterogeneity of the effects of house price changes.

The findings of the study carry important policy implications particularly with respect to the current policy debate on the effectiveness of housing policies and the negative consequences of house price increases on the wider economy. The findings call for Chinese government to take actions to counter house price inflation. Measures such as restrictions of purchases, implementation of property-holding tax and tightening of mortgage terms may help to fight speculative market behaviour (Głuszek et al., 2018), curb house price inflation and lessen its negative effect on the growth of industrial sector. On the other hand, this policy may be less effective if it is merely implemented at the aggregate level. Because the negative effect of house prices inflation is stronger when the housing market is persistently buoyant, the need of such policy actions is particularly urgent for such periods. Similarly, tougher measures should be taken to curb the fast growth of house prices in under-developed cities to protect industrial growth. In the same time, government can allow for mild growth of house prices in better-developed cities as this will not hinder industrial growth in a significant way.

We should note that these policy recommendations seem to run against the neo-liberal idea that emphasises the market enabling function. Moreover, because real estate prices are determinants of real estate investments which create demand for industrial goods, policies that suppresses house prices are also likely to negatively affect industrial growth. Care needs to be taken when implementing policies to counter rising house prices.

The study has several limitations. First, although our model includes variables about the characteristics of cities that are considered to influence industrial growth, the effects of house prices may still be confounded by other factors. These may include other city specific and region-specific idiosyncrasies that may also influence industrial growth. Yet data constraints do not allow us to control for these effects. Second, the study acknowledges that house prices may influence industrial growth positively or negatively. Our study, however, does not examine when the negative effects outweigh the positive effects or vice versa. Similarly, our study has considered various channels through which house prices influence industrial growth, but it does not consider which channels are more important than others. As these channels are interrelated, further research is needed to isolate the effects of each individual channels and how these channels interact to jointly influence industrial growth.

Notes

1. From the spirit of Cobb-Douglas production function, more city level antecedents of industry growth, such as capital, labour and R&D should be included in the model. However, data for these variables are typically published annually rather than monthly. Therefore these variables are not included in the model.
2. For convenience of expression, we use one month lag for the house price variable in Model (2) below, but Table 2 will show the results using lags of 1, 2, 3, and 4 months, respectively.

3. Wind Information Co., Ltd (Wind Info) is a leading integrated service provider of financial data, information, and software. The Wind data are frequently used by media, consultants and academics.
4. The results are available from authors
5. More technical details can be found in Bry and Boschan (1971).

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