International Review of Economics and Finance 96 (2024) 103541

Contents lists available at ScienceDirect

International Review of Economics and Finance

journal homepage: www.elsevier.com/locate/iref

Has fiscal expansion inflated house prices in China? Evidence from an estimated DSGE model

Chunping Liu [a], Zhirong Ou [b,*]

[a] Nottingham Trent University, UK
[b] Cardiff University, UK

ARTICLE INFO

JEL classification:
E62
R31

Keywords:
Fiscal policy
House prices
China
DSGE model

ABSTRACT

We evaluate the impacts of government spending and government investment on the house price dynamics in China during its Great Housing Boom. Government spending is defined as public expenditures on non-productive public goods and services, while government investment is defined as expenditures on productive public capital. By estimating a DSGE model which allows for potential non-separability between government spending and housing in household utility, and a policy feedback rule governing government investment, we find: (a) government spending exhibits a crowding-out effect on housing consumption, though empirically it does not affect the housing price much; (b) government investment, which exhibits a strong wealth effect on household income and then the demand for houses, affects the housing price positively and substantially; (c) both government spending and government investment are effective instruments for stimulating output, but given that government investment can inflate house prices unnecessarily, policy makers who aim to stimulate the economy without destabilising the housing market would be better off utilising government spending.

1. Introduction

In this paper we study the impact of fiscal policy on the dynamics of house prices in China. The research is motivated by three observations. First, while the 'Great Housing Boom' (Chen & Wen, 2017) of China has triggered an extensive discussion on what made it happen, existing studies have revealed very little about the role played by the fiscal policy – a device frequently used by the Chinese government to intervene in the economy. Second, the 'Tiebout hypothesis' (Tiebout, 1956) suggests that government spending can affect the housing price positively if it results in better provision of public goods and services that improve the quality of living; but while this is supported by some early empirical work (Afonso & Sousa, 2009; Aye et al., 2014; Khan & Reza, 2016; Oates, 1969, 1973), it remains unclear how this could (and whether it will) happen in a structural model that allows for the potential non-separability between government spending and housing.[1] Last but not least, local governments in China are the main investors in many major infrastructural projects, and some of these governments rely heavily on land sales proceeds – a phenomenon known as 'land financing'; while these give the perception that 'government investment inflated house prices as house developers passed on the cost of lands to the price of houses', the transmission mechanism is never explained with a model, nor is this statement ever tested. We argue that the existing literature is lacking a theory that carefully addresses how these important fiscal instruments have affected the house price boom in China, which is the gap we aim to fill in this research.

* Correspondence to: B14, Aberconway building, Colum Drive, Cardiff, CF10 3EU, UK
E-mail address: ouz@cardiff.ac.uk (Z. Ou).

[1] Indeed, there is also evidence against Tiebout; *e.g.*, Brasington (2002), Hilber and Mayer (2009) and Hilber (2011) find the degree of capitalisation depends on the scarcity of lands/houses; Ruiz and Vargas-Silva (2016) find house prices respond little to government spending.

https://doi.org/10.1016/j.iref.2024.103541
Received 19 June 2022; Received in revised form 3 January 2024; Accepted 25 August 2024
Available online 6 September 2024

The state-of-the-art approach to structural analysis of the housing market has been, since Iacoviello (2005) and Iacoviello and Neri (2010), based on a New Keynesian model with (heterogeneous) households, entrepreneurs, retailers, and a central bank governing the monetary policy. Fiscal policy (usually represented by 'government spending') in most cases is either omitted, or if not, condensed to an exogenous AR(1) process in log which by construction would only affect the market aggregate but not the ways in which market interactions happen. The intuition behind this simplification is that in major free economies fiscal policy was much less used for intervening in the economy, at least before the emergence of the 'Zero Lower Bound' problem. When this type of model is applied to the Chinese market, such a convention is mostly followed. Thus, Minetti et al. (2019), Ng (2015) and Wen and He (2015) have all omitted the public sector, so government spending is not given a role; on the other hand, while government investment has been effectively accounted for as part of 'total investment' in these works, none of them has distinguished it from private investment and so, none has been able to disentangle the impact of this instrument, either. He et al. (2017), Liu and Ou (2021) and Hu (2022) have not omitted government spending; but they only let it follow an AR(1) process as just mentioned. Zhou and Jariyapan (2013) and Guo et al. (2015) have both modelled government investment explicitly; but they both force government investment to be driven by land sales proceeds which is a misconception of the land financing feature of China, since the proceeds – being part of the government's revenue supporting its policy – are not themselves targets driving that policy.

Our account of the role of fiscal policy is innovative in two aspects. First, we allow for the potential non-separability between housing and government spending in the utility function of households. The idea follows the literature on the allowance of non-separability between private consumption and government spending (*e.g.*, Bouakez & Rebei, 2007; Cardia et al., 2003; Féve & Sahuc, 2015; Marattin & Palestini, 2013), though here we replace private consumption with housing for the Tiebout hypothesis to be allowed for. As can be seen from our model below, this modification of the otherwise standard CRRA utility function allows the marginal utility of housing to vary with the level of government spending; if the marginal utility is a rising function of government spending, government spending complements housing and hence, the more public goods and services are provided, the more housing services are demanded, as predicted by the Tiebout hypothesis. However, we do not impose any assumption about the variables' empirical relation; instead, we let the data decide whether government spending promotes or suppresses housing consumption, or the two variables just have no intrinsic link. Second, in modelling government investment under the context of land financing, we let government investment be driven by a policy feedback rule in the spirit of Leeper et al. (2010) where the instrument is driven by the policy's targets, rather than the solution of the government budget equation.[2] Land sales proceeds in our case only finance, but not drive, government investment, though government does collateralise them in borrowing to raise funds. Nevertheless, since government investment is governed by the feedback rule, such borrowing – like the proceeds themselves – would have no direct impact on the investment. Both these revenues would only affect the amount of tax to be levied and we let this be a lump-sum tax in the model.

By estimating our model using the Bayesian method with data between 2004 and 2016, we find: (a) Government spending is a substitute, instead of a complement, for housing. In contrary to 'crowding in' housing consumption as the Tiebout hypothesis would predict, it 'crowds out' housing, causing house prices to fall on impact. However, in practice such an impact is hardly significant as shocks to the spending are generally small. (b) Government investment inflates house prices. It is the second most important determinant of house prices (after housing demand) in the short and medium runs, and it becomes dominating in the long run. Historically, it revitalised the lacklustre market after the Financial Crisis, via a strong wealth effect on household income which shifted up the demand for houses. (c) Government spending and government investment both exhibit a multiplier effect on output. But while investment is much more effective in stimulating growth — the investment multiplier being some four times as big as the spending multiplier, it also exhibits a multiplier effect on house prices such that it can only stimulate growth at the cost of house price inflation; by contrast, although spending is less effective in stimulating growth, it can do so without destabilising house prices as it hardly affects them. Thus, fiscal expansion with a view of stimulating growth should take into account its impact on house prices when the 'right' instrument is to be chosen.

This paper — being the first to examine the Tiebout hypothesis of 'capitalisation of government spending into house prices' in a structural model, and one of the few efforts which model the government's investment behaviour using an explicit policy feedback rule while taking the land financing feature of China seriously — uncovers the importance of government investment that existing studies have never documented. While we still echo the widely-accepted conclusion that housing demand shock dominates the determination of house prices, we point out that these studies overstated its role. Stabilisation of the housing market requires Chinese officials to be more cautious about the side effect of government investment on house prices.

The rest of this paper is organised as follows: Section 2 constructs the DSGE model; Section 3 estimates the model using the Bayesian method; Section 4 analyses the roles of government spending and government investment in the determination of house prices; Section 5 concludes.

2. Model

Our model is a variant of the canonical Iacoviello (2005) model, modified to allow for capitalisation of government spending (the Tiebout hypothesis), a government investment fiscal rule, and the unique features of land financing in China. There are two types of households, one 'Ricardian' and one 'non-Ricardian', both consume, buy houses, and work in both the goods and housing sectors. Entrepreneurs produce intermediate goods and houses using labour, capital and land. Retailers convert intermediate goods

[2] See also Bhattarai and Trzeciakiewicz (2017).

to final products sold to households. Monetary policy is governed by a Taylor rule. Government spending follows an AR(1) process, but under the assumption of non-separability between housing and government spending it enters the household utility functions. Government investment is governed by a fiscal feedback rule; like private investment, it is converted to 'public capital' which we assume will improve the efficiency of production in the goods sector. Government is the sole provider of land. The whole government expenditure is financed by a lump-sum tax, land sales proceeds, and borrowing backed by such proceeds expected in the future. The working of the model is detailed below.

2.1. Ricardian households

Ricardian households are labelled 'R'. They consume (c_t^R), buy houses (h_t^R) and work ($n_{c,t}^R$ and $n_{h,t}^R$) for both goods and housing productions, and have lifetime utility:

$$U_0^R = E_0 \sum_{t=0}^{\infty} (\beta^R)^t j_t \left\{ \begin{array}{l} \Gamma^R \ln\left(c_t^R - \vartheta c_{t-1}^R\right) + \phi_t \ln\left(h_t^R + \mu \frac{g_{s,t}}{q_{h,t}}\right) \\ -\frac{\psi_t}{1+\eta^R}\left[(n_{c,t}^R)^{1+\xi^R} + (n_{h,t}^R)^{1+\xi^R}\right]^{\frac{1+\eta^R}{1+\xi^R}} \end{array} \right\} \tag{1}$$

where β^R is the discount factor, Γ^R is a scaling factor,[3] ϑ is the degree of consumption habit persistence, η^R is the inverse of wage elasticity, ξ^R is the substitutability between labour in different sectors, and j_t, ϕ_t and ψ_t are shocks to time preference, housing demand and labour supply, respectively.

Eq. (1) distinguishes itself from a 'standard' utility function in that housing is non-separable from government spending ($g_{s,t}$) normalised by the real housing price ($q_{h,t}$). This is to allow for the Tiebout hypothesis (Tiebout, 1956) which suggests that government spending, *e.g.*, on municipal amenities, health and security services, education and environment, can improve the quality of living, such that – if it crowds in consumption on housing – it will be 'capitalised' into house prices. When $\mu \in [-1, 1] < 0$, government spending and housing are complementary; when $\mu > 0$, they are substitutes; when $\mu = 0$, the utility function reduces to the standard case where the marginal utility of housing is independent of government spending. Since the Tiebout hypothesis requires complementarity between government spending and housing, the estimate of μ can be used to evaluate to what extent this basic assumption is met. However, it is worth noting that our model is not itself a version of the Tiebout model which was originally designed to study how local public goods provision affects cross-jurisdiction residential movement and hence, need not be restricted by the full set of Tiebout model assumptions.

Ricardian households are house owners who also rent houses to non-Ricardian households. They also buy private capital, rent it to entrepreneurs, and resell the undepreciated capital back to capital producers at the end of each period. The Ricardian household budget constraint is:

$$\begin{aligned} & c_t^R + q_{h,t}\left[h_t^R - \left(1-\delta_h\right) h_{t-1}^R\right] + q_{h,t}\left[h_t^{NR} - \left(1-\delta_h\right) h_{t-1}^{NR}\right] + q_{kc,t}k_{c,t} + q_{kh,t}k_{h,t} + s_t + t_t \\ = \; & w_{c,t}^R n_{c,t}^R + w_{h,t}^R n_{h,t}^R + r_{h,t}h_t^{NR} + r_{kc,t}k_{c,t-1} + r_{kh,t}k_{h,t-1} + q_{kc,t}\left(1-\delta_{kc}\right)k_{c,t-1} + q_{kh,t}\left(1-\delta_{kh}\right)k_{h,t-1} \\ & + (1+r_{t-1})s_{t-1} + \Pi_t^K + \Pi_t^{Gds} \end{aligned} \tag{2}$$

where h_t^{NR} is the rental housing and $r_{h,t}$ is the rental rate; $k_{c,t}$ and $k_{h,t}$ are capitals in the goods and housing sectors, priced at $q_{kc,t}$ and $q_{kh,t}$, and rented at $r_{kc,t}$ and $r_{kh,t}$, respectively; $w_{c,t}^R$ and $w_{h,t}^R$ are real wages; s_t and r_{t-1} are household savings and the saving rate; δ_h, δ_{kc} and δ_{kh} are depreciation rates of houses and the two capitals; Π_t^K and Π_t^{Gds} are lump-sum profits transferred from capital producers and retailers modelled below; t_t is a lump-sum tax levied by the fiscal authority.

The Ricardian household problem is to maximise (1) by choosing c_t^R, h_t^R, h_t^{NR}, $n_{c,t}^R$, $n_{h,t}^R$, $k_{c,t}$, $k_{h,t}$ and s_t, subject to (2). The first order conditions (which we detail in Appendix A) determine their demand for goods, houses and private capitals, and their supply of labour.

2.2. Non-Ricardian households

Non-Ricardian households are labelled 'NR'. Their utility function is similar to that of Ricardian households, except that: (a) because non-Ricardian households have no access to the financial market, they are unable to optimise intertemporally but can just allocate resources *within* each period by rule of thumb; (b) because non-Ricardian households do not 'keep up with the Joneses' (Galí, 1994), their consumption exhibits no habit persistence.

Non-Ricardian households are modelled as house renters. In each period they maximise:

$$U_t^{NR} = \ln c_t^{NR} + \phi_t \ln\left(h_t^{NR} + \mu \frac{g_{s,t}}{q_{h,t}}\right) - \frac{\psi_t}{1+\eta^{NR}}\left[(n_{c,t}^{NR})^{1+\xi^{NR}} + (n_{h,t}^{NR})^{1+\xi^{NR}}\right]^{\frac{1+\eta^{NR}}{1+\xi^{NR}}} \tag{3}$$

by choosing c_t^{NR}, h_t^{NR}, $n_{c,t}^{NR}$ and $n_{h,t}^{NR}$, subject to:

$$c_t^{NR} + r_{h,t}h_t^{NR} = w_{c,t}^{NR}n_{c,t}^{NR} + w_{h,t}^{NR}n_{h,t}^{NR} \tag{4}$$

[3] $\Gamma^R \equiv \frac{1-\vartheta}{1-\vartheta\beta^R}$. This is to ensure the marginal utility of consumption is equal $\frac{1}{\bar{c}^R}$ in the steady state (See *e.g.*, Iacoviello & Neri, 2010).

where parameters/variables have their usual meanings. The first order conditions determine the non-Ricardian household demand for goods and houses, and their supply of labour.[4]

2.3. Entrepreneurs

Entrepreneurs are labelled 'E'. They are producers of intermediate goods (y_t) and houses (ih_t), with technologies:

$$y_t = \left[Z_{c,t}(n^R_{c,t})^{\alpha}(n^{NR}_{c,t})^{1-\alpha}\right]^{1-u_c}(k_{c,t-1})^{u_c}\left(k_{g,t-1}\right)^{\varsigma} \tag{5}$$

and

$$ih_t = \left[Z_{h,t}(n^R_{h,t})^{\alpha}(n^{NR}_{h,t})^{1-\alpha}\right]^{1-u_h-v_h}(k_{h,t-1})^{u_h}(l_{t-1})^{v_h} \tag{6}$$

where $Z_{c,t}$ and $Z_{h,t}$ are sectoral productivities; α, u_c, u_h, ς and v_h are input shares. Goods production is assumed to be determined partially by public capital ($k_{g,t-1}$), converted from government investment which we model later in the public sector problem. This is to reflect the substantial investment in infrastructures by the Chinese government, which is believed to have a profound impact on China's production over the past decades.[5] House production also involves the use of land (l_{t-1}).

Entrepreneurs have lifetime utility:

$$U^E_0 = E_0\sum_{t=0}^{\infty}(\beta^E)^t j_t \Gamma^E \ln(c^E_t - \vartheta c^E_{t-1}) \tag{7}$$

where parameters/variables have the usual meanings (however, $\beta^E < \beta^R; \Gamma^E \equiv \frac{1-\vartheta}{1-\vartheta\beta^E}$). Their budget constraint is:

$$\begin{aligned} & c^E_t + r_{kc,t}k_{c,t-1} + r_{kh,t}k_{h,t-1} + q_{l,t}l_t + (1+r_{t-1})b^E_{t-1} \\ & + w^R_{c,t}n^R_{c,t} + w^R_{h,t}n^R_{h,t} + w^{NR}_{c,t}n^{NR}_{c,t} + w^{NR}_{h,t}n^{NR}_{h,t} \\ = \; & \frac{y_t}{x_t} + q_{h,t}ih_t + b^E_t \end{aligned} \tag{8}$$

of which $q_{l,t}$ and $1/x_t$ are real prices of land and intermediate goods, and borrowing (b^E_t) is constrained by the discounted value of asset – put as collateral – at maturity:

$$b^E_t \le \varpi^E \frac{E_t(q_{l,t+1}l_t)}{1+r_t} \tag{9}$$

where ϖ^E is the loan-to-value ratio.

Entrepreneurs maximise (7) by choosing c^E_t, $n^R_{c,t}$, $n^R_{h,t}$, $n^{NR}_{c,t}$, $n^{NR}_{h,t}$, $k_{c,t-1}$, $k_{h,t-1}$, l_t and b^E_t, subject to (5), (6), (8) and (9). The first order conditions determine their demand for goods, labour, rental (private) capitals and land. The collateral condition pins down the demand for loans. The production functions determine the supply of intermediate goods and houses at the optimum.

2.4. Capital producers

Private capital is produced by capital producers. In each period, they buy old undepreciated capital from Ricardian households and recast it with new investments $i_{c,t}$ and $i_{h,t}$. The accumulation process follows:

$$k_{c,t} - k_{c,t-1} = \varepsilon_t(i_{c,t} - adj_{i_c,t}) - \delta_{kc}k_{c,t-1} \tag{10}$$

and

$$k_{h,t} - k_{h,t-1} = \varepsilon_t(i_{h,t} - adj_{i_h,t}) - \delta_{kh}k_{h,t-1} \tag{11}$$

where the costs are:

$$adj_{i_c,t} = \frac{\zeta_c}{2}\left(\frac{i_{c,t}}{i_{c,t-1}} - 1\right)^2 i_{c,t} \tag{12}$$

and

$$adj_{i_h,t} = \frac{\zeta_h}{2}\left(\frac{i_{h,t}}{i_{h,t-1}} - 1\right)^2 i_{h,t} \tag{13}$$

ζ_c and ζ_h govern the marginal costs; ε_t is the shock to investment efficiency.

[4] Mankiw (2000), Galí et al. (2007), Straub and Coenen (2005) and Marto (2013) are earlier examples. For a setup more similar to ours, see Alpanda and Zubairy (2016).

[5] See also Guo et al. (2015) and Wang and Wen (2017). A good example of this would be the rapid expansion of the highway and high-speed rail networks over the past 10–15 years.

New capital produced is sold to Ricardian households (who thereupon rent it to entrepreneurs). Capital producers have lifetime profit:

$$E_0 \sum_{t=0}^{\infty} (\beta^R)^t V_{0,t} \Pi_t^K \tag{14}$$

where profit in each period is[6]:

$$\Pi_t^K = q_{kc,t} k_{c,t} + q_{kh,t} k_{h,t} - q_{kc,t}\left(1-\delta_{kc}\right) k_{c,t-1} - q_{kh,t}\left(1-\delta_{kh}\right) k_{h,t-1} - i_{c,t} - i_{h,t} \tag{15}$$

The optimisation problem is to find $i_{c,t}$ and $i_{h,t}$, subject to (10)–(13), such that (14) is maximised. The first order conditions determine the two investments, hence, the supply of private capitals.

2.5. Retailers

Retailers convert intermediate goods to differentiated final products sold to households. Differentiation in products creates market power whereby we assume retailers are able to set prices in the spirit of Calvo (1983) here. We follow Smets and Wouters (2003) to let the fraction who are able to reoptimise be $1-\omega$, while the rest update prices following an indexation rule. Under the standard setup,[7] the optimal pricing strategy of retailers implies the New Keynesian Phillips curve:

$$\pi_t = \frac{\beta^R}{1+\beta^R\epsilon} E_t \pi_{t+1} + \frac{\epsilon}{1+\beta^R\epsilon}\pi_{t-1} + \frac{(1-\omega)(1-\omega\beta^R)}{\omega(1+\beta^R\epsilon)}(-\hat{x}_t) + \hat{\varepsilon}_{\pi,t} \tag{16}$$

which relates inflation (π_t) to change in real marginal cost of production ($\hat{x}_t$), given expected future and past inflations. $\hat{\varepsilon}_{\pi,t}$ is the inflation shock.

Normalising the general price level to 1, the retailer profit in each period equals:

$$\Pi_t^{Gds} = (1 - \frac{1}{x_t}) y_t \tag{17}$$

We let this be transferred as a lump-sum to Ricardian households.

2.6. The public sector

2.6.1. Monetary policy

Monetary policy follows a Taylor rule[8]:

$$1 + R_t = (1 + R_{t-1})^{\rho_R} (1+\pi_t)^{(1-\rho_R)\varphi_\pi} \left(\frac{gdp_t}{\overline{gdp}}\right)^{(1-\rho_R)\varphi_x} (1+\bar{r})^{(1-\rho_R)} \varepsilon_{MP,t} \tag{18}$$

where nominal interest rate (R_t) responds to inflation and GDP (φ_π and φ_x), and is 'smoothed' by ρ_R. $\bar{r}$ is the steady-state value of real interest rate. $\varepsilon_{MP,t}$ is the monetary policy shock.

2.6.2. Fiscal policy

Fiscal policy is a combination of government spending ($g_{s,t}$) and government investment ($g_{i,t}$). The former embraces all non-productive expenditures on public goods and services, such as education, social security, health care and municipal amenities; the spending is allowed to affect the marginal utility of housing as specified by (1) and (3). The latter embraces all productive expenditures which will form capital for production, such as expenditures on the construction of transportation, water and power facilities; the investment is assumed to affect the efficiency of goods production as specified by (5). This categorisation is consistent with Aschauer (1989).

Government spending is determined exogenously, following:

$$g_{s,t} = \varepsilon_{gs,t} \bar{g}_s \tag{19}$$

where $\bar{g}_s$ is the steady-state value of $g_{s,t}$, and $\varepsilon_{gs,t}$ is the government spending shock.

---

[6] This is assumed to be owned by and fully transferred in the end of each period to households. $V_{0,t} \equiv \lambda_t^R/\lambda_0^R$ in (14) is the marginal rate of substitution between incomes received in periods 0 and t, where $\lambda_{i=0,t}^R$ is the Lagrangian multiplier in the Ricardian household optimisation problem.

[7] That is, the retailer lifetime profit $E_0 \sum_{t=0}^{\infty} \left(\omega\beta^R\right)^t V_{0,t} \left[\left(\frac{p_t(j)}{p_t}\right) - \frac{1}{x_t}\right] y_t(j)$, the indexation rule $p_{t+i}(j) = p_t(j)\left(\frac{p_{t+i-1}}{p_{t-1}}\right)^{\epsilon}$ (Christiano et al., 2005), the demand aggregator $y_t(j) = \left[\frac{p_t(j)}{p_t}\right]^{-\theta} y_t$ (Dixit & Stiglitz, 1977), and the general price aggregator $p_t = \left[\int_0^1 p_t(j)^{1-\theta} dj\right]^{\frac{1}{1-\theta}}$. j is the index for individual firms; ϵ is the degree of inflation indexation; θ is the price elasticity.

[8] We use a Taylor rule here for the sake of circumventing the well-known difficulties in measuring monetary aggregates due to financial deregulation and innovation (A good example for China would be the recent boom in electronic payment methods such as Alipay and Wechat Pay). A money supply rule may well be used, though it would not alter the way the main variables in our model respond to a 'monetary policy shock'. The Taylor rule here can be interpreted as an implicit interest rate target the PBoC aims to achieve — by whatever means, whether using money supply, guidance, or other policy instruments.

Government investment stabilises GDP and public debt in the form of Leeper et al. (2010), though here feedback goes to investment, rather than spending, as in Bhattarai and Trzeciakiewicz (2017):

$$g_{i,t} = \varepsilon_{gi,t}\bar{g}_i(\frac{gdp_t}{\overline{gdp}})^{\gamma_x}(\frac{b^G_{t-1}}{\overline{b^G}})^{\gamma_b} \tag{20}$$

where γ_x, $\gamma_b < 0$, and $\bar{g}_i$ and $\varepsilon_{gi,t}$ are the steady-state value of $g_{i,t}$ and the government investment shock, respectively.

The accumulation of public capital follows:

$$k_{g,t} - k_{g,t-1} = \varepsilon_t g_{i,t} - \delta_{kg}k_{g,t-1} \tag{21}$$

where capital depreciates at δ_{kg}. For simplicity we assume there is no cost; and the investment shock confronted by government is the same as that confronted by capital producers.

The whole government expenditure is financed by a lump-sum tax, land sales proceeds, and borrowing:

$$g_{s,t} + g_{i,t} + b^G_{t-1}(1 + r_{t-1}) = t_t + q_{l,t}l_t + b^G_t \tag{22}$$

of which the last is backed by expected land sales proceeds by the time the borrowing is due (subject to ϖ^G):

$$b^G_t = \varpi^G \frac{E_t(q_{l,t+1}l_{t+1})}{1 + r_t} \tag{23}$$

$q_{l,t}l_t$ and b^G_t in (22) reflect the broad features of land financing in China we introduced at the beginning.

2.7. Market clearing

Let land supply of government be fixed at its steady-state level ($\bar{l}$), subject to a land supply shock ($\varepsilon_{l,t}$) partially affected by innovations to government investment[9]:

$$l_t = \varepsilon_{l,t}\bar{l} \tag{24}$$

This is to reflect that, under land financing, government may finance unexpected expenditure on investment projects by temporarily selling more lands to the market.

GDP is defined to be:

$$gdp_t = y_t + \bar{q}_h ih_t \tag{25}$$

where $\bar{q}_h$ is the steady-state value of housing price.

Nominal and real interest rates are linked by the Fisher Equation:

$$R_t = r_t + E_t\pi_{t+1} \tag{26}$$

General equilibrium is reached when the following conditions are satisfied:

(Goods market clearing):

$$c_t + i_t + g_{s,t} = y_t \tag{27}$$

where $c_t = c^R_t + c^{NR}_t + c^E_t$, $i_t = i_{c,t} + i_{h,t} + g_{i,t}$.

(Housing market clearing):

$$h^R_t - \left(1 - \delta_h\right)h^R_{t-1} + h^{NR}_t - \left(1 - \delta_h\right)h^{NR}_{t-1} = ih_t \tag{28}$$

(Financial market clearing):

$$s_t = b^E_t + b^G_t \tag{29}$$

All shocks in the model are let follow an $AR(1)$ process.

3. Estimation

The model is estimated using the Bayesian method. Parameters known to be hard to identify or sensitive to model specification in the DSGE literature are calibrated for key features of the data to be met. Other parameters are estimated based on their prior distributions. The posteriors are found by the Monte Carlo optimisation routine (random-walk Metropolis), with a total of 1,000,000 draws from two independent Markov Chains, discarding for each of these the first 50% as burn-in. Convergence of the Markov Chains is diagnosed with the standard trace plots which confirm the chains are well mixed and there is no trend in the sampled values.

[9] See equation (A.65) in Appendix A.

Table 1
Calibrations.

Parameter	Value	Parameter	Value
β^R	0.975	δ_{kc}	0.1
β^E	0.97	δ_{kh}	0.12
u_c	0.53	δ_{kg}	0.1
ς	0.22	$\bar{\phi}$	0.16
u_h	0.2	ϖ^E	0.6
υ_h	0.1	ϖ^G	0.6
δ_h	0.015	$\bar{x}$	1.1

Table 2
Steady-state ratios.

Features	$\bar{c}/\overline{gdp}$	$\bar{\imath}/\overline{gdp}$	$\bar{q}_h\overline{ih}/\overline{gdp}$	$\bar{g}_s/\overline{gdp}$
Model	40.6%	37.6%	7.48%	14.3%
Data[a]	40.1%	38.0%	7.49%	14.4%

[a] Period between 2004–2016.

3.1. Calibration

We calibrate the discount factors, input shares, depreciation rates, loan-to-value ratios, and two steady-state values ($\bar{\phi}$ and $\bar{x}$), based on the Chinese data and/or established empirical literature on the Chinese economy.

We follow Liu and Ou (2021) to set the entrepreneur discount factor (β^E) to 0.97 and then, the Ricardian household discount factor (β^R) to 0.975 (which is somewhat higher), to motivate entrepreneur borrowing and ensure that the entrepreneur borrowing constraint in the steady state is binding. The share of private capital for goods production (u_c) is set to 0.53, which echoes Bai and Qian (2010). The share of public capital (ς) is set to 0.22 to follow Guo et al. (2015). Unfortunately, there is no direct evidence for shares in the housing sector. Here we set the capital share (u_h) to 0.2 and the land share (υ_h) to 0.1.[10] The former is based on the assumption that house production is generally more labour intensive so capital share in this sector is low; the latter follows Davis and Heathcote (2005), by assuming land shares for house production are similar in modern economies. The depreciation rate of houses (δ_h) is set to 0.015, and the steady-state preference to housing ($\bar{\phi}$) is set to 0.16. The combination implies a steady-state residential investment ratio ($\frac{\bar{q}_h\overline{ih}}{\overline{gdp}}$) of 7.48%, which replicates the data of 7.49%. The depreciation rates of capital for goods production (both δ_{kc} and δ_{kg}) are set to 0.1 following Wang and Wen (2017), while that for house production (δ_{kh}) is set to 0.12 – somewhat higher – to reflect the shorter service life of construction machinery (Iacoviello & Neri, 2010). The loan-to-value ratio of entrepreneurs (ϖ^E) is set to 0.6 to match the average liability ratio of industrial enterprises over the sample period (around 0.58). The same value is assigned to the LTV of government (ϖ^G), assuming that the public sector is at least as capable in accessing to loans. The steady-state price markup to intermediate products ($\bar{x}$) is set to 1.1 as estimated by Liu and Ma (2015). Table 1 summarises the calibrated parameters.

In Table 2 we compare the key steady-state ratios of our model to those of the data. The calibrations are found to have well replicated the macro evidence.

3.2. Priors

The estimated parameters are those about preferences, labour share and substitutabilities, elasticities, nominal rigidity, policies and shock processes. Since existing studies on the Chinese economy have yet to form consensus on priors of most of them, we refer to those established in the DSGE literature — however, making them sufficiently diffuse such that the posteriors are able to reflect the Chinese data.[11]

The habit in consumption (ϑ) follows a beta distribution with a mean of 0.5. μ follows a uniform distribution (within [−5; 5]) to reflect our agnostic view on whether government spending and housing are complements, substitutes, or separated. The share of Ricardian household labour (α) follows a beta distribution with a mean of 0.65 (Alpanda & Zubairy, 2016). The substitutabilities between labour skills (ξ^R and ξ^{NR}) follow a normal distribution around 0.5. The wage elasticities (η^R and η^{NR}) and investment costs (ζ_c and ζ_h) all follow a gamma distribution with means of 0.5, 0.5, 10 and 10, respectively. Inflation indexation (ϵ) and the Calvo parameter (ω) follow a beta distribution with means of 0.5 and 0.67. The interest rate responses to inflation (φ_π) and GDP (φ_x) are normally distributed around 1.5 and 0.15, while the smoothness of policy (ρ_R) follows a beta distribution with a mean of 0.75. The responses of government investment to GDP (γ_x) and debt (γ_b) are normally distributed around −0.07 and −0.4 (Leeper et al., 2010). These are summarised in Table 3.

Table 4 lists the priors of the shock parameters which are standard in the literature.

[10] These imply a labour share of 70%, which mimics Bai and Qian (2010).

[11] Figure C.1 in Appendix compares the priors and posteriors. It is clear that the data have reshaped the distributions of most parameters quite substantially. Hence, there is no clear sign that our estimation was dictated by strong priors.

Table 3
Priors and posteriors – structural parameters.

Parameter	Prior			Posterior			
	Distribution	Mean	Std. Err.	Mode	Mean	2.5%	97.5%
ϑ	Beta	0.5	0.08	0.63	0.62	0.50	0.74
μ	Uniform	0	2.89	1.18	1.10	0.89	1.25
α	Beta	0.65	0.05	0.85	0.86	0.82	0.90
ξ^R	Normal	0.5	0.1	0.56	0.56	0.38	0.75
ξ^{NR}	Normal	0.5	0.1	0.51	0.52	0.32	0.71
η^R	Gamma	0.5	0.1	0.33	0.34	0.21	0.48
η^{NR}	Gamma	0.5	0.1	0.48	0.49	0.31	0.69
ζ_c	Gamma	10	2.5	3.76	4.01	2.71	5.31
ζ_h	Gamma	10	2.5	9.39	10.1	5.45	15.13
ϵ	Beta	0.5	0.2	0.48	0.64	0.26	0.97
ω	Beta	0.67	0.05	0.92	0.92	0.90	0.94
ρ_R	Beta	0.75	0.1	0.96	0.96	0.95	0.98
φ_π	Normal	1.5	0.1	1.60	1.60	1.42	1.78
φ_x	Normal	0.15	0.1	0.12	0.12	0.08	0.16
γ_x	Uniform	−0.07	0.05	−0.07	−0.08	−0.15	−0.00
γ_b	Uniform	−0.4	0.2	−0.01	−0.06	−0.14	−0.00

Table 4
Priors and posteriors – shock processes.

Parameter	Prior			Posterior			
	Distribution	Mean	Std. Err.	Mode	Mean	2.5%	97.5%
ρ_{Zc}	Beta	0.5	0.2	0.70	0.69	0.61	0.76
ρ_{Zh}	Beta	0.5	0.2	0.91	0.89	0.81	0.96
ρ_j	Beta	0.5	0.2	0.70	0.68	0.54	0.81
ρ_ϕ	Beta	0.5	0.2	0.94	0.89	0.77	0.99
ρ_ψ	Beta	0.5	0.2	0.50	0.51	0.14	0.88
ρ_ε	Beta	0.5	0.2	0.18	0.18	0.03	0.35
ρ_π	Beta	0.5	0.2	0.22	0.24	0.03	0.46
ρ_{MP}	Beta	0.5	0.2	0.50	0.51	0.29	0.74
ρ_{gs}	Beta	0.5	0.2	0.70	0.69	0.51	0.87
ρ_{gi}	Beta	0.5	0.2	0.99	0.99	0.99	0.99
ρ_l	Beta	0.5	0.2	0.36	0.33	0.16	0.49
ρ_{lg}	Beta	0.5	0.2	0.50	0.49	0.13	0.85
$100\sigma_{Zc}$	Inv. gamma	0.1	2	7.29	7.75	6.06	9.53
$100\sigma_{Zh}$	Inv. gamma	0.1	2	12.3	12.7	10.2	15.4
$100\sigma_j$	Inv. gamma	0.1	2	1.72	1.78	1.29	2.3
$100\sigma_\phi$	Inv. gamma	0.1	2	3.10	6.72	1.56	12.7
$100\sigma_\psi$	Inv. gamma	0.1	2	0.05	0.09	0.02	0.26
$100\sigma_\varepsilon$	Inv. gamma	0.1	2	19.0	20.3	14.5	26.6
$100\sigma_\pi$	Inv. gamma	0.1	2	0.32	0.32	0.22	0.44
$100\sigma_{MP}$	Inv. gamma	0.1	2	0.05	0.05	0.04	0.06
$100\sigma_{gs}$	Inv. gamma	0.1	2	3.11	3.21	2.61	3.85
$100\sigma_{gi}$	Inv. gamma	0.1	2	2.99	3.08	2.53	3.68
$100\sigma_l$	Inv. gamma	0.1	2	12.1	12.8	10.3	15.4

3.3. Data

There are ten observable variables: total consumption, total private investment, government spending, government investment, new house production, total labour hours, inflation, real housing price, real land price, and nominal interest rate. The real-sector variables are measured in per-capita terms. All variables, except inflation and nominal interest rate, are in natural logarithm. The measurement equations connecting the observable variables to the log-linearised model are:

$$\begin{bmatrix} \ln c_t^{Obs} - \ln c_{t-1}^{Obs} \\ \ln i_t^{Obs} - \ln i_{t-1}^{Obs} \\ \ln g_{s,t}^{Obs} - \ln g_{s,t-1}^{Obs} \\ \ln g_{i,t}^{Obs} - \ln g_{i,t-1}^{Obs} \\ \ln ih_t^{Obs} - \ln ih_{t-1}^{Obs} \\ \ln n_t^{Obs} - \ln n^{Mean} \\ \pi_t^{Obs} - \pi^{Mean} \\ \ln q_{h,t}^{Obs} - \ln q_{h,t-1}^{Obs} \\ \ln q_{l,t}^{Obs} - \ln q_{l,t-1}^{Obs} \\ R_t^{Obs} - R^{Mean} \end{bmatrix} = \begin{bmatrix} \hat{c}_t - \hat{c}_{t-1} \\ \hat{\imath}_t - \hat{\imath}_{t-1} \\ \hat{g}_{s,t} - \hat{g}_{s,t-1} \\ \hat{g}_{i,t} - \hat{g}_{i,t-1} \\ \widehat{ih}_t - \widehat{ih}_{t-1} \\ \hat{n}_t \\ \pi_t \\ \hat{q}_{h,t} - \hat{q}_{h,t-1} \\ \hat{q}_{l,t} - \hat{q}_{l,t-1} \\ \tilde{R}_t \end{bmatrix} \tag{30}$$

where 'Obs' denotes the observable variables and '$Mean$' denotes the sample mean value of them, '$\wedge$' and '$\sim$' denote the percentage and level deviations of a model variable from its steady-state value, respectively.

The data is observed between 2004Q1 and 2016Q4. The time series of consumption, private investment, government spending, government investment, inflation, land price level and nominal interest rate are collected from the Center for Quantitative Economic Research (Chang et al., 2016).[12] The time series for house production and house price level are collected from the National Bureau of Statistics of China. The time series for labour hours (measured as the product of the average labour hours and total employment) is collected from the *China Statistical Yearbook of Labour*. For constructing the variables in per-capita terms, we also collect the time series for total working-age population from Oxford Economics. Appendix B details the raw data collected and the relevant adjustments required for producing the processed data. The processed data are shown by Fig. 1.

3.4. Posteriors

Posteriors of the estimated parameters are compared to the priors in Tables 3 and 4. The data are proven quite informative, as for most parameters there is a clear shift in their distributions (See also Appendix C for a graphical comparison). The most obvious changes are from the labour parameters of Ricardian households, where the data suggest a clear dominance of their input share (α), and a higher wage elasticity ($1/\eta^R$). The cost of investing in the goods sector (ζ_c) is much lower, while nominal contracts have even longer lives (ω). Monetary policy is rather smoothed (ρ_R), while government investment hardly responds to debt (γ_b). The data also identify a substituting relationship between government spending and housing (a positive estimate of μ). The shocks are mostly quite persistent (the $\rho' s$); but as their sizes (the $\sigma' s$) are considered, they are very different.

4. Fiscal policy and house prices

4.1. Is government spending capitalised into house prices?

As reviewed at the beginning of this paper, one possible way government spending could have affected house prices is via the 'capitalisation effect', whereby expansion of spending on public goods and services result in better living conditions capitalised into the value of houses. Such a 'Tiebouthypothesis' has implicitly assumed complementarity between government spending and housing. The subtext is that government spending could encourage purchase of houses, as households maximise utility by taking more housing when the marginal utility of it is boosted by the spending. The capitalisation effect is reflected by a positive response of house prices to a government spending shock.

While the literature has yet to establish a structural model for such a complementing relationship to be tested, our allowance for non-separability between government spending and housing in (1) and (3) nests the Tiebouthypothesis, for the first time ever, as a special case of $\mu < 0$. Interestingly, what we discover (as Table 3 has already reported) is that μ is well above zero, with a posterior mode of 1.18 and a 95% lower bound of 0.89. This suggests government spending and housing, instead of being complements, are substitutes to each other. While we believe this is the first evidence about the Tiebout hypothesis established with a full DSGE model, our finding with the Chinese data undermines its basis, and hence, its corollary of house price capitalisation.

Such a substituting relationship could mean that households are willing to trade living space with higher living quality provided by better public goods and services. In terms of impulse responses this would imply (on impact) a fall in the demand for houses in response to a positive government spending shock. This is precisely what we find with Ricardian households here, as Fig. 2 illustrates. The demand of non-Ricardian households is affected in a similar way, but in this case it is dominated and reversed by a wealth effect from the rise in household income.[13] The combined effect on this occasion, where the fall in the Ricardian demand outweighs the rise in the non-Ricardian demand, resolves a fall in the total demand, followed by a fall in housing price. Hence, government spending is not capitalised into house prices.

4.2. The effect of government investment

Government investment is the most frequently used fiscal instrument in China. The best known stimulus packages in the past decades include those proposed after the Financial Crisis which many, given the background of land financing, believe to have catalysed the housing boom. The general perception is that the need for land sales proceeds implies that high land costs are passed on to home buyers as inflated house prices. However, few has been able to provide an explanation on how this might be happening in the context of a structural model.

In our setting, government investment is transmitted to house prices via two channels. The first is by the wealth effect on housing demand as just mentioned but in this case it arises as government investment is converted to public capital that boosts output (Eqs. (5) and (21)). The other is by a feedback to land supply, which we assume here that an unexpected rise in the investment will lure the government into selling more land in the following period (Eq. (24), and A.65 in Appendix A). The former has a tendency of

[12] Private investment is measured by the gross fixed capital formation in the private sector (excluding investments by households, state-owned enterprises, and other non-state-owned enterprises such as joint ventures). Government investment is measured by the gross fixed capital formation invested by the general government.

[13] The same wealth effect happens to Ricardian households. But as the impulse response shows it does not dominate the crowding-out effect of government spending there.

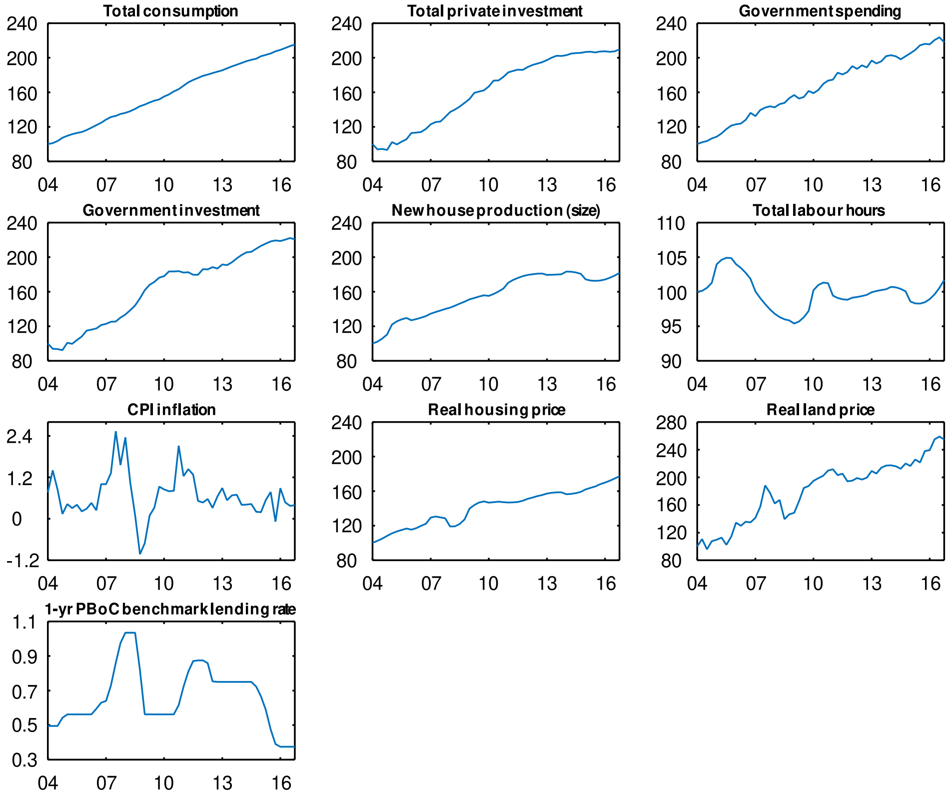

Fig. 1. Data used by measurement equations.

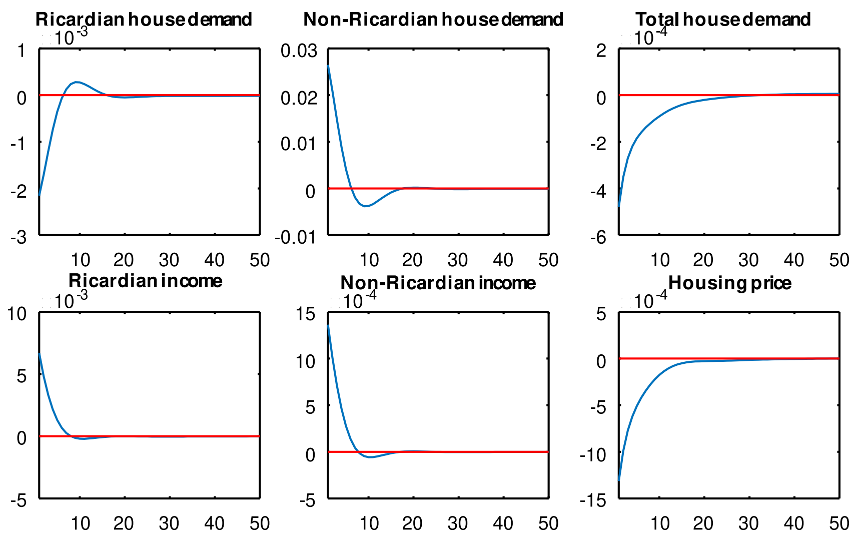

Fig. 2. Impulse responses to a government spending shock.

raising house prices, while the latter tends to lower them. The net effect is clearly a joint outcome depending on the demand/supply elasticities in both the housing and land markets.

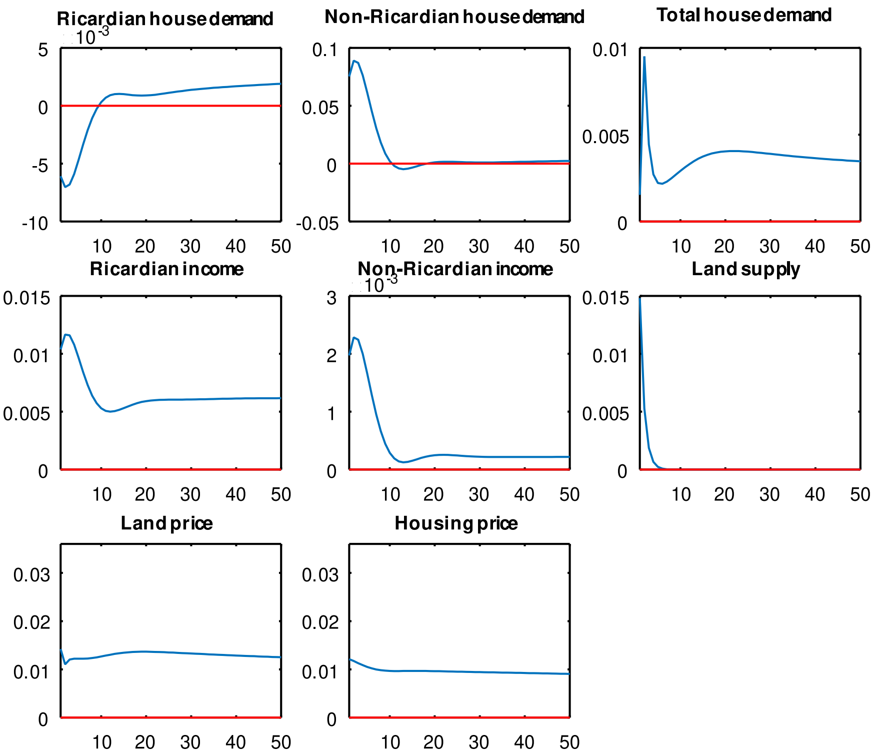

Fig. 3. Impulse responses to a government investment shock.

What we find here is that a government investment shock first raises both households' incomes and hence their demand for houses[14]; land supply rises on the other hand, but with a short-lived effect. The rise in housing demand causes a rise in land demand; the rise in land supply increases production of houses. The overall effect in the housing market is a rise in house prices (as the wealth effect dominates the offsetting effect of land supply). The overall effect in the land market is similar so that land price also rises. The impact is illustrated by the impulse responses in Fig. 3. Clearly, a positive government investment shock has a lasting, positive impact on house prices. The persistence is partially due to the shock itself as already reported for the posteriors (where ρ_{gi} has hit the theoretical boundary of 0.99, similar to Leeper et al. (2010)).

It is worth pointing that, while the above *happens to be* consistent with the perception that 'government investment leads land price to rise', the rise in land price is indeed *not the reason* why house prices have risen. As the last two paragraphs implied, the upward pressure on land price comes from the demand side as more land is needed when housing demand rises in response to a positive government investment shock. Apart from this the only other way government investment could have affected the land market would be via land supply, whose rise is a downward pressure on prices. Thus, government investment does *not* first lead to a rise in land price, which is then transmitted to house prices to reflect higher construction costs. Rather, it reaches the housing market causing a rise in housing demand and *in consequence* a rise in land demand; and housing price and land price both rise to clear the markets. Since government investment is governed by the fiscal policy rule but not the government budget constraint, the above correlations hold regardless of the way such investment is financed, whether or not by land sales proceeds (provided that it does not affect the relative price of houses as we briefly remark in the conclusion). Thus, reduced form evidence built on correlations among these variables could have been statistical artefacts which misinterpret the wealth effect as a cost pass-through.

4.3. How much do the instruments count?

We now turn to evaluate the empirical importance of the fiscal instruments. Two assessments are conducted. The first is forecast error variance decomposition (FEVD), which predicts how each shock in the model contributes to the volatility of a variable over a chosen forecast horizon. The second is historical decomposition (HD), where we first calculate the shocks that actually occurred, and then use them to reproduce how each of them has contributed in shaping the sample data. We focus on housing price and house production as per the aim of this paper.

[14] The demand of Ricardian households rises with lags, presumably due to temporary substitution of consumption demand.

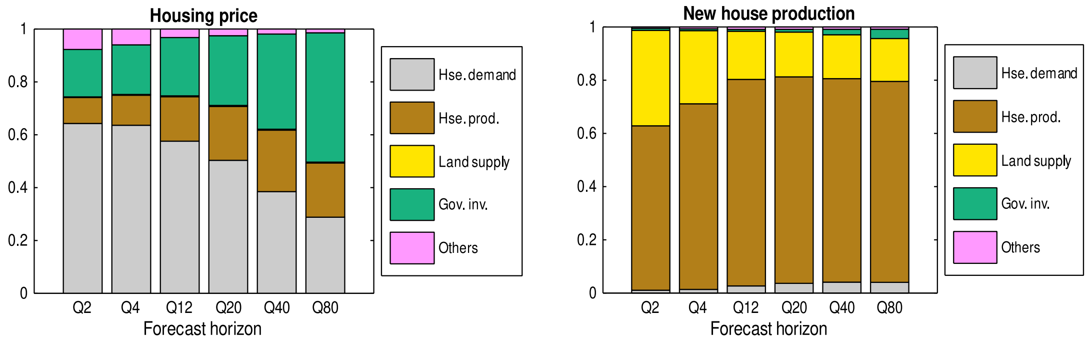

Fig. 4. Forecast error variance decompositions.

4.3.1. Forecast error variance decomposition

Fig. 4 decomposes the forecast error variance of housing price and house production over a selection of time horizons covering the short run (less than 1 year ahead), the medium run (3 to 5 years ahead) and the long run (10 years and longer).

We find that housing price is dominated by the housing demand shock (in grey), which accounts for up to 65% of its variations, in the short run, in contrast to the second and third most important determinants — government investment (green) and housing productivity (brown), which account for some 20% and 10%, respectively. While Section 4.1 has identified an impact of government spending, empirically it affects little for the shock is small; here, it is embraced by the remaining others (pink) which are mainly private investment, preference and goods-sector productivity. However as it moves towards the long run, government investment and housing productivity both become more influential. The former overtakes the housing demand shock and becomes dominating, accounting for up to 50% in the end. The housing demand shock remains important (ranked 2nd), but its impact has fallen to under 30%. The remaining is picked up by housing productivity.

On the other hand, house production is always governed by housing productivity. The shock dominates less overwhelmingly in the short run (yet, still over 60%), and more (up to 75%) in the medium and long runs. The land supply shock (yellow) contributes to a substantial portion (over 35% on average) within one year and then levels off at near 20% thereafter. Neither housing demand nor government investment affects substantially, despite their negligible 'long-run effects' caused by the persistence of the shocks. Government spending and the remaining others are not affecting, either, due to the small shock sizes.

These findings are important advances on understanding what determines house prices in China with evidence from a DSGE model. As for what has become consensus in existing studies, we confirm that housing demand shocks are the main driver, whether they are assisted by monetary policy (*e.g.*, Ng, 2015) or not (*e.g.*, Liu & Ou, 2021; Wen & He, 2015). Yet, by allowing for non-separability between government spending and housing, and government investment linked to goods production and land supply, we uncover that fiscal policy – here, found to affect via government investment – is another key determinant suppressed in previous studies built on regular monetary models designed for developed economies. Nevertheless, we do find that this only affects the house prices, but not the house production.

4.3.2. Historical decomposition

We now decompose the sample data of housing price and house production into shocks affected them to understand how cycles in the housing market were determined. The historical shocks, which we back out from the estimated model based on the observable variables, are plotted in Fig. 5. In Fig. 6 we decompose the timelines of housing price and house production.

While there are two major episodes of boom and bust of house prices, we find the upswing between 2004 and 2007 was literally a boom in housing demand, which dominated the negative impact of contraction of government investment (See also Fig. 5 for the shocks' evolution). The Financial Crisis then reversed such demands, causing a deep (but short-lived) slowdown, deepened by improved productivity in housing, in 2008. The prices then rebounded very quickly and reached the peak of a new cycle in mid-2009, as government investment surged in response to the crisis (known as the '4 Trillion Stimulus Packages'), and demand was recovering. Since 2010, a series of property purchase restrictions came into force, which greatly suppressed demand; as government investment was stabilised gradually and housing productivity improved again, housing price levelled off at just above the steady-state level between 2011 and 2013. However, as housing demand was further impaired by tighter property purchase policies (known as the 'Five New Rules of the State Council'),[15] prices fell again and found a trough (almost as deep as that during the crisis) in 2014. However, lacking strong supports from government investment (due to accumulated debt problems) on this occasion, a fast rebound did not happen. Instead, as the impact of the new policies was digested only very slowly, prices were corrected very slowly.

Turning to the cycles of production, we find booms and busts alternated much less frequently. Thus, production had been growing continuously since 2004 until a peak was reached in the end of 2011. The main contributing factor had been the rise in housing productivity, assisted a little by higher demand for houses, but offset in many occasions by a reduction in land supply. Production

[15] Principles published on February 20th, 2013, with details refined on March 1st.

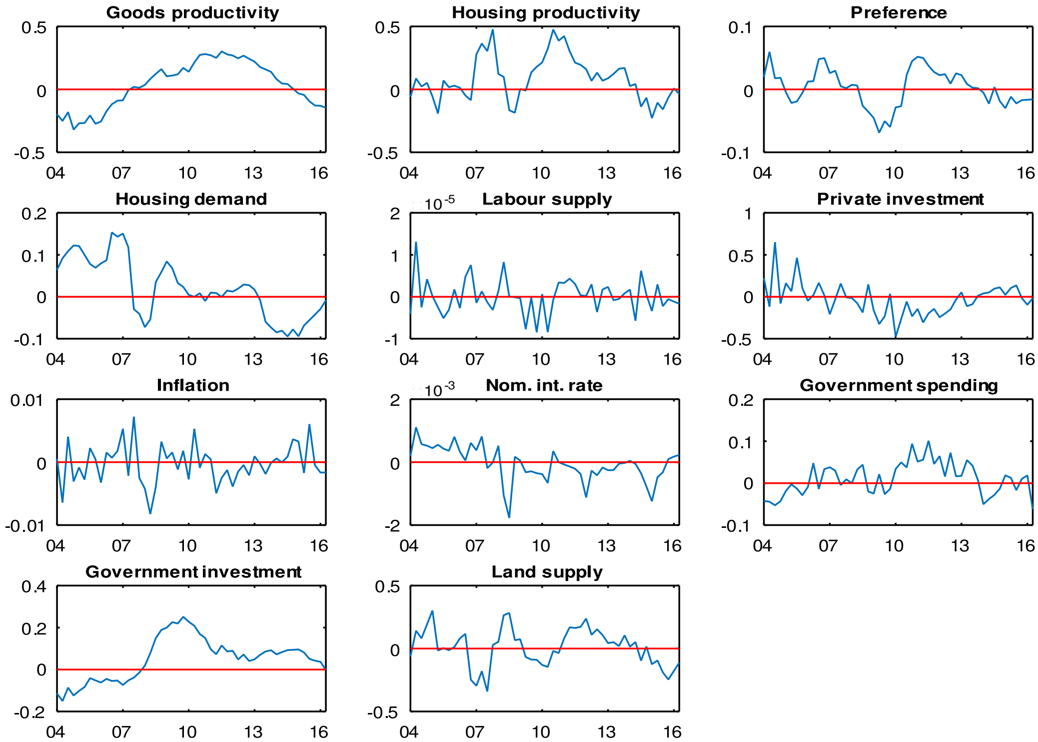

Fig. 5. Historical shocks.

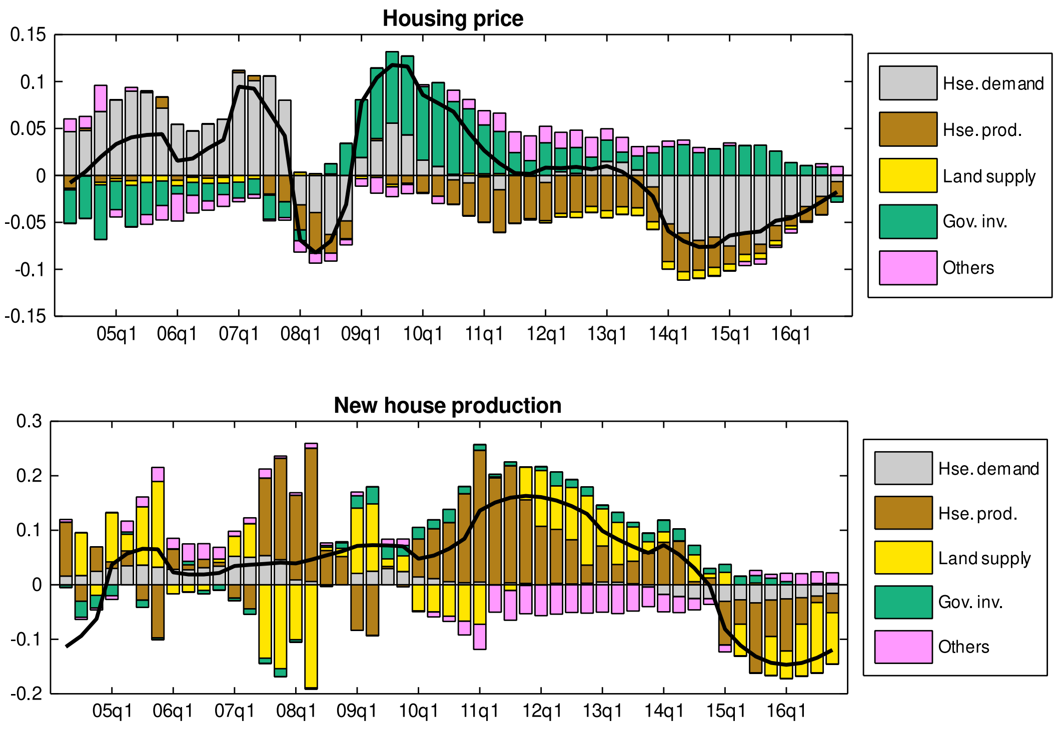

Fig. 6. Historical decompositions.

Table 5
Present value multipliers for output and house prices.

	Q1	Q4	Q12	Q20	Inf.
	Government spending multiplier				
$\frac{PV(\Delta y)}{PV(\Delta g_s)}$	1.38	1.45	1.40	1.32	1.28
$\frac{PV(\Delta q_h)}{PV(\Delta g_s)}$	−0.06	−0.07	−0.08	−0.09	−0.09
	Government investment multiplier				
$\frac{PV(\Delta y)}{PV(\Delta g_i)}$	4.70	6.34	5.45	4.87	4.53
$\frac{PV(\Delta q_h)}{PV(\Delta g_i)}$	1.78	1.72	1.57	1.53	1.46

then started to decline as productivity reduced from 2012. However as land supply remained high the pace was modest. Nevertheless, as productivity and land supply both continued to fall and reversed in 2014 (and negative housing demand was pushing), a bust happened finally.

Thus, fiscal policy affected the house price cycle with investment but its role and influence were quite varied in different episodes: when government investment was below the steady-state level before the Financial Crisis, it was a stabilising factor that prevented house prices from rising 'too immoderately' despite the boom caused by the huge demands; when it responded strongly to the crisis in 2009, it dominated the other factors and became the key destabiliser that led to the bigger boom that followed; since 2011, it had been maintained at just above the steady-state level — this time, it was the only factor corrected the market in the face of the pressure brought by tighter property purchase policies.

4.4. The fiscal multipliers

It would be helpful to know how effective these fiscal instruments are should policy-makers be confronted with targets these instruments could help to achieve. Since output is usually the variable of most concern for fiscal policy, and what this paper studies is how the latter affects housing price, we focus on the fiscal multipliers for these variables here.

We follow the recent literature (*e.g.*, Leeper et al., 2010; Mountford & Uhlig, 2009; Zubairy, 2014) to account for the cumulative effects by calculating the present value multiplier, defined as the ratio of the sum of discounted values of change in one variable over T periods, to that of another over the same time horizon.[16] The calculation is reported in Table 5.[17]

Both government spending and investment are very effective stimulus for output. The spending multiplier is greater than 1 at all horizons, which is clearly higher than those found by Mountford and Uhlig, and Leeper et al. (ranging from a negative value to no greater than 0.7 for the US). Few in the literature has studied the investment multiplier as it is rarely used in developed economies. But we find this instrument very powerful in China, being more than triple that of the spending multiplier, with the maximum effect being six times the initial investment happening one year after. By contrast, these instruments are much less effective in manipulating house prices: the spending multiplier is hardly significant at all horizons; the investment multiplier is positive and greater than 1, but its efficacy is weaker at longer horizons.

Since government spending and investment both affect output positively but their impacts on housing price are opposite, there is a combination of them which allows policy-makers to deliver a desired output without disturbing house prices, at least theoretically. Thus, any expansionary/contractionary fiscal policies need not result in unintended turbulence of house prices. Of course, how such instruments should be combined would depend on the specific targets, considering both the end objectives and time efficiency. Yet from what we calculate here, it seems that if fiscal expansion is not to destabilise the housing market, it should count more on government spending.

5. Conclusion

In this paper we investigated the role of fiscal policy in the determination of the Great Housing Boom of China. We considered both government spending and government investment — both of which are frequently used in intervening in the economy, but generally not modelled explicitly (or properly) to reflect the fiscal behaviour of the Chinese government in practice.

By estimating a canonical DSGE model which we extend to embrace potential non-separability between housing and government spending and a fiscal rule governing government investment, we find: (a) government spending crowds out housing consumption but empirically it hardly affects the housing price; (b) government investment is the second most predominant determinant of house prices in the short and medium runs, and it becomes dominating in the long run. Historically, it was what caused the rebound of house prices when housing demand had become rather slack after the Financial Crisis; (c) both government spending and government investment are effective instruments for manipulating output, but the two have opposite impacts on house prices. Unless policy is

[16] The formula we use is: $\frac{PV(\Delta Y)}{PV(\Delta X)} = \frac{E_t \sum_{i=0}^{T}(1+r^{ss})^{-i}(Y_{t+i}-\bar{Y})}{E_t \sum_{i=0}^{T}(1+r^{ss})^{-i}(X_{t+i}-\bar{X})} \approx \frac{E_t \sum_{i=0}^{T}(1+r^{ss})^{-i}\hat{Y}_{t+i}}{E_t \sum_{i=0}^{T}(1+r^{ss})^{-i}\hat{X}_{t+i}} \frac{\bar{Y}}{\bar{X}}$. The calculation in Table 5 has used the sample mean of output-spending ratio and output-investment ratio as proxies for the corresponding steady-state ratios.

[17] We also calculated the impact multipliers, which give similar numbers.

to deliver a drastic boost in output, stabilisation of the housing market would recommend any fiscal stimulus for growth to be implemented through provision of public goods and services, *i.e.*, government spending, rather than government investment.

This paper is the first to evaluate the Tiebout hypothesis of capitalisation of government spending into house prices; it is also one of the few existing efforts which model the investment behaviour of the Chinese government where the land financing feature of its budget is carefully accounted for. That we find that government investment is a key determinant of house prices establishes entirely new evidence about what drives China's house price dynamics that previous studies – by suppressing its role – have never been able to discovered. While this finding seems to be consistent with the (somehow widely spread) perception that land financing, which is a primary means of funding such investment, is liable for the house price boom, it is worth pointing that what really matters here is the investment itself, *not the way in which it is financed*. Government investment under our setting affects house prices via a wealth effect through its impact on output, and then household income and the demand for houses. While the same effect could in principle happen in any similar model that allows public capital to enter the production function, it should not be surprising that this effect is particularly strong in China given its fast public capital formation – much due to the 'GDP tournament' between its local governments which keeps boosting the aggregate level of public investment – and that the country has an arguably high public capital productivity compared to many others. Thus, although land sales proceeds (and borrowing backed by them) form part of the government revenue, the government budget constraint only determines how much tax is needed given such proceeds. *Unless the levy of tax implies a change in the relative price of houses – e.g.*, via an *ad valorem* house property tax, it hardly matters whether such investment is financed by land sale proceeds or other sources. Although a house property tax has not been levied nation-wide yet so our data do not carry information of its effect, it would be interesting to study how it would affect the role of fiscal policy should it come into play in the (likely near) future.[18] We leave this topic for future research.

Acknowledgements

We are grateful to the editor, two anonymous referees, and the participants of seminars at Cardiff University, Guizhou University, Southeastern University and Zhongnan University of Economics and Law, for insightful comments which have helped us improve the paper substantially. Any remaining errors will be ours.

Appendices

All appendices are available online at https://ars.els-cdn.com/content/image/1-s2.0-S1059056024005331-mmc1.pdf.

References

Afonso, A., & Sousa, R. (2009). *The macroeconomic effects of fiscal policy in Portugal: a Bayesian SVAR analysis*. Working Papers Department of Economics, ISEG - Lisbon School of Economics and Management, Department of Economics, Universidade de Lisboa.
Alpanda, S., & Zubairy, S. (2016). Housing and tax policy. *Journal of Money, Credit and Banking*, *48*(2–3), 485–512.
Aschauer, D. (1989). Is public expenditure productive? *Journal of Monetary Economics*, *23*(2), 177–220.
Aye, G. C., Balcilar, M., Gupta, R., Jooste, C., Miller, S. M., & Ozdemir, Z. A. (2014). Fiscal policy shocks and the dynamics of asset prices: the South African experience. *Public Finance Review*, *42*(4), 511–531.
Bai, C., & Qian, Z. (2010). The factor income distribution in China: 1978–2007. *China Economic Review*, *21*(4), 650–670.
Bhattarai, K., & Trzeciakiewicz, D. (2017). Macroeconomic impacts of fiscal policy shocks in the UK: A DSGE analysis. *Economic Modelling*, *61*, 321–338.
Bouakez, H., & Rebei, N. (2007). Why does private consumption rise after a government spending shock? *Canadian Journal of Economics*, *40*(3), 954–979.
Brasington, D. (2002). Edge versus center: finding common ground in the capitalization debate. *Journal of Urban Economics*, *52*(3), 524–541.
Calvo, G. A. (1983). Staggered prices in a utility-maximizing framework. *Journal of Monetary Economics*, *12*(3), 383–398.
Cardia, E., Kozhaya, N., & Ruge-Murcia, F. J. (2003). Distortionary taxation and labor supply. *Journal of Money, Credit and Banking*, *35*(3), 351–373.
Chang, C., Chen, K., Waggoner, D. F., & Zha, T. (2016). Trends and cycles in China's macroeconomy. *NBER Macroeconomics Annual, University of Chicago Press*, *30*(1), 1–84.
Chen, K., & Wen, Y. (2017). The great housing boom of China. *American Economic Journal: Macroeconomics*, *9*(2), 73–114.
Christiano, L. J., Eichenbaum, M., & Evans, C. L. (2005). Nominal rigidities and the dynamic effects of a shock to monetary policy. *Journal of Political Economy*, *113*(1), 1–45.
Davis, M., & Heathcote, J. (2005). Housing and the business cycle. *International Economic Review*, *46*(3), 751–784.
Dixit, A. K., & Stiglitz, J. E. (1977). Monopolistic competition and optimum product diversity. *American Economic Review*, *67*(3), 297–308.
Féve, P., & Sahuc, J. (2015). On the size of the government spending multiplier in the Euro Area. *Oxford Economic Papers*, *67*(3), 531–552.
Galí, J. (1994). Keeping up with the joneses: consumption externalities, portfolio choice, and asset prices. *Journal of Money, Credit and Banking*, *26*(1), 1–8.
Galí, J., López-Salido, J. D., & Vallés, J. (2007). Understanding the effects of government spending on consumption. *Journal of the European Economic Association*, *5*, 227–270.
Guo, S., Liu, L., & Zhao, Y. (2015). The business cycle implications of land financing in China. *Economic Modelling*, *46*, 225–237.
He, Q., Liu, F., Qian, Z., & Chong, T. T. L. (2017). Housing prices and business cycle in China: A DSGE analysis. *International Review of Economics & Finance*, *52*, 246–256.
Hilber, C., & Mayer, C. (2009). Why do households without children support local public schools? Linking house price capitalization to school spending. *Journal of Urban Economics*, *65*(1), 74–90.
Hu, Z. (2022). Six types of government policies and housing prices in China. *Economic Modelling*, *108*, Article 105764.
Iacoviello, M. (2005). House prices, borrowing constraints and monetary policy in the business cycle. *American Economic Review*, *95*(3), 739–764.
Iacoviello, M., & Neri, S. (2010). Housing market spillovers: Evidence from an estimated DSGE model. *American Economic Journal: Macroeconomics*, *2*, 125–164.

[18] Yet, two pilot projects have been running in Shanghai and Chongqing, respectively, since 2011, with different details regarding what are taxable and the relevant tax rates.

Khan, H., & Reza, A. (2016). House prices and government spending shocks. In *Carleton economic papers*. Carleton University, Department of Economics.
Leeper, E. M., Plante, M., & Traum, N. (2010). Dynamics of fiscal financing in the United States. *Journal of Econometrics*, *156*(2), 304–321.
Liu, Z., & Ma, Hong (2015). Trade liberalization, market structure, and firm markup: evidence from China. Working Paper, Available at: https://www.nottingham.ac.uk/gep/documents/conferences/2015-16/china/ma.pdf. (Accessed 29 December 2016).
Liu, C., & Ou, Z. (2021). What determines China's housing price dynamics? New evidence from a DSGE-VAR. *International Journal of Finance and Economics*, *26*(3), 3269–3305.
Mankiw, N. G. (2000). The savers-spenders theory of fiscal policy. *American Economic Review*, *90*(2), 120–125.
Marattin, L., & Palestini, A. (2013). Government spending under non-separability: a theoretical analysis. *International Review of Economics*, *61*(1), 39–60.
Marto, R. (2013). Assessing the impacts of non-ricardian households in an estimated New Keynesian DSGE model. *Swiss Society of Economics and Statistics*, *150*(4), 353–398.
Minetti, R., Peng, T., & Jiang, T. (2019). Keeping up with the Zhangs and house price dynamics in China. *Journal of Economic Dynamics & Control*, *109*(December), http://dx.doi.org/10.1016/j.jedc.2019.103778.
Mountford, A., & Uhlig, H. (2009). What are the effects of fiscal policy shocks?. *Journal of Applied Econometrics*, *24*, 960–992.
Ng, E. C. Y. (2015). Housing market dynamics in China: Findings from an estimated DSGE model. *Journal of Housing Economics*, *29*, 26–40.
Oates, W. (1969). The effects of property taxes and local public spending on property values: an empirical study of tax capitalization and the Tiebout hypothesis. *Journal of Political Economy*, *77*(6), 957–971.
Oates, W. (1973). The effects of property taxes and local public spending on property values: a reply and yet further results. *Journal of Political Economy*, *81*(4), 1004–1008.
Ruiz, I., & Vargas-Silva, C. (2016). The impacts of fiscal policy shocks on the US housing market. *Empirical Economics*, *50*(3), 777–800.
Smets, F., & Wouters, R. (2003). An estimated dynamic stochastic general equilibrium model of the Euro Area. *Journal of the European Economic Association*, *1*(5), 1123–1175.
Straub, R., & Coenen, G. (2005). Non-ricardian households and fiscal policy in an Estimated DSGE model of the Euro Area. In *Computing in economics and finance*: *vol. 102*, Society for Computational Economics.
Tiebout, C. (1956). A pure theory of local expenditures. *Journal of Political Economy*, *64*(5), 416–424.
Wang, X., & Wen, Y. (2017). Macroeconomic effects of government spending in China. *Pacific Economic Review*, 1–31.
Wen, X. W., & He, L. (2015). Housing demand or money supply? A new Keynesian dynamic stochastic general equilibrium model on China's housing market fluctuations. *Physica A. Statistical Mechanics and its Applications*, *432*, 257–268.
Zhou, Z., & Jariyapan, P. (2013). The impact of macroeconomic policies to real estate market in People's Republic of China. *The Empirical Econometrics and Quantitative Economics Letters*, *2*(3), 75–92.
Zubairy, S. (2014). On fiscal multipliers: estimates from a medium scale DSGE model. *International Economic Review*, *55*(1), 169–195.