Macroeconomic Dynamics, **20**, 2016, 1873–1905. Printed in the United States of America.
doi:10.1017/S1365100515000322

REAL ESTATE CYCLES, ASSET REDISTRIBUTION, AND THE DYNAMICS OF A CRISIS

SUPARNA CHAKRABORTY
University of San Francisco

In this paper, I explore the dynamics of real estate market fluctuations and business cycle co-movements in a neoclassical setting. Applying a dynamic stochastic general equilibrium model of collateral constraints with asset reallocation to Japan, I find that public policy shocks account well for the business cycle dynamics. In particular, taxes on land holdings of households mimic the impact of a housing preference shock, and if volatile enough, can trigger large asset price fluctuations. However, in the absence of volatility, the impact on prices is intrinsically linked to the persistence of shocks. Dependence on fixed assets such as real estate to secure collateral-based financing significantly amplifies the effect of initial shocks on the real macro aggregates. The financial accelerator works through the "redistribution channel," shifting a large fraction of the collateral between constrained and unconstrained agents in response to an external stimuli.

Keywords: Financial Accelerator, Business Cycles, Real Estate Dynamics, Land Prices, Land Reallocation, Credit Constraints, Fiscal Policy

1. INTRODUCTION

The unfolding of the recent U.S. crisis has brought to light once again the close link between the real estate market and the aggregate economy. A seemingly innocuous external trigger might lead to fluctuations in asset prices that translate into fluctuations in collateral value, eventually resulting in large macroeconomic consequences [Krishnamurthy (2010)].

The chain of events is not unique to the United States. Japan, the second largest economy in the world, saw its fair share of asset market fluctuations followed by the economic downturn during the "lost decade" of the nineties. Given the similar

I would like to express my gratitude to Dr. William A. Barnett (the Editor), the anonymous associate editor, and the anonymous referees for their valuable suggestions, which have greatly improved the manuscript. My special thanks to Dr. Zheng Liu for his advice and to numerous conference and seminar participants for their comments, which helped in modifying and improving the current version. Portions of this manuscript are derived from my dissertation at the University of Minnesota, and I thank Dr. V.V. Chari, Dr. Michele Boldrin, and Dr. Ellen McGrattan for their guidance. Financial assistance from the Faculty Development Fund of the University of San Francisco is gratefully acknowledged. All remaining errors are my own. Address correspondence to: Suparna Chakraborty, Department of Economics, University of San Francisco, 2130 Fulton Street, San Francisco, CA 94117, USA; email: schakraborty2@usfca.edu.

 1365-1005/16

experience of two of the world's largest economies, the goal of this paper is to understand the underlying link between the real estate market and the broader economy. I attempt to analyze this question in a series of steps: (1) What drives the real estate market? (2) What is the mechanics of the spillover to the broader economy? and (3) Quantitatively, how big (or small) is the effect of the spillover?

Motivated by Hoshi and Kashyap (2010), who note the similarity between the Japanese lost decade and the 2008 U.S. crisis, I choose Japan as my laboratory to investigate these three questions.

The baseline model, following the canonical models of Bernanke and Gertler (1989) and Kiyotaki and Moore (1997), is a standard real business cycle model with an endogenous collateral constraint. The model is appended to allow a dual role of real estate—-a primary residence that adds value to a consumer's utility function and an input to the production process that can also be used as collateral to secure debt financing. My choice to focus on economic fundamentals to explain real estate market movements, instead of attributing land price run-ups to a price bubble from the get-go, is guided by Garber (1990).[1] Actual choice of the primary drivers is a more complex issue.[2] One of the earliest suspects in this regard is monetary policy [Kashyap et al. (1993)]. Other potential suspects examined are fluctuations in total factor productivity or TFP [Benk et al. (2005); Jermann and Quadrini (2012)], changes in credit availability [Caballero and Krishnamurthy (2001); Peek and Rosengren (2005); Jermann and Quadrini (2012)], and fiscal changes [McGrattan and Ohanian (2010); McGrattan (2012)]. In this paper, I explore the dynamics of movements in TFP and changes in public policy related to real estate taxation, both commercial and residential, as the primary drivers of the economy.

The mechanics of the spillover, commonly referred to as the financial accelerator, is standard. Primitive shocks to the economy lead to changes in real estate value, which affect debt financing through real estate collateral, which translates into further macroeconomic fluctuations. Although theoretically straightforward, finding quantitative support for the financial accelerator has been a challenge in the literature. This paper is closely linked to and adds to several recent papers that have looked at the issue of real estate dynamics and business cycles. There are three questions examined, each related and contributing to a certain genre of literature that I discuss one at a time.

The first question examines the drivers of a real estate bubble, and I introduce the notion of a "public policy shock" in the form of time-varying taxation rules. Traditionally, the literature has found it very difficult to generate asset price volatility relying on TFP shocks alone [Kocherlakota (2000); Cordoba and Ripoll (2004)]. The failure of these earlier papers led to some new literature that looks at alternative shocks that might explain the asset price fluctuations. In a series of papers, Miao and coauthors have pinpointed some very promising alternatives. Miao et al. (2012) revisit the well-known equity premium puzzle with a new twist—they explore the role of "ambiguity aversion," where a household has no priors on the probability of a particular event happening. The role of human sentiments or preferences is then extended to study asset market bubbles in the United States. Miao et al. (2013) argue that it is the belief or the "sentiment" of a household (the lender) about the stock market value of the borrower that ends up creating or bursting a bubble, a feature also investigated by Martin and Ventura (2012). The sentiment shock can explain asset price bubbles during the 1990s and the recent 2008 bursting of the U.S. asset market bubble to a great extent.[3] Miao et al. (2014) extend a standard DSGE model to incorporate a wedge between land price and house rent to show that any shock that influences this wedge plays an important role in explaining aggregate output fluctuations.

Taking an alternative track, Liu et al. (2013) highlight the role of housing demand,[4] a channel supported by Iacoviello and Neri (2010). Liu et al. (2013) find that housing demand shocks can far outperform traditional TFP shocks in explaining asset price and business cycle movements. The fiscal shock in my model is in this second genre. I introduce land taxation policy as a primary source of land demand fluctuations, thus tying these unobserved housing demand fluctuations to data and establishing the source of such fluctuations in government policy. Next, taking a cue from the business cycle accounting literature proposed by Chari et al. (2007), I show that taxes on landholding of households have the same implications as shocks to housing preferences in the literature and apply a modified business cycle accounting procedure to evaluate the impact of such preference shocks. In addition, the tax on landholding of the entrepreneur acts like an investment shock, with a further potential to affect land prices.

Once we zero in on some possible drivers, the second question relates to how well these forces can account for the observed data. Solving the model using calibration techniques,[5] I find that the benchmark model captures the fluctuations in output and the real estate dynamics well—especially shifts in land ownership patterns. TFP, by itself, performs poorly, as expected, and the model performance improves when fluctuations in land taxes are taken into account. However, the performance of the model in matching land price fluctuations is intrinsically linked to the assumption of persistence of shocks. Assuming temporary shocks compromises the model's ability to account for price fluctuations, whereas allowing shocks to be permanent markedly improves the match. The role of persistence of shocks is understated in the literature. For example, the housing demand shock of Liu et al. (2013), which turns out to be very successful in accounting for the volatility of the data, follows an AR1 process with a persistence parameter modal value of 0.9997. Adopting a similar AR1 process for evolution of land taxes (akin to housing demand and investment shocks in our model), I show that even a persistence parameter estimate of 0.91 falls short in accounting for asset price fluctuations, but assuming a permanent shock improves the match, thus highlighting the role of persistence of shocks in explaining data.

The last question is one of amplification. My results show that the financial accelerator can often manifest itself through a redistribution of the asset holdings—what I term the "redistribution channel." A positive shock increases the incentive to hold land, thereby driving up land prices, which works to increase land value. At the same time, the heterogeneous nature of the impact of positive shocks studied creates a stronger incentive for the constrained agent to hold or dispose of land than the unconstrained agent. For example, in Japan, businesses pay a much higher statutory tax on their real estate holdings than do residence owners. Hence changes in real estate taxation policies have a greater impact on the businesses than on the unconstrained agents—a fact that can trigger significant fluctuations in real estate holding, affecting the balance sheet and collateral value. Kocherlakota (2000) first highlighted that income shocks are not enough to generate the degree of amplification that theoretical endogenous collateral constraint models promise. Cordoba and Ripoll (2004) highlight the same and provide us with an explanation. They suggest that the response of output to a shock comes from four channels: output response = (productivity gap) $\times$ (collateral share in production) $\times$ (production share of constrained agents) $\times$ (redistribution of collateral between constrained and unconstrained agents).

So all or any of these four factors can play an important role in generating amplification. The first three factors are fairly restricted when a production function is concave.[6] The difference comes in the fourth factor—the redistribution channel. Although Cordoba and Ripoll (2004) assert that the main source of amplification comes from the redistribution channel, they also highlight the difficulty of physically getting amplification through this channel. For example, when a positive shock hits the economy, the constrained entrepreneur utilizes this shock to secure more debt from the unconstrained agent and demand more production assets from the market. However, to induce the unconstrained agent to actually finance the debt, the interest rate has to rise, putting a damper on the extent of redistribution of the assets between the unconstrained and constrained agents, which limits output response.

In our model, we make this fourth factor work better by providing an additional incentive for the constrained agent to borrow, a tax shelter—where interest paid to the lender can be claimed as a deduction from the entrepreneur's corporate tax liability, which creates a wedge between the market interest rate and the "effective" interest rate that an entrepreneur has to bear. The effective rate is lower than the market interest rate. Therefore, although it remains true that a positive shock induces an increase in interest rate on loans, or the marginal cost of borrowing rises with a positive shock, entrepreneurs also have an added marginal benefit—the tax deduction that can be claimed. This tax advantage results in a greater degree of redistribution of assets in our model, which garners a better output response than previously noted. In addition, as noted earlier, income or TFP shocks are not the only primitives we rely on. We introduce land taxes that act as shocks to housing demand (for the unconstrained agent) and shocks to investment (for the constrained agent), further assisting us in getting better output responses. The third question is an attempt to revisit the rather pesky issue of finding quantitative support for the financial accelerator and explore the model dynamics to generate larger amplifications, as predicted by theory.

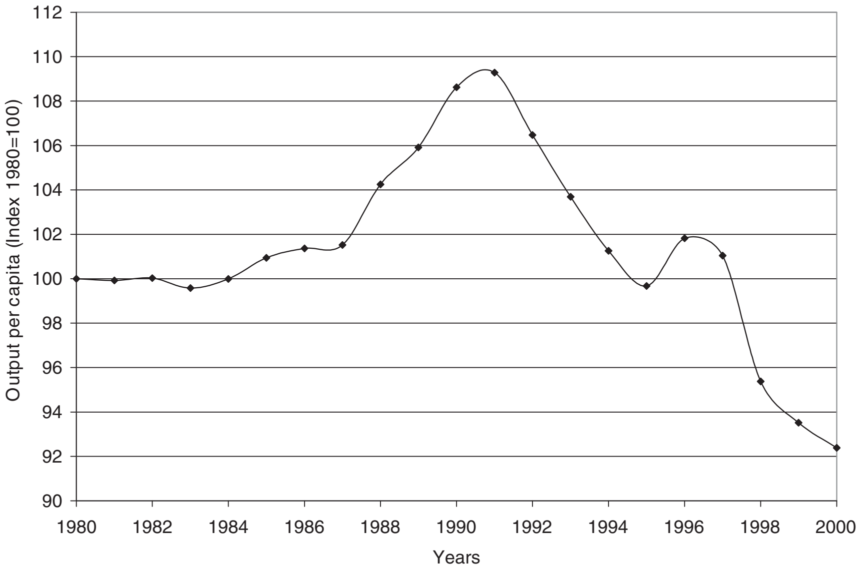

FIGURE 1. Output per capita.We measure GDP per capita during the period 1980–2000 and detrend the series by a long-term trend of 2.15%. The graph is plotted as an index with output per capita in 1980 pegged at 100.
Source: The data are from the Japan Statistical Yearbooks provided by the Statistical Bureau of Japan.

The rest of the paper is organized as follows. Section 2 discusses the empirical motivation and Section 3 discusses the model. Section 4 discusses the theoretical propositions. Numerical results and extensions are outlined in Sections 5 and 6. Section 7 concludes.

2. EMPIRICAL MOTIVATION

Japan, in the last two decades of the twentieth century, witnessed two major upheavals: in output and in real estate. As our data (source: Japan Statistical Yearbooks) reveal, after decades of growing at a constant rate, Japan experienced a sudden growth spurt during the late eighties that was rather short-lived, with a sharp decline in per capita GDP growth rate after 1991 (Figure 1).[7]

This pattern was mirrored in the real estate market (Figures 2 and 3), where average land prices increased by 109% between 1980 and 1991 (76.25% more than what land price would have been had it maintained a steady state annual rate of growth of 3%[8] per year since 1960) and then fell by 32% by 2000 (47% lower than what prices would have been averaging a steady growth of 3% per year). The price of land underlying residences increased by 108% during the eighties and then fell by 21%, while land underlying commercial properties increased by 87% between 1980 to 1991 before registering a fall of 18% by 2000.[9]

https://doi.org/10.1017/S1365100515000322 Published online by Cambridge University Press

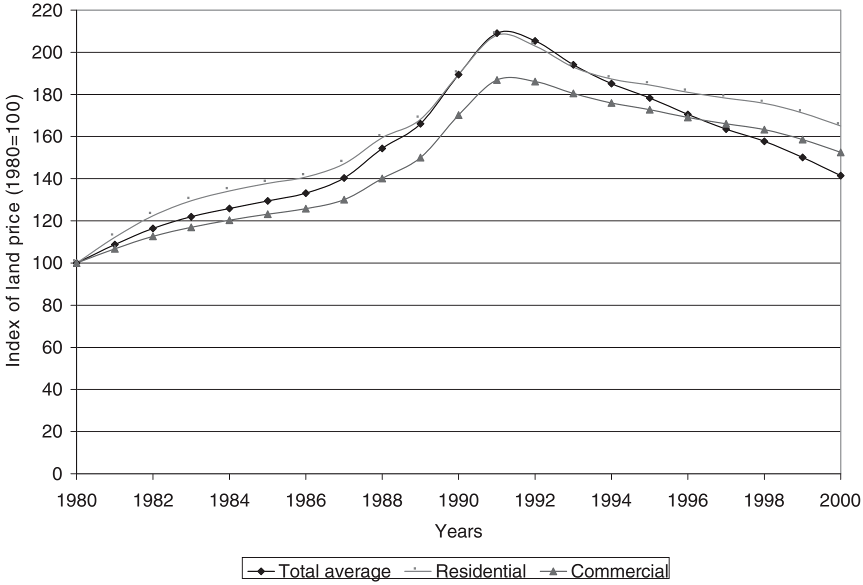

FIGURE 2. Average land prices for all of Japan (total land, residential land, and commercial land) during 1980 to 2000.
Source: The data are from the Japan Statistical Yearbooks provided by the Statistical Bureau of Japan.

During the same period, significant land redistribution occurred between the residential and corporate sectors. During the early eighties, the corporate sector held about 12% of the total land (about 13% in the top three metropolitan areas of Tokyo, Nagoya, and Osaka), which is almost 52% of its total tangible asset holding. To put these numbers into perspective, the corporate sector in the United States owns about 9% of the total land. During the late eighties, land ownership by the corporate sector went up by 20% (27% in the top three metropolitan areas), and in the nineties, land held by the corporate sector fell by 7% (almost 15% in the top three metropolitan areas) (Figure 4).[10]

While the real economy and the real estate market were witnessing historic fluctuations, economic fundamentals were also changing. Hayashi and Prescott (2002) found that whereas during the late eighties TFP grew at 3.7% (the comparable figure for the United States being 2.6%), during the nineties, it fell to 0.3%. Jorgenson and Motohashi (2005), although providing less pessimistic numbers, found a similar trend. They found that Japan's TFP growth rate declined from 1.52% in 1975–1990 to 0.56% in 1990–1995. However, afterwards it recovered slightly to 0.69% in 1995–2000.

On the policy front, two major changes were noted (among others). As Ishi (2001) reports, the government of Japan reduced the effective tax on land by more than half during the eighties in an effort to boost infrastructure to support

https://doi.org/10.1017/S1365100515000322 Published online by Cambridge University Press

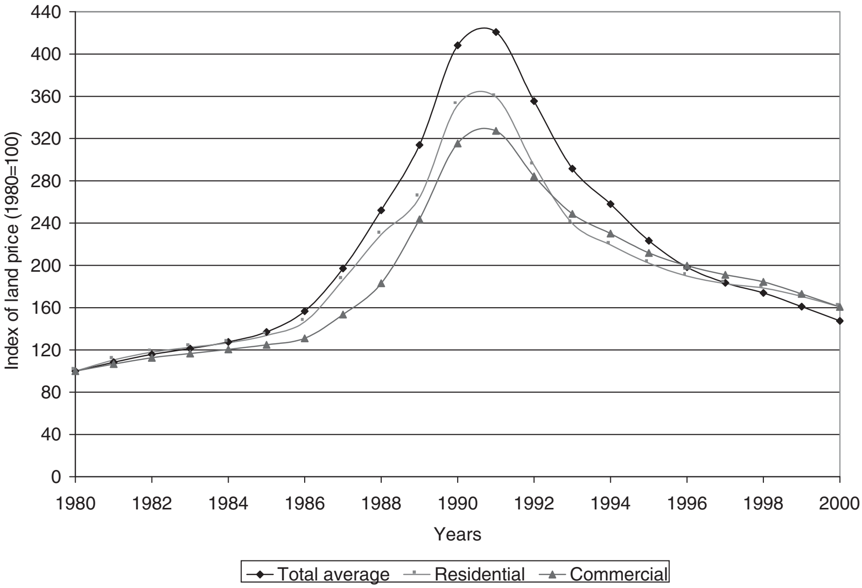

FIGURE 3. Average land prices for the six major cities, also known as the *ku*-areas (Tokyo, Nagoya, Osaka, Yokohama, Kyoto, and Kobe), during 1980 to 2000.
Source: The data are from the Japan Statistical Yearbooks provided by the Statistical Bureau of Japan.

the growing economy and provide small and medium-sized firms with additional collateral to secure investment funds. However, it started to rein in the tax cuts in the nineties and gradually increased the rates back to the early eighties level.

These changes in fiscal policy were accompanied by changes in the financial climate with financial liberalization and optimistic mortgage-backed lending to the small-scale and real estate sectors during the eighties, followed by stricter requirements on bank capital positions since the nineties.

3. THEORETICAL MODEL

3.1. General setup

I model a closed economy with two groups of heterogeneous agents: workers and entrepreneurs. Every period, there is a measure N_{1t} of workers and N_{2t} of entrepreneurs. To keep matters simple, I assume that a person is born either as an entrepreneur or as a worker and it is not possible to switch types. For simplicity, the proportion of workers to entrepreneurs every period is a constant ζ such that

$$N_{1t} = \zeta . N_{2t}. \tag{1}$$

https://doi.org/10.1017/S1365100515000322 Published online by Cambridge University Press

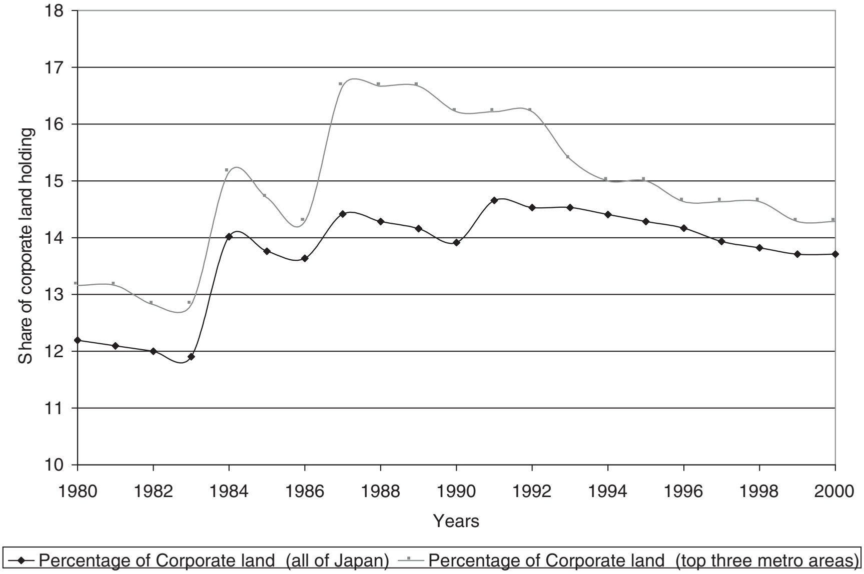

FIGURE 4. Share of corporate land holding during 1980–2000 as a percentage of total land, where total land is the sum of residential and commercial land underlying buildings. *Source*: The data on land holding are available from the Japan Statistical Yearbooks provided by the Statistical Bureau of Japan.

In my numerical analysis, I assume a constant rate of population growth η.[11] This implies that $N_{2t} = (\eta)^t N_{20}$, where N_{20} is the number of entrepreneurs in period 0, which is normalized to unity for quantitative purposes. Similarly, $N_{1t} = \zeta (\eta)^t N_{20}$. Agents are infinitely lived. Workers are endowed every period with one unit of time, spent partly in working for the entrepreneur and the rest in leisure. Workers earn income from two sources: wages and interest earnings. After-tax income is either consumed, saved, or invested in land. In my model, I assume that land holdings of the workers directly add to their utility [similarly to Iacoviello (2005)].[12]

Entrepreneurs are the owners of the production process and endowed with one unit of time. I assume that the skill sets of the entrepreneurs and workers are imperfect substitutes, so both are needed for production. The entrepreneurs derive utility from consumption of the final good and leisure.[13] Consistent with earlier literature, whereas the workers derive direct utility from consumption of land, entrepreneurs hold land exclusively for production and for collateral purposes, not for consumption.[14] Entrepreneurs combine capital, labor (of workers and their own), and land to produce final output using the available production technology. The after-tax proceeds of the output sale are used to pay wages and interest and finance consumption. Any remaining funds are invested in land and capital for future use in production. In addition to the two types of agents, the economy has a government sector that balances the budget every period. Income from taxation is spent on consumption and the rest is transferred back to the private sector.

What motivates borrowing and why is collateral important? The government of Japan, in keeping with international traditions, allows firms to deduct the interest payments on borrowed funds from the taxable corporate income. Such tax shelters are not allowed on profits on internally generated funds or funds secured by equity financing (see Proposition 1 for further discussion). This differential tax treatment of the two financing methods creates a bias towards debt financing. However, the maximum amount that an entrepreneur can borrow is restricted by the value of the collateral put forward. Land, being an important collateral asset, therefore plays an important role in the economy.[15]

3.2. Workers

The problem of the representative worker (denoted by a superscript w) is a standard one, except that it includes land holdings in the utility function. Workers maximize the present discounted value of a lifetime utility function given by $E_0 \sum_{t=0}^{\infty} \beta^t u_t^{\mathrm{w}}(c_t^{\mathrm{w}}, 1-h_t^{\mathrm{w}}, l_t^{\mathrm{w}})$, where E_0 is the expectations operator, $\beta \in (0, 1)$ is the discount factor, c_t^{w} denotes consumption of the worker at time t, l_t^{w} denotes land holdings of the worker at time t, and h_t^{w} denotes the hours worked. In our numerical analysis, we assume a standard felicity function (log linear in consumption, leisure, and land holdings),

$$u_t^{\mathrm{w}}(c_t^{\mathrm{w}}, 1-h_t^{\mathrm{w}}, l_t^{\mathrm{w}}) = \log\ c_t^{\mathrm{w}} + \alpha_1 \log\ (1-h_t^{\mathrm{w}}) + \alpha_2 \log\ (l_t^{\mathrm{w}}). \tag{2}$$

The workers maximize lifetime utility subject to a budget constraint,

$$c_t^{\mathrm{w}} + q_t(l_{t+1}^{\mathrm{w}} - l_t^{\mathrm{w}}) + \tau_{lt}^{\mathrm{w}} q_t l_t^{\mathrm{w}} + a_{t+1} \leq w_t h_t^{\mathrm{w}}(1-\tau_{ht}) + (1+r_t(1-\tau_{at}))a_t + Tr_t^{\mathrm{w}}, \tag{3}$$

where q_t denotes the price of land, w_t is the wage rate, and r_t is the rate of interest earned on savings. All prices are expressed in terms of the output (the numeraire). The workers are assessed a tax on their labor income at the rate τ_{ht}, a tax on their interest earnings at the rate τ_{at}, and a tax on their land holding at the rate τ_{lt}^{w}. The workers also get transfers Tr_t^{w} from the government every period. The after-tax earnings are used to finance consumption. The remaining portion of the income is invested in land (denoted by $l_{t+1}^{\mathrm{w}} - l_t^{\mathrm{w}}$) and saved ($a_{t+1}$). In addition to the budget constraint, the workers face the usual non-negativity constraints when they maximize their lifetime utility.

3.3. Entrepreneurs

The representative entrepreneur (denoted by a superscript e) maximizes the present discounted value of a lifetime utility function given by $E_0 \sum_{t=0}^{\infty} \beta^t u_t^{\mathrm{e}}(c_t^{\mathrm{e}}, 1-h_t^{\mathrm{e}})$, where E_0 is the expectations operator, $\beta \in (0, 1)$[16] is the discount factor, c_t^{e} denotes consumption of the entrepreneurs at time t, and h_t^{e} denotes the hours

https://doi.org/10.1017/S1365100515000322 Published online by Cambridge University Press

worked by the entrepreneurs. As distinct from the workers, land does not directly add to the entrepreneurs' utility. The felicity function is log-linear in consumption and leisure:

$$u_t^{\mathrm{e}}(c_t^{\mathrm{e}}, 1 - h_t^{\mathrm{e}}) = \log\ c_t^{\mathrm{e}} + \alpha_1 \log\ (1 - h_t^{\mathrm{e}}). \quad (4)$$

The entrepreneurs maximize lifetime utility subject to a budget constraint

$$\begin{aligned} &c_t^{\mathrm{e}} + q_t(l_{t+1}^{\mathrm{e}} - l_t^{\mathrm{e}}) + \tau_{lt}^{\mathrm{e}} q_t l_t^{\mathrm{e}} + (k_{t+1} - (1-\delta)k_t) \\ &\quad \leq (1 - \tau_{yt})(y_t - w_t h_t^{\mathrm{wd}} - \delta k_t - r_t b_t) + b_{t+1} - b_t + Tr_t^{\mathrm{e}}, \end{aligned} \quad (5)$$

where y_t is output produced at time t. The entrepreneurs are assessed a tax on their corporate income at the rate τ_{yt} and a tax on their land holding at the rate τ_{lt}^{e}. They also receive transfers Tr_t^{e} from the government every period. In addition, they can claim the wage income paid to the workers $(w_t h_t^{\mathrm{wd}})$,[17] the depreciation on their existing capital stock (δk_t), and interest paid on borrowed funds $(r_t b_t)$ as deductible from the corporate income tax calculation. Given the deductions allowed, the taxable income of the entrepreneur is given by $(y_t - w_t h_t^{\mathrm{wd}} - \delta k_t - r_t b_t)$. After the loans of the last period and the interest incurred on them have been repaid, the remaining after-tax earnings are used to finance consumption. Any remaining amount is invested in land $(l_{t+1}^{\mathrm{e}} - l_t^{\mathrm{e}})$ and capital $(k_{t+1} - (1-\delta)k_t)$. The entrepreneurs can supplement their retained earnings by borrowing $(b_{t+1} - b_t)$. However, unlimited borrowing is not allowed and the entrepreneurs face an upper limit on their borrowing:

$$b_{t+1} \leq B_{t+1}. \quad (6)$$

The constraint can be exogenously set so that $b_{t+1} \leq \overline{B}_{t+1}$, where $\overline{B}_{t+1}$ is exogenously determined and is independent of the entrepreneurs' net asset positions. In practice, most often it is endogenously determined by the wealth holding of the entrepreneurs. In my setup that means the value of capital and land holdings of the entrepreneurs determine the maximum amount that they can borrow. The borrowing constraint is modeled as a margin call [Mendoza and Smith (2006)], where the assets are deposited with the lender at the time the loans are negotiated,

$$b_{t+1} \leq \phi_t(k_{t+1} + q_t l_{t+1}^{\mathrm{e}}), \quad (7)$$

or the loan-to-value ratio determines the fraction of the net holdings that can be borrowed. ϕ_t summarizes information about the debt repudiation technology available in the economy. The idea is that in case of default, the lender liquidates the collateral to recover the loan. However, the process involves some costs that depend on the institutional or policy constraints that are prevalent in the financial markets. For example, the legal system of a country or informational constraints on the market often determine the ease with which the lender can liquidate the collateral in the case of nonrepayment of loans. Hence for any given amount of collateral pledged by the borrower ($k_{t+1} + q_t l_{t+1}^{\mathrm{e}}$ in our model), the lender is left with only a fraction of it, $\phi_t(k_{t+1} + q_t l_{t+1}^{\mathrm{e}})$, in case of delinquency. The remaining amount, $(1 - \phi_t)(k_{t+1} + q_t l_{t+1}^{\mathrm{e}})$, is spent in administrative expenses of loan recovery. Consequently, the maximum amount the lender brings to the table is determined by the net amount that the lender recovers, or $\phi_t(k_{t+1} + q_t l^{\mathrm{e}}_{t+1})$.

On the production front, the entrepreneurs own a production technology of the Cobb–Douglas form. Therefore, the production possibility constraint is given by

$$y_t \leq A_t F_t(k_t,\ l^{\mathrm{e}}_t,\ h^{\mathrm{wd}}_t,\ h^{\mathrm{e}}_t) = A_t k_t^{\theta_k} l_t^{\mathrm{e}\theta_{le}} h_t^{\mathrm{wd}\theta_{hw}} h_t^{\mathrm{e}1-\theta_k-\theta_{le}-\theta_{hw}}. \tag{8}$$

A_t is the productivity parameter and the inputs are capital, land held by entrepreneurs, labor of workers, and labor of entrepreneurs.

3.4. Government and Resource Constraints

The role of the government is a passive one. Government collects tax revenues and spends them on consumption. Any remaining amount is transferred back to the entrepreneurs and the workers to balance the budget every period. The government's budget constraint can therefore be summarized by the equation

$$\begin{aligned} &N_{1t}\left(w_t h^{\mathrm{w}}_t \tau_{ht} + r_t \tau_{at} a_t + \tau^{\mathrm{w}}_{lt} q_t l^{\mathrm{w}}_t\right) + N_{2t}\tau_{yt}(y_t - w_t h^{\mathrm{wd}}_t - \delta k_t - r_t b_t) \\ &\quad + N_{2t}\tau^{\mathrm{e}}_{lt} q_t l^{\mathrm{e}}_t \leq g_t + N_{1t} T r^{\mathrm{w}}_t + N_{2t} T r^{\mathrm{e}}_t. \end{aligned} \tag{9}$$

I complete the model by summarizing the resource constraints every period. The goods market clearing condition is given by

$$N_{1t} c^{\mathrm{w}}_t + N_{2t}\left(c^{\mathrm{e}}_t + k_{t+1} - (1-\delta)k_t\right) + g_t \leq N_{2t} y_t. \tag{10}$$

The financial market clearing condition stipulates that aggregate borrowing must be less than or equal to aggregate saving:

$$N_{2t} b_t \leq N_{1t} a_t. \tag{11}$$

In addition to the goods market and the financial market, we have the market for trade in land and the market for trade in labor, where market clearing entails

$$N_{1t} l^{\mathrm{w}}_t + N_{2t} l^{\mathrm{e}}_t \leq 1 \tag{12}$$

and

$$N_{2t} h^{\mathrm{wd}}_t \leq N_{1t} h^{\mathrm{w}}_t. \tag{13}$$

Equation (12) states that the aggregate demand for land holdings must be less than or equal to the total endowment of land in the economy, which we assume to be one unit every period. Similarly, equation (13) states that the demand for labor by the entrepreneurs every period is less than or equal to supply of labor by workers.

3.5. Equilibrium

Given exogenous productivity $\{A_t\}$, exogenous loan-to-value ratio $\{\phi_t\}$, the set of exogenous fiscal policy instruments $\{\tau_{ht},\ \tau^{\mathrm{e}}_{lt},\ \tau^{\mathrm{w}}_{lt},\ \tau_{yt},\ \tau_{at},\ g_t\}$, and the state of the

https://doi.org/10.1017/S1365100515000322 Published online by Cambridge University Press

economy $\{k_t,\ l_t^{\mathrm{e}},\ l_t^{\mathrm{w}},\ b_t,\ a_t\}$, an equilibrium is given by a sequence of allocations $\{c_t^{\mathrm{w}}, c_t^{\mathrm{e}}, l_{t+1}^{\mathrm{w}}, l_{t+1}^{\mathrm{e}}, k_{t+1}, h_t^{\mathrm{w}}, h_t^{\mathrm{wd}}, h_t^{\mathrm{e}}, y_t, b_{t+1}, a_{t+1,}\ Tr_t^{\mathrm{w}}, Tr_t^{\mathrm{e}}\}_{t=0}^{\infty}$ and prices $\{w_t, r_t, q_t\}_{t=0}^{\infty}$ such that[18]

(1) The set of allocation functions $\{c_t^{\mathrm{w}},\ l_{t+1}^{\mathrm{w}},\ \ h_t^{\mathrm{w}},\ a_{t+1}\}$ solve the worker's utility maximization problem given the prices $\{w_t, r_t, q_t\}_{t=0}^{\infty}$;

(2) The allocation functions $\{c_t^{\mathrm{e}},\ l_{t+1}^{\mathrm{e}},\ k_{t+1},\ h_t^{\mathrm{wd}},\ h_t^{\mathrm{e}},\ y_t,\ b_{t+1}\}$ solve the entrepreneurs' utility maximization problem given the prices $\{w_t, r_t, q_t\}_{t=0}^{\infty}$;

(3) The government budget is balanced every period; and

(4) The resource constraints are satisfied every period.

4. STEADY STATE PROPOSITIONS

I first conduct partial equilibrium analysis (in the steady state) to understand the impact of changes in government policy on entrepreneurial borrowing. This exercise requires establishing that the borrowing constraint binds in equilibrium.[19]

A balanced growth path in our model is characterized by the following:

(1) The per capita allocation variables $c_t^{\mathrm{w}},\ c_t^{\mathrm{e}},\ k_{t+1},\ \ y_t,\ b_{t+1},\ a_{t+1,}\ Tr_t^{\mathrm{w}}$, and Tr_t^{e} grow at a constant rate g_z, the long-term growth rate of productivity A_t. In other words, along the balanced growth path, $x_{t+s} = (1 + g_z)x_{t+s-1}$, $s \in \{0, 1, 2, 3, ...\}$, where x denotes the per capita allocation variables stated previously.

(2) The per capita allocation of land between entrepreneurs and workers, $l_{t+1}^{\mathrm{w}},\ l_{t+1}^{\mathrm{e}}$, the hours worked $h_t^{\mathrm{w}},\ h_t^{\mathrm{wd}},\ h_t^{\mathrm{e}}$, and the prices, $w_t,\ r_t$, are constant, or $x_{t+s} = x_{t+s-1}$, $s \in \{0, 1, 2, 3, ...\}$, where $x \in \{l^{\mathrm{w}}, l^{\mathrm{e}}, h^{\mathrm{w}}, h^{\mathrm{wd}}, h^{\mathrm{e}}, w, r\}$.

(3) The price of land q_t and the aggregate amount of government expenditure g_t grow at the constant rate $g_z\eta$, where g_z is the long-term growth rate of productivity A_t and η is the population growth rate. That is, $x_{t+s} = (1 + g_z)\eta x_{t+s-1}$, $s \in \{0, 1, 2, 3, ...\}$, where $x \in \{q, g\}$.

If we detrend the variables along the balanced growth path by the relevant growth rates, we get the steady state.

PROPOSITION 1. *In the steady state, the borrowing constraint of the entrepreneur holds with equality if and only if the tax charged on the interest earnings of the workers is less than the corporate income tax rate; i.e.,*

$$b_{t+1} = B_{t+1} \text{ iff } \tau_y > \tau_a.$$

Proof. The formal proof is in the Appendix. In the model, the entrepreneurs weigh the two options: the savings generated by the ability to deduct interest payments from corporate tax calculations and the expenses of tax on interest income at the lenders' end that is eventually passed on to them through the market interest rate. A rational entrepreneur favors debt financing as long as the savings of the tax shelter scheme outweigh the increase in the interest rate. This happens if the corporate income tax rate is higher than the tax rate on interest earnings. In this scenario, the entrepreneur borrows up to the limit allowed by the collateral constraint. The larger the difference between τ_y and τ_a, the tighter is the collateral constraint and the stronger is the impact of an external trigger. When the two tax rates are equal, the entrepreneur is essentially indifferent between debt or equity financing, in which case the borrowing constraint does not hold for the entrepreneur; hence the role of the financial accelerator is limited. ■

PROPOSITION 2. *In the steady state, there exists an inverse relationship between the tax charged on the land holdings of the entrepreneurs and the value of their land holding with respect to output. On the other hand, the steady state capital–output ratio is independent of the tax on land holdings.*

Proof. In the steady state, the value of land held by the entrepreneur and the capital stock as a share of output can be expressed as

$$\frac{ql^{e}}{y} = \frac{\theta_h \eta (1+g_z)}{\left[\theta_k \frac{y}{k} - \delta - \frac{\eta(1+g_z)(1-\tau_{le})-1}{1-\tau_y}\right]},$$

$$\frac{k}{y} = \frac{\theta_k}{\left[\frac{1-\phi}{1-\tau_y}\left(\frac{1+g_z}{\beta}-1\right)+\delta+\phi r\right]}.$$

Taking the first derivative of the share of entrepreneurial land holding in output and the capital–output ratio with respect to the landholding tax τ_{le},

$$\frac{d\frac{ql^{e}}{y}}{d\tau_{le}} = -\frac{\theta_h \eta (1+g_z)}{\left[\theta_k \frac{y}{k} - \delta - \frac{\eta(1+g_z)(1-\tau_{le})-1}{1-\tau_y}\right]^2} \frac{\eta(1+g_z)}{1-\tau_y} < 0,$$

$$\frac{d\frac{k}{y}}{d\tau_{le}} = 0.$$

Therefore a decline in the value of τ_{le} leads to an increase in the value of entrepreneurial land (as a share of output) and vice versa. On the other hand, changes in land taxes do not affect the steady state capital–output ratio. ■

PROPOSITION 3. *In the steady state, under an endogenously determined borrowing constraint regime, the amount that an entrepreneur can borrow (as a share of output) varies inversely with the tax on the land holdings of the entrepreneur.*

Proof. Given that Proposition 1 holds, and the borrowing constraint binds with equality, the share of borrowing in output can be expressed as

$$\frac{b}{y} = \phi\left[\frac{k}{y} + \frac{ql^{e}}{y\eta(1+g_z)}\right],$$

where

$$\frac{ql^{e}}{y} = \frac{\theta_h \eta (1+g_z)}{\left[\theta_k \frac{y}{k} - \delta - \frac{\eta(1+g_z)(1-\tau_{le})-1}{1-\tau_y}\right]}$$

https://doi.org/10.1017/S1365100515000322 Published online by Cambridge University Press

and

$$\frac{k}{y} = \frac{\theta_k}{\left[\frac{1-\phi}{1-\tau_y}\left(\frac{1+g_z}{\beta} - 1\right) + \delta + \phi r\right]}.$$

Taking the first derivative of the borrowing-to-output ratio with respect to land-holding tax levied on the entrepreneur, we get

$$\frac{d\frac{b}{y}}{d\tau_{le}} = \frac{d\frac{k}{y}}{d\tau_{le}} + \frac{d\frac{ql^e}{y}}{d\tau_{le}}.$$

Given Proposition 2, we can express this relation as

$$\frac{d\frac{b}{y}}{d\tau_{le}} = \frac{d\frac{ql^e}{y}}{d\tau_{le}} = -\frac{\theta_h \eta(1+g_z)}{\left[\theta_k \frac{y}{k} - \delta - \frac{\eta(1+g_z)(1-\tau_{le})-1}{1-\tau_y}\right]^2}\frac{\eta(1+g_z)}{1-\tau_y} < 0.$$

Proposition 3 establishes that, at least in the steady state, an inverse relationship exists between fiscal policy (i.e., tax on land holdings) and borrowing, outlining the impact of fiscal changes on the economy. ■

5. QUANTITATIVE EVIDENCE

5.1. Solution Procedure

Proposition 1 establishes that the borrowing constraint holds with equality in the steady state. By extension [see Iacoviello (2005)], I assume that the borrowing constraint also holds with equality in the neighborhood of the steady state and employ the log linearization technique [King et al. (1988)] to solve for the policy functions. The first step is to calibrate the parameters from data and the steady state equations.

Calibration. The model is calibrated to match the moments of the Japanese data during 1980–1984[20] in accordance with the National Income Accounting and Balance Sheet concepts.[21] The average taxes are set at their mean values for this period: the tax on labor income is 33% and the tax on interest income is 35%. The corporate income tax rate is considerably higher at 49.5%. These mean tax rates are slightly higher than the corresponding mean tax rates in the United States during this period.[22] In terms of real estate taxes, tax levied on land holdings of the corporate sector is 1.67% and about 0.56% for the noncorporate sector. In our numerical simulations, we let the land taxes vary while holding the remaining taxes constant at their 1980–1984 means.

We fix the population growth rate at 0.81%, which is the average growth rate of the working population (population aged 20–69) during 1960–2000 . The long-run growth rate of the per capita variables is 2.15% (average growth rate of GDP per working population).

Given the capital–output ratio and the investment–output ratio, the depreciation rate of capital stock or δ is estimated to be 0.1002. The corresponding measure from Hayashi and Prescott (2002) is 0.09. In the benchmark analysis, I use the debt-to-output ratio and the ratio of total collateral to output to pin down ϕ to 0.66. In an Online Appendix, I relax the assumption of a constant ϕ and test the effect of evolution of ϕ_t on the macroeconomy. Matching the discount factor to an interest rate of 4.25% prevalent during this period yields a β estimate of 0.99. I assume that the share of workers in total output is given by the share of compensation of employees in aggregate output, which is 0.59.

Lacking data on entrepreneurial consumption as distinct from workers' consumption, I further assume that the share of workers in aggregate consumption is proportional to their income. The consumption of the entrepreneurs is the aggregate consumption minus the workers' consumption. This implies an $\alpha_1 = 1.96$. The elasticity of substitution between consumption and land holding of the worker, α_2, is estimated as 0.0471 to match the steady state value of housing-to-output ratio of 272% for residential stock (in the United States, this measure is 140%).

The share of capital in output or $\theta_k = 0.37$, and the share of entrepreneurial land in output or $\theta_{h^e} = 0.04$, is set to match the capital–output ratio of 2.446 and the ratio of corporate land value to output of 0.91. As for the share of transfer going to the worker, although there are no data that separately provide the share of total transfers going to the entrepreneur as distinct from the workers, I consider a rule where the transfers are proportional to the tax burden [Ishi (2001)]. The workers' share of the aggregate transfer that ensures this is 0.86. The aggregate transfers by the Japanese government as a percentage of output are 6.73%. The calibrated parameters are summarized in Table 1 and include relevant calibrations from Davis and Heathcote (2005) and Iacoviello (2005) for comparison purposes.

Benchmark analysis. In my benchmark analysis, I assume ϕ_t to be a constant (fixed at its steady state value). The twin sources of shocks are TFP and land taxes (both residential and corporate).

Given the data, the calibrated share parameters, and the Cobb–Douglas production function, TFP is estimated as the Solow residual (Figure 5 and Table 2). Whereas during the mid to late eighties, productivity exceeded expectations, growing at an average rate 1.85% above trend, the downturn since the early nineties was more significant, and within the span of a decade, productivity declined, growing by a meager average of 0.2% (except for a brief period of respite during 1994–1996).[23]

Land taxes in Japan: The land tax system in Japan is a complicated one.[24] The statutory tax rate on corporate land during the early eighties stood at 3.1%, with a cap of 3.8%. Residential land holdings were charged a lower statutory tax rate, about one-third the corporate sector tax rate. However, the effective tax rates for land is much lower, because the tax is not assessed on the market value, but on a certain percentage of the official land value. The formula for the effective tax rate is as follows:

TABLE 1. Calibrated parameters

Parameter description	Parameter symbol	Numerical value: Our model	MI	DH[a]
		Utility function parameters		
Elasticity of substitution:				
Consumption and leisure	α_1	1.96	1.01	2.06
Consumption and land	α_2	0.0471	0.10	0.13
Rate of time preference	β	0.99	0.99	0.95
		Production function parameters		
Rate of depreciation of capital	δ	0.1002	0.12	0.06
Share of capital in output	θ_k	0.37	0.30	0.31
Share of entrepreneurial land in output	θ_{l^e}	0.04	0.03	0.106[b]
Share of aggregate labor in output	$1 - \theta_k - \theta_{l^e}$	0.59	0.66	0.594
		Borrowing constraint parameter		
Loan-to-value ratio	ϕ	0.66	0.89	

Notes: The parameters are calibrated to match the moments of the Japanese data for the period 1980 to 1984. MI denotes Iacoviello (2005) and DH stands for Davis and Heathcote (2005). We state the parameters as estimated in Iacoviello (2005) and Davis & Heathcote (2005) to provide a comparison with our calculations. Note that MI and DH calibrate their models to match the U.S. data.
Source: The calibration is based on data collected from the Japan Statistical Yearbooks. TFP is based on the author's calculations from the raw data and data on land taxes are from Ishi (2001).
[a] The DH model differs from ours and focuses on mortgage markets.
[b] There is a distinction between new and old housing and land share in housing is distinct for the two. Here we state land share in new housing.

Effective land tax rate = (Statutory tax rate× Assessment ratio× Official land value)/Market value.

Every year, the National Land Agency of Japan publishes a bulletin (*kouji-kakaku*) that provides the official land valuation in the Tokyo metropolitan area and the different prefectures. The official land value typically ranges from 70% to 90% of the market price at which land is being traded, with an average valuation at 80% of the market value across all prefectures over time. Following these statistics, I set the ratio of official land value to market value at 80% for all periods. The statutory corporate land tax rate of Japan has remained fairly constant at about 3.1% over time (this comprises a 1.4% property tax, a 0.3% city planning tax, and a 1.4% land holding tax). The fluctuations in the tax rate comes from the third component—changing assessment ratios. In an effort to give further impetus to a booming economy in the eighties, for Japan as a whole, assessment ratios were lowered from 67.4% to 36.3%. In the big cities, the assessment ratios were even lower. However, when the stock market burst in 1989 and the potential for a real estate bust became stronger in the nineties, in a bid to put a stop to further land price increase, the assessment ratio was increased till it came back up to the early eighties level by 1997, at about 70%. The idea was that an increasing assessment

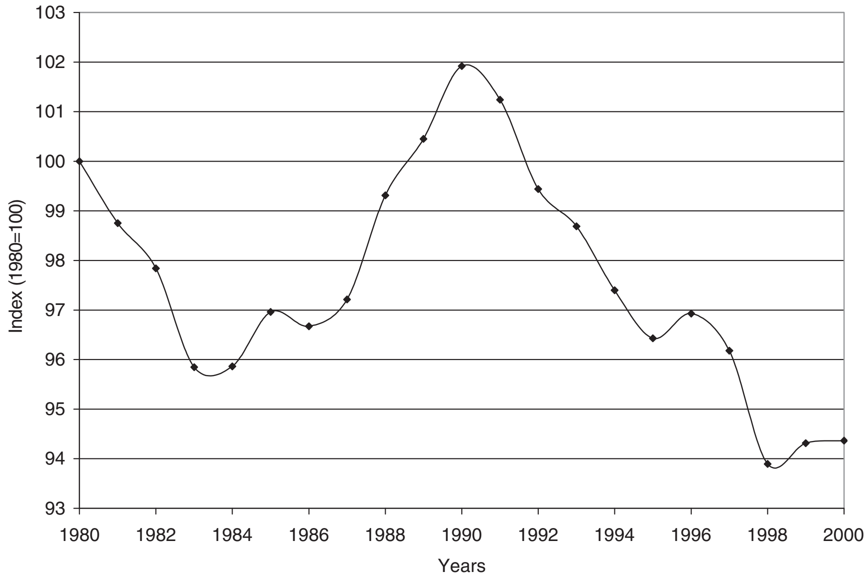

FIGURE 5. Detrended TFP, measured as the Solow residual and detrended by the long-term rate of technological progress, 2.15%.
Source: The TFP is calculated by the author based on data compiled from the Japan Statistical Yearbooks provided by the Statistical Bureau of Japan.

ratio would increase the effective tax rate and reduce the incentive of households and entrepreneurs to invest in land, thereby putting a stop to the ever-increasing land price. Since 1997, there has not been much change in the rate [Ishi (2001)]. What this meant for the *effective* land tax was a drop from 1.67% in the eighties to 0.90% in the late eighties and a gradually return to the pre-1990s value by 1997 [the annual data are collected from Ishi (2001) for the sample period] (Figure 6 and Table 2). The average effective residential land tax rate stands at about one-third the corporate tax rate during this period.

For the quantitative analysis, TFP and effective land taxes are modeled as a vector autoregressive process of order one:

$$\Phi(t) = P\Phi(t-1) + \epsilon(t),$$

where $\Phi(t) = \{\widetilde{A}_t, \widetilde{\tau^{\mathrm{e}}}_{lt}, \widetilde{\tau^{\mathrm{w}}}_{lt}, \widetilde{g}_t\}$ and $\epsilon(t) = \{\widetilde{\epsilon}_{At}, \widetilde{\epsilon^{\mathrm{e}}}_{lt}, \widetilde{\epsilon^{\mathrm{w}}}_{lt}, \widetilde{\epsilon}_{gt}\}$, where $\widetilde{A}_t$ and $\widetilde{g}_t$ denote the log deviations of productivity and government expenditure from their steady state, and $\widetilde{\tau^i}_{lt}$, $i \in \{e,\ w\}$, denotes the deviation of the land taxes from their steady state. Epsilon or the error terms capture the shocks. P is a 4×4 matrix that summarizes the parameters underlying the stochastic process. The innovations $\{\widetilde{\epsilon}_{At}, \widetilde{\epsilon^{\mathrm{e}}}_{lt}, \widetilde{\epsilon^{\mathrm{w}}}_{lt}, \widetilde{\epsilon}_{gt}\}$ are serially independent, multivariate normal random variables. The variance–covariance matrix of the innovations is summarized by another 4×4 matrix that we call Q. I assume no contemporaneous correlation

https://doi.org/10.1017/S1365100515000322 Published online by Cambridge University Press

TABLE 2. Trends in TFP and taxes on land holdings

	Change			
	TFP		Landholding taxes	
	Undetrended	Detrended	Corporate	Residential
1980:1991				
Mean	1.85%	0.48%	−2.96%	−2.34%
Standard deviation	1.10%	1.08%	12.56%	10.89%
1991:2000				
Mean	0.21%	−1.10%	12.19%	12.14%
Standard deviation	1.85%	1.24%	10.70%	10.20%

Notes: TFP is calculated as the Solow residual after accounting for the contributions of capital, land, and labor to output. We present the summary statistics of changes in TFP both undetrended and detrended with a long-term rate of 2.15%. Landholding taxes are the "effective taxes." The change figures reported are changes in these effective tax rates. The corporate land taxes on an annual basis are collected from Ishi (2001). The effective residential land tax rates are one-third the effective corporate land taxes on the average; hence the means and standard deviations of the percentage changes in land taxes are very similar for residential and corporate land.
Source: TFP is based on the author's calculations. The data on land taxes are from Ishi (2001).

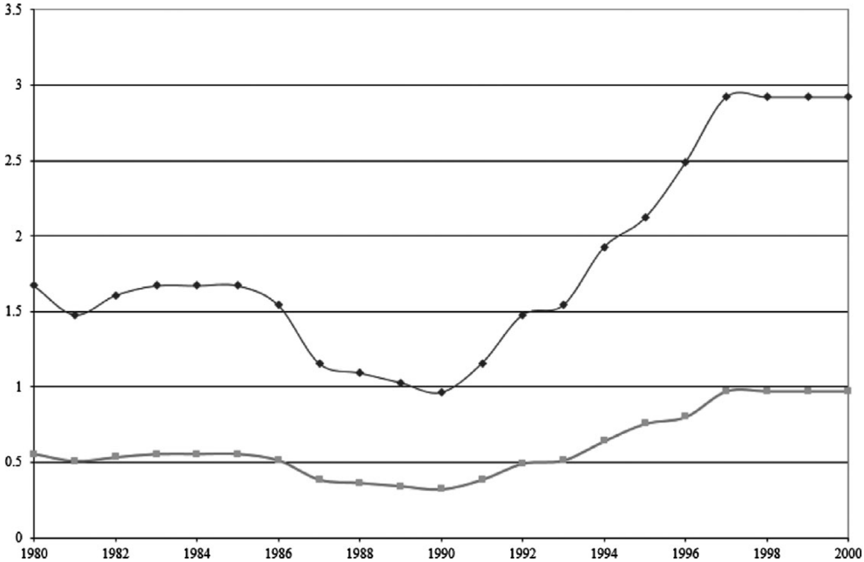

FIGURE 6. Effective landholding taxes plotted for the corporate sector (top line—entrepreneurs in the model) and the residential sector (bottom line—households in the model). The fluctuations in land taxes reflect the declining assessment ratios of the eighties and the subsequent increase since 1991. The residential land taxes stood at an average of one-third of the corporate land taxes during this period.
Source: The data on land taxes is from Ishi (2001).

https://doi.org/10.1017/S1365100515000322 Published online by Cambridge University Press

TABLE 3. Parameters of the shock process

$$\mathbf{P} = \begin{pmatrix} 0.51 & 0 & 0 & 0 \\ 0 & 0.91 & 0 & 0 \\ 0 & 0 & 0.91 & 0 \\ 0 & 0 & 0 & 0.95 \end{pmatrix}$$

$$\mathbf{Q} = \begin{pmatrix} 0.007\hat{}2 & 0 & 0 & 0 \\ 0 & 0.002\hat{}2 & 0 & 0 \\ 0 & 0 & 0.002\hat{}2 & 0 \\ 0 & 0 & 0 & 0.004\hat{}2 \end{pmatrix}$$

Note: The matrices P and Q outline the stochastic process underlying the exogenous shocks to productivity, taxes on land holding of the households, taxes on land holding of the entrepreneurs, and the government expenditure.
Source: The matrices are determined based on the author's calculations.

of the shocks. The matrix values derived from the Japanese data are outlined in Table 3.

Methodology. Given the exogenous processes summarized by a vector $\Psi(t) = \{A_t, \tau_{lt}^{\mathrm{e}}, \tau_{lt}^{\mathrm{w}}, g_t\}$ and a vector of endogenous state variables $\Omega(t) = \{k_t, b_t\ a_t, l_t^{\mathrm{e}}, l_t^{\mathrm{w}}\}$, I solve for the policy functions determining the evolution of the endogenous control variables summarized by the vector of allocations $\Xi(t) = \{c_t^{\mathrm{w}}, c_t^{\mathrm{e}}, l_{t+1}^{\mathrm{w}}, l_{t+1}^{\mathrm{e}}, h_t^{\mathrm{w}}, h_t^{\mathrm{wd}}, h_t^{\mathrm{e}}, y_t, b_{t+1}, a_{t+1,}\ Tr_t^{\mathrm{w}}\ Tr_t^{\mathrm{e}}, k_{t+1}\}$, and a sequence of prices $\Theta(t) = \{w_t, r_t, q_t\}$, where $\Xi(t) = f(\Psi(t), \Omega(t))$ and $\Theta(t) = g(\Psi(t), \Omega(t))$, using log-linearization techniques and the Blanchard–Kahn algorithm. Next, I evaluate to what extent the exogenous forces can account for fluctuations in real time data.

5.2. Results

Steady state implications. I start my analysis by comparing two economies in the steady state under two alternative circumstances: (1) they are identical in every respect, except that one economy has higher land taxes (both commercial and residential) than the other, or (2) one economy has a higher productivity. I assume that the effective tax rate on corporate land in the high-tax economy is 1.67% and the tax on residential land is 0.56% (the average tax rates during the bust in Japan). In the low-tax economy, the tax rates are 0.9% on corporate land and 0.3% on residential land (the average tax in Japan during the boom). Propositions 2 and 3 tell us to expect the high-tax economy to have lower output, land price, and corporate land than the low-tax economy. Our results summarized in Table 4 are consistent with our expectations. Output in the low-tax economy is higher by 1.01% than that in the high-tax economy. Land prices are higher by 29.27% and corporate land holdings exceed those in the high-tax economy by 84.12%. Moreover, the numbers suggest that, at least in the steady state, the

TABLE 4. Steady state comparison

Variable	Symbol	Percentage change Model with collateral constraint Endogenous	Exogenous
Economy with high versus low landholding taxes, all other factors the same			
Output per capita	y	Higher by 1.01% in the economy with low taxes	Higher by 0.34% in the economy with low taxes
Land price	q	Higher by 29.27% in the economy with low taxes	Higher by 5.66% in the economy with low taxes
Per capita land holding of the entrepreneur	l^e	Higher by 84.12% in the economy with low taxes	Higher by 67.60% in the economy with low taxes
Economy with high versus low TFP, all other factors the same			
Output per capita	y	Higher by 0.83% in the economy with high TFP	Higher by 0.80% in the economy with high TFP
Land price	q	Higher by 0.83% in the economy with high TFP	Higher by 0.80% in the economy with high TFP
Per capita land holding of the entrepreneur	l^e	No change	No change

Notes: Implications for macro variables in two economies in steady state that differ in land taxes and TFP. First, we assume the two economies are identical in every respect except land taxes. Land tax on the corporate sector is 1.67% in the high-tax economy and 0.90% in the low-tax economy. Correspondingly, the land tax on the residential sector is 0.56% in the high-tax economy and 0.30% in the low-tax economy. Next, we assume all other things including land taxes are the same and experiment with a scenario where TFP in the two economies differs by 1.00%.
Source: Author's calculations.

difference between the two economies in terms of output, corporate land holding, and land prices is much more pronounced if credit constraints are endogenously determined by entrepreneurs' wealth. The second experiment assumes that TFP in one economy is higher by 1% (all other factors remain identical). Higher TFP results in increased output (0.83%) and land prices (0.83%), except now the land holdings of the entrepreneurs do not differ (Table 4). The endogenous credit constraint, once again, amplifies the effect of TFP as expected. Do these results hold when we study the transition dynamics?

Numerical accounting. Impulse responses (Figure 7) illustrate two points: (1) The effect of an increase in TFP and a decline in land holding taxes are both conducive to borrowing, and consequently output.[25] (2) In comparison with the impact of changes in land taxes, the effect of TFP shocks is more subdued; in particular, the response of land prices is negligible. One possible reason for this is the temporary nature of TFP shocks in our model. In an Online Appendix, we also test if our findings are robust to assuming more permanent shocks. Note that the external shocks bring about significant shifts in land holding by the entrepreneurs. We term this effect the "redistribution mechanism." An increase (decrease) in TFP or a decline (increase) in land holding taxes increases (decreases) the returns to

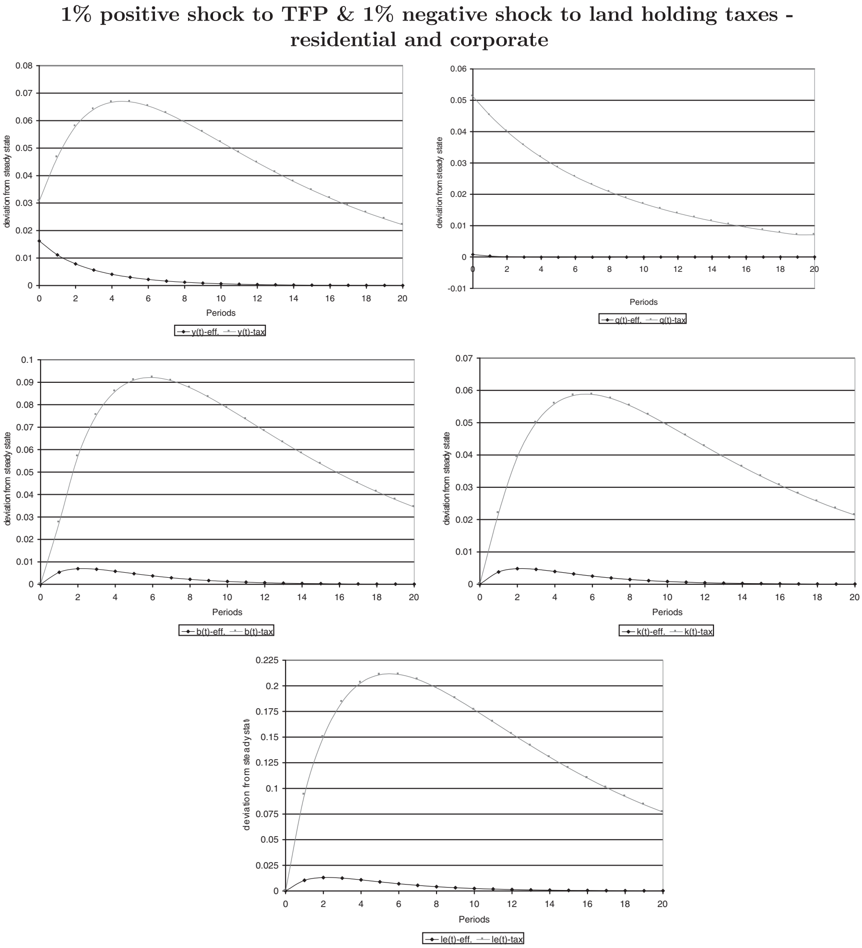

FIGURE 7. Impulse responses. We plot the response of output per capita, land price, borrowing of the entrepreneur, and capital and per capita land holding of the entrepreneur to alternative shocks: 1% positive shock to productivity and 1% negative shock to taxes on land holding, both residential and corporate.

land and prompts the entrepreneurs to hold more (less) land. This in turn boosts (reduces) the amount of collateral; hence we see a marked increase (reduction) in borrowings, reinforcing the financial accelerator.

Next, given the policy functions, I feed in the time-varying TFP process and the time series of land holding taxes (taxes on land holdings of both the households and the entrepreneurs), one by one, as well as jointly in my model to discern their impact on the economy. The results are analyzed separately for the boom (1980–1991) and the bust period (1991–2000) (numerical results in Table 5; figures available in the Online Appendix). TFP increases of the eighties predict an 11.6%

https://doi.org/10.1017/S1365100515000322 Published online by Cambridge University Press

TABLE 5. Business cycle implications

		Model			
	Data	TFP	Land tax	Joint	Permanent shocks
			1980:1991		
			Output		
Change	9.29%	11.57%	2.76%	14.65%	22.14%
Mean growth rate	0.82%	1.02%	0.25%	1.27%	1.90%
Standard deviation	1.04%	2.07%	0.28%	2.26%	3.76%
			Land price		
Change	76.25%	0.33%	0.69%	1.03%	24.24%
Mean growth rate	5.67%	0.03%	0.06%	0.09%	2.09%
Standard deviation	9.32%	0.08%	0.45%	0.45%	4.73%
			Entrepreneur's land holding		
Change	20.17%	9.07%	22.57%	33.65%	35.86%
Mean growth rate	1.83%	0.82%	1.89%	2.76%	2.97%
Standard deviation	5.92%	2.24%	2.43%	4.38%	5.70%
			1991:2000		
			Output		
Change	−15.46%	−20.95%	−7.79%	−27.10%	−45.46%
Mean growth rate	−1.59%	−2.13%	−0.78%	−2.90%	−5.82%
Standard deviation	2.07%	2.93%	0.52%	3.14%	4.50%
			Land price		
Change	−47%	−1.76%	−2.95%	−3.43%	−46.53%
Mean growth rate	−7.33%	−0.18%	−0.36%	−0.41%	−6.41%
Standard deviation	3.18%	0.35%	0.51%	0.53%	4.90%
			Entrepreneur's land holding		
Change	−6.45%	−18.3%	−44.02%	−52.00%	−48.24%
Mean growth rate	−0.13%	−2.08%	−5.20%	−6.14%	−4.98%
Standard deviation	1.98%	6.16%	4.49%	7.09%	9.14%
			Correlations		
Output and land price	0.85	0.80	0.79	0.62	0.95
Output and entrepreneur's land holding	0.35	0.69	0.98	0.94	0.61

Note: The data are collected from the Japan Statistical Yearbooks. The model predictions are based on the author's calculations and model solutions. The results for permanent shocks are based on feeding in TFP as well as both land taxes jointly in the model.

increase in output with respect to the long-term trend, whereas the declining TFP of the nineties in our model generates a 21% decline in output. Fluctuations in land taxes, for their part, predict a 2.8% increase in output during the eighties (the era of tax cuts). In the nineties (the era of tax increases), the predicted output fall is 8%. If we allow TFP and land taxes to vary jointly in our model, the predicted fluctuations in output overshoot the data.

https://doi.org/10.1017/S1365100515000322 Published online by Cambridge University Press

Although our model generates significant output fluctuations, the model performance regarding fluctuations in land prices, though consistent with the sign, falls short of our expectations regarding magnitude. Whereas TFP alone predicts an increase of 0.33% during the eighties (as compared to 76% in the data), during the nineties, the predicted fall is 1.76% (47% in the data). Land taxes perform slightly better, predicting a 0.69% increase in eighties and a 3% fall in the nineties. Even when the exogenous shocks are fed in jointly, the performance is not much better. In the eighties, the predicted increase is 1.03%, followed by a decline of 3.4% in the nineties. Although the land holding taxes on the households act like a shock to housing preferences, a trigger that has the potential to generate large asset price fluctuations [Liu et al. (2013)] aided by land taxes on entrepreneurial land holding that acts as investment shocks, a good estimate requires the shocks to be volatile enough. However, in our data, the standard deviation of the land taxes is 0.002 as compared with a standard deviation of 0.0462 noted in housing preference shocks modeled in Liu et al. (2013).

As our impulse responses suggest, the financial accelerator acts through the aforementioned redistribution channel. Exogenous changes in TFP and land holding taxes result in a significant amount of land changing hands between the corporate sector (in our model, the entrepreneurs) and the residential sector (the workers). In the eighties, the model predicts that corporate land holding increases by 33.7% (20.2% in the data), and in the nineties, that land holdings decline by 52% (7% in the data). These findings are robust to alternative parameterizations.[26]

Note that our model predictions significantly overshoot the redistribution of land as compared to data, particularly during the decline of the nineties.[27] Part of this is due to the fact that we have assumed costless transformation of land between residential and commercial uses. To the extent that zoning laws and regulations prevent such costless transformation, a model extension that takes zoning laws into account has the potential to generate a better match in terms of magnitude of redistribution—a point we check in the Online Appendix.

6. EXTENSIONS

6.1. Endogenous versus Exogenous Collateral Constraint

Financial accelerator theory emphasizes the ability of endogenous collateral constraints to generate big impacts from small shocks that hit the economy in any period of time. Quantitative evidence to date is inconclusive [Cordoba and Ripoll (2004); Kocherlakota (2000)]. What does our model suggest? I compare the benchmark with an alternative model where credit constraints are exogenously set. For my analysis this implies that the credit constraint is given by

$$b_{t+1} \leq \overline{B}_{t+1}(1+g_z)^{t+1}, \tag{14}$$

where $\overline{B}_{t+1}$ is the exogenously set borrowing limit.[28] I conduct the same exercise as before and feed in time-varying TFP and landholding taxes in unison (numerical

https://doi.org/10.1017/S1365100515000322 Published online by Cambridge University Press

TABLE 6. Evidence of amplification

	Data	Model (TFP and land taxes jointly) Credit constraint: Exogenous	Model (TFP and land taxes jointly) Credit constraint: Endogenous
1980:1991			
Output			
Change	9.29%	4.30%	14.65%
Mean growth rate	0.82%	0.39%	1.27%
Standard deviation	1.04%	0.68%	2.26%
Land price			
Change	76.25%	0.29%	1.03%
Mean growth rate	5.67%	0.03%	0.09%
Standard deviation	9.32%	0.06%	0.45%
Entrepreneur's land holding			
Change	20.17%	2.58%	33.65%
Mean growth rate	1.83%	0.23%	2.76%
Standard deviation	5.92%	0.26%	4.38%
1991:2000			
Output			
Change	−15.46%	−4.51%	−27.10%
Mean growth rate	−1.59%	−0.47%	−2.90%
Standard deviation	2.07%	0.54%	3.14%
Land price			
Change	−47.00%	−1.38%	−3.43%
Mean growth rate	−7.33%	−0.35%	−0.41%
Standard deviation	3.18%	0.20%	0.53%
Entrepreneur's land holding			
Change	−6.45%	−3.50%	−52.00%
Mean growth rate	−0.13%	−0.29%	−6.14%
Standard deviation	1.98%	0.67%	7.09%
Correlations			
Output and land price	0.85	0.52	0.62
Output and entrepreneur's land holding	0.35	0.90	0.94

Notes: The data are collected from the Japan Statistical Yearbooks. The model predictions are based on the author's calculations and model solutions. In the model with an exogenous collateral constraint, the wealth of an entrepreneur does not influence her ability to raise financial capital. The upper limit on borrowing is set exogenously.

results summarized in Table 6, figures in the Online Appendix). For the same variations in TFP and land taxes, the benchmark model generates much greater fluctuations in all three variables of interest than the alternative model considered in this section. For example, if we look at output fluctuations, ignoring endogeneity of credit constraints would predict a 4.3% increase in output followed by a 4.5%

decline. With endogeneity, the fluctuations are three times greater. The action comes primarily from a redistribution of land holdings, though even for land prices, where our model predictions miss much of the action, endogeneity of collateral generates greater fluctuations than an exogenously fixed collateral limit. The results thus provide us with quantitative evidence of the amplification possible with an endogenous credit limit, but in our variant of the classical RBC model, the action comes primarily through asset redistribution.

6.2. Housing Demand Shocks: A Business Cycle Accounting Approach

The limited role of TFP and other popular shocks such as monetary policy in generating observed fluctuations in asset markets has led to a focus on housing demand shocks that just might do the job [Iacoviello and Neri (2010); Liu et al. (2013)]. In our model, we have taxes on household land holdings that act like a shock to housing demand. However, as our benchmark results indicate, the tax fluctuations in the data are not enough to generate the observed land price fluctuations, a contradiction to the existing literature. Here, we investigate this apparent contradiction further. One possible explanation forwarded before is the lack of requisite volatility in the land tax data.

Here, we ask an alternative question: If the tax on housing is not merely a fiscal policy tool decided by the government, but incorporates broader distortions of the real estate market that influence price volatility, to what extent does our model performance change? This is the classical business cycle accounting (BCA) approach developed by Chari et al. (2007). The idea is that any market distortions that affect an economy can be replicated in a standard, prototype business cycle model using taxes, where "taxes" have a wider implication than a simple fiscal policy and represent broader market distortions.

Although a full-scale BCA analysis is outside the scope of this paper, we do two things:

(a) We theoretically show that a housing demand shock in an endogenous collateral constraint model such as that of Liu et al. (2013) is equivalent to the tax on household land holding in our benchmark model (called the equivalence proposition in the BCA literature). Therefore, if we move away from interpreting the tax on household land holding as merely a fiscal policy, and allow a broader interpretation of this tax as embodying a wider market friction, then one way to think about this tax would be as a shock to housing demand. Because we are speaking about housing preferences here, we restrict our attention to the household sector only; the problem of the entrepreneur remains the same.

(b) Second, we estimate the time-varying housing preference shocks from the data using BCA techniques and feed the time series of these shocks thus estimated back into our model by itself and in unison with the other shocks to ascertain to what extent the model performance improves under this alternative.

This exercise serves two purposes. The BCA equivalence analysis establishes that indeed the tax on household land holdings play the role of a housing demand shock, thus establishing that housing demand shocks are incorporated into the benchmark model through the household landholding tax. Then the BCA estimation results, if they proved to match the model volatility better, would establish to some extent that the inability of the tax on land holdings (or housing preferences) in our benchmark model to match land price and output volatility was not a failing of the model itself, but rather due to a lack of volatility in the data. Direct estimation of this shock process from the model and the macroeconomic data, by bypassing the lack of volatility in observed tax data, might do a better job even in our model, thus reconciling our findings with past literature.

Equivalence of housing demand shocks and a tax on land holdings. We keep our model structure as close as possible to the benchmark. The only change we introduce is in the household felicity function:

$$u_t^{\mathrm{w}}(c_t^{\mathrm{w}}, 1-h_t^{\mathrm{w}}, l_t^{\mathrm{w}}) = \log\ c_t^{\mathrm{w}} + \alpha_1 \log\ (1-h_t^{\mathrm{w}}) + \varphi_t \log\ (l_t^{\mathrm{w}}), \qquad \mathbf{(15)}$$

where φ_t is a shock to household taste for land services [as in Liu et al. (2013)].

The other modification is to the workers' budget constraint, to exclude taxes on land holdings:

$$c_t^{\mathrm{w}} + q_t(l_{t+1}^{\mathrm{w}} - l_t^{\mathrm{w}}) + a_{t+1} \leq w_t h_t^{\mathrm{w}}(1-\tau_{ht}) + [1 + r_t(1-\tau_{at})]a_t + Tr_t^{\mathrm{w}}. \quad \mathbf{(16)}$$

The problem of the entrepreneur remains as in the benchmark case.

PROPOSITION 4. *Consider an economy with a shock to housing preferences. The aggregate equilibrium allocations of this economy coincide with those of an economy with a tax on household land holdings.*

Proof. Consider the first-order condition of the benchmark model with respect to investment in land,[29]

$$\beta E_t \left[\frac{\alpha_2}{l_{t+1}^{\mathrm{w}}} + \frac{q_{t+1}}{c_{t+1}^{\mathrm{w}}}(1-\tau_{lt+1}^{\mathrm{w}}) \right] = \frac{q_t}{c_t^{\mathrm{w}}},$$

where the R.H.S. denotes the current loss in utility from diverting consumption to invest in one unit of land (marginal cost), and the L.H.S. denotes the present discounted value of future utility generated by one unit of land invested in, net of any landholding taxes paid (marginal benefit). Note that a decline in landholding taxes, τ_{lt+1}^{w}, increases the marginal benefit of investing in land and therefore has the potential to increase land demand, which, given that land is in fixed supply, would translate to an increase in land price. Now, consider the first-order condition of the model with housing preferences:

$$\beta E_t \left(\frac{\varphi_{t+1}}{l_{t+1}^{\mathrm{w}}} + \frac{q_{t+1}}{c_{t+1}^{\mathrm{w}}} \right) = \frac{q_t}{c_t^{\mathrm{w}}}.$$

An increase in preferences for land, φ_{t+1}, also increases the marginal benefit of a unit of land investment, given the marginal cost, and would result in an increased demand for land, and therefore land prices as well, much like a decline in landholding taxes. Note that the first-order conditions of the two models are identical where

$$\beta E_t \left[\frac{\alpha_2}{l^{w}_{t+1}} + \frac{q_{t+1}}{c^{w}_{t+1}}(1 - \tau^{w}_{lt+1}) \right] = \beta E_t \left(\frac{\varphi_{t+1}}{l^{w}_{t+1}} + \frac{q_{t+1}}{c^{w}_{t+1}} \right).$$

Because the entrepreneur's problem and all other relevant first-order conditions remain the same, this equality establishes equivalence of the two alternative models. ■

Housing preferences and model implications. In the previous section, we established that "taxes" can have a broader implication and mimic housing preference shocks. In this section, we use this interpretation to see how our model implications change if we directly estimate the shock process from the first-order conditions and the data. The implementation has a challenge: preference shocks enter our model within an expectations operator requiring some prior about household expectations about the evolution of the shock. A full-scale business cycle accounting procedure requires Kalman filtering techniques and the observation that by construction all shocks together should replicate the data exactly to back out the unknown shock processes. In this paper, we follow a simpler technique of using a deterministic version of the business cycle model [Chari et al. (2002); Chakraborty (2009)] and the data on consumption and value of residential land to back out the evolution of the housing preference shock. We also keep the rate of time preference, or β, the same as in our benchmark model. Once we have the housing preference shock estimated, we posit an AR1 process for the shock,

$$\ln \varphi_t = (1 - \rho_\varphi) \ln \overline{\varphi} + \rho_\varphi \ln \varphi_{t-1} + \sigma_\varphi \varepsilon_{\varphi t}, \quad \textbf{(17)}$$

where ρ_φ is the persistence parameter, $\overline{\varphi}$ is a constant determined in the steady state, σ_φ is the standard deviation, and $\varepsilon_{\varphi t}$ is an i.i.d. standard normal distribution (details of the estimation are in the Online Appendix). We estimate $\rho_\varphi = 0.9895$, which is pretty close to Liu et al.'s (2013) persistence measure at 0.9997. Our standard deviation measure $\sigma_\varphi = 0.1014$ is higher than that of Liu et al. (2013), who get 0.0462 from U.S. data, and it is also much higher than the standard deviation of 0.002 for the household land holding taxes in the benchmark model.

The results are outlined in Table 7. With a positive shock to housing preferences only during 1980–1991, we get a much better match to land price volatility, in line with Liu et al. (2013), but the impact on output is tempered. This results from a failure to match land redistribution. An increase in housing preferences alone reallocates land away from the entrepreneur to the household, though an increase in land price relaxes the borrowing constraint and aids investment. Because

TABLE 7. Impact of housing preference shocks

		Model shocks	
	Data	Housing preference only	All shocks jointly
	1980:1991		
	Output		
Change	9.29%	2.03%	11.48%
Mean growth rate	0.82%	0.21%	0.69%
Standard deviation	1.04%	0.15%	1.26%
	Land price		
Change	76.25%	32.89%	44.03%
Mean growth rate	5.67%	1.73%	2.19%
Standard deviation	9.32%	2.16%	2.45%
	Entrepreneur's land holding		
Change	20.17%	−2.13%	1.65%
Mean growth rate	1.83%	−0.03%	0.74%
Standard deviation	5.92%	0.23%	0.82%
	1991:2000		
	Output		
Change	−15.46%	−3.16%	−12.16%
Mean growth rate	−1.59%	−0.97%	−0.98%
Standard deviation	2.07%	0.84%	1.64%
	Land price		
Change	−47.00%	−18.38%	−27.43%
Mean growth rate	−7.33%	−0.85%	−1.31%
Standard deviation	3.18%	0.82%	1.53%
	Entrepreneur's land holding		
Change	−6.45%	2.98%	−0.92%
Mean growth rate	−.13%	0.09%	−0.14%
Standard deviation	1.98%	0.17%	0.29%
	Correlations		
Output and land price	0.85	0.82	0.88
Output and entrepreneur's land holding	0.35	−0.01	0.14

Note: The data are collected from the Japan Statistical Yearbooks. The model predictions are based on the author's calculations and model solutions. The housing preference shocks are estimated from the model and data using business cycle accounting techniques.

entrepreneurial land is a factor input, reallocation of land to the household has a dampening effect on output, which otherwise would have increased even more. The opposite happens during 1991–2000, when housing preference shocks are negative. Jointly feeding in all shocks result in two strong impacts—during the boom period of 1980–1991, a positive shock to housing preferences increases the household's incentive to hold land, and at the same time, a decline in land holding taxes on the entrepreneur, along with an increase in productivity, increases the entrepreneur's incentive to hold land. So households and entrepreneurs both try to acquire land from each other (because the entire land supply is held either by the households or by the entrepreneurs). Land price increases as a result. The increase in land price relaxes the budget constraint and increases investment. The result is an increase in output. The opposite happens during 1991–2000. To get a sense of how shocks to housing preferences perform in our model, note that shocks to housing preferences alone account for 39%–43% of the land price movements and explain about 20%–22% of output movements. Thus, in our alternative model, shocks to housing preferences work by affecting land prices and the redistribution channel is not in play.

7. CONCLUSION

Generating asset price volatility, along with appropriate macroeconomic fluctuations, has been a challenge in the applied macroeconomics literature. Recently, a class of models have proved promising by introducing novel features such as "sentiment" shocks or changes in consumer preferences for housing into canonical business cycle models with endogenous collateral constraints. This paper adds to this recent literature by highlighting another such feature—a public policy shock manifest in time-varying patterns of real estate taxation.

We find that a model with endogenous collateral constraint is capable of generating amplifications as theoretically predicted, provided shocks or changes in public policy are viewed by economic agents as highly persistent, or the shocks themselves are very volatile. The financial accelerator works through redistribution of the collateral asset among constrained and unconstrained agents in response to external triggers. The past literature has succeeded in generating limited amplification, as the redistribution channel has not been strong. In this paper, we introduce an additional incentive in the form of a tax shelter that allows constrained agents to claim a tax deduction on interest payments made on business loans. This feature allows us to improve the extent of redistribution that we can achieve and better match the macroeconomic fluctuations observed in the data.

An area of improvement in the benchmark model remains the ability to match asset price volatility without compromising the ability to match changes in output. Introducing housing demand shocks, mimicked by a tax on land holdings, proves to be a promising channel, as highlighted by recent literature, provided it is volatile enough. However, in our paper, housing demand shocks cannot get the redistribution of assets right, which compromises our ability to tie down both output and asset redistribution, as well as price volatility, at the same time. The future challenge rests in finding a combination of shocks or model modifications that can generate both asset price movements and macro fluctuations, including asset reallocations consistent with the data.

NOTES

1. Garber (1990), in studying the "famous first bubbles" of economic history, stressed the need to eliminate fundamental causes before delegating any asset price run-ups to the bubble category.

2. Other studies in this area are by Stone and Ziemba (1993), Mera (2000), Kim and Suh (2005), and Barseghyan (2010).

3. Some other studies that introduce psychology in explaining economic occurrences include Dressler and Kersting (2014), who look at "confidence" shocks to study business cycles, and Tortorice (2014), who studies changing beliefs to explain consumption growth volatility.

4. Such "taste" shocks have also been used in studies of the equity home bias puzzle, such as Feng (2014).

5. This is in contrast to the previous recent literature, which uses Bayesian vector autoregression tools.

6. In our model, the productivity gap is determined by the household labor share in output, whereas the total output is contributed by the constrained agent.

7. The variables are detrended with respect to their long-term average growth rates. A quick note on the detrending procedure: results of DSGE models in general are quite sensitive to the detrending procedure used [Canova (1998)]. I follow earlier literature on Japanese business cycle [Hayashi and Prescott (2002)] and opt for linear detrending because of two potential problems of HP detrending [Canova (1998)]—first, if a series is driven by deterministic trends and we decide to use HP filtering on the series, then the results can be spurious; second, Canova's (1998) experiments with HP filtering lead him to conclude there are instances where selecting cycles of 4–6 years duration and applying HP filtering may "throw away a large portion of the variability of a series (e.g. productivity)." Because, in Japan, we do have evidence of a 4–6 year cycle (for example, the boom from 1986 to 1991, the subsequent decline from 1991 to 1994, and the further decline from 1996 to 2000), I opt for linear detrending.

8. 3% was the average rate of growth of land prices from the Second World War till the beginning of the eighties.

9. The numbers were more dramatic for the six major cities of Tokyo, Yokohama, Osaka, Nagoya, Kyoto, and Kobe, where total land price increased by 321% by 1991 before falling by 65% by 2000. In these regions, residential land prices increased by 260%, while commercial land prices increased by 227% during the same period. During the nineties, both fell, with the former falling by 55% by 2000 while the latter fell by 51%.

10. Note that according to the data from the Ministry of Land, Infrastructure, Transport and Tourism, although the trend in the eighties was that of an increasing fraction of land being held by the corporate sector, if with some intermittent fluctuations, the decline in land holding since the early nineties is fairly monotonic.

11. I further assume that consumers and entrepreneurs both grow at the same rate η.

12. In alternative robustness checks in the Online Appendix, I also model workers' demand for land in an alternative way by introducing a production technology for household services where land is an input [Davis and Heathcote (2005)]. The workers then derive direct utility from consumption of household services. Our results are robust to this alternative specification.

13. In general practice, it is assumed that entrepreneurs do not value leisure [Kiyotaki-Moore (1997); Cordoba and Ripoll (2004); Iacoviello (2005)]. This seems to be a restrictive assumption, and allowing for leisure might nontrivially affect the entrepreneurs' policy function. We therefore err on the side of caution by including leisure in our framework.

14. This assumption is guided by data shortcomings. It is not possible to disentangle the fraction of the total land holding that entrepreneurs use for consumption and the fraction that they devote to production.

15. The role of collateral is also explored by Agénor et al. (2014) in the context of finance premia.

16. In our analysis, in contrast to the earlier literature, β is the same for the workers and the entrepreneurs.

17. h_t^{wd} denotes the demand for the workers' labor by the entrepreneurs at time t. At equilibrium, the demand for workers' labor by the entrepreneurs is equal to the supply of labor by the workers.

18. The details of the first-order conditions are summarized in the Online Appendix.

19. Interested readers can refer to the Online Appendix for the steady state equations.

20. A period of relative calm when output per capita was growing at a steady rate of 2.15%.

21. Details of the data are outlined in the Online Appendix.

22. Davis and Heathcote (2005) estimate that, in the United States, the average tax on capital earnings is 37.9% whereas that on labor is 28.9%.

23. The slight difference of calculations from Hayashi and Prescott (2002) or Jorgenson and Motohashi (2005) is due to the fact that I include land as a factor of production in contrast to the other studies.

24. Ishi (2001) discusses in detail many features of land taxation in Japan.

25. The effect of a decline in TFP or an increase in land holding taxes would be just the opposite.

26. Results outlined in an Online Appendix.

27. This factor is also responsible for the high correlation between land redistribution and output noted in our results.

28. Note that I asume that the borrowing limit grows at the long-term growth rate of the economy g_z to maintain consistency with my balanced growth path approach.

29. The details of the first-order conditions are in the Online Appendix.

30. Steady state equations are available in the Online Appendix.

REFERENCES

Agenor, Pierre-Richard, George J. Bratsiotis, and Damjan Pfajfar (2014) Credit frictions, collateral, and the cyclical behavior of finance premium. *Macroeconomic Dynamics* 18, 985–997.

Barseghyan, Levon (2010) Non performing loans, prospective bailouts, and persistent declines in economic activity. *Journal of Monetary Economics* 57, 873–890.

Benk, Szilárd, Max Gillman, and Michael Kejak (2005) Credit shocks in the financial deregulatory era: Not the usual suspects. *Review of Economic Dynamics* 8, 668–687.

Bernanke, Ben S. and Mark Gertler (1989) Agency costs, net worth, and business fluctuations. *American Economic Review* 79, 14-31.

Caballero, Ricardo J. and Arvind Krishnamurthy (2001) International and domestic collateral constraints in a model of emerging market crises. *Journal of Monetary Economics* 48, 513–548.

Canova, Favio (1998) Detrending and business cycle facts. *Journal of Monetary Economics* 41, 475–512.

Chakraborty, Suparna (2009) The boom and the bust of the Japanese economy: A quantitative look at the period 1980 to 2000. *Japan and the World Economy* 21, 116–131.

Chari, Vardarajan V., Patrick J. Kehoe, and Ellen R. McGrattan (2002) Business Cycle Accounting. Working paper 625, Federal Reserve Bank of Minneapolis.

Chari, Vardarajan V., Patrick J. Kehoe, and Ellen R. McGrattan (2007) Business cycle accounting. *Econometrica* 75, 781–836.

Cordoba, Juan C. and Marla Ripoll (2004) Credit cycles redux. *International Economic Review* 45, 1011–1046.

Davis, Morris A. and Jonathan Heathcote (2005) Housing and the business cycle. *International Economic Review* 46, 751–784.

Dressler, Scott J. and Erasmus K. Kersting (2014) Economies of scale in banking, confidence shocks, and business cycles. *Macroeconomic Dynamics* 18, 1069–1080.

Feng, Ling (2014) Taste shocks, endogenous labor supply, and equity home bias. *Macroeconomic Dynamics* 18, 1437–1465.

Garber, Peter M. (1990) Famous first bubbles. *Journal of Economic Perspectives* 4, 35–54.

Hayashi, Fumio and Edward C. Prescott (2002) The 1990s in Japan: A lost decade. *Review of Economic Dynamics* 5, 206–235.

Hoshi, Takeo and Anil K. Kashyap (2010) Will the U.S. bank recapitalization succeed? Lessons from Japan. *Journal of Financial Economics* 97, 398–417.

Iacoviello, Matteo (2005) House prices, borrowing constraints and monetary policy in the business cycle. *American Economic Review* 95, 739–764.

Iacoviello, Matteo and Stefano Neri (2010) Housing market spillovers: Evidence from an estimated DSGE model. *American Economic Journal—Macroeconomics* 2, 125–164.

Ishi, Hiromitsu (2001) *The Japanese Tax System*. New York: Oxford University Press.

Jermann, Urban J. and Vincenzo Quadrini (2012) Macroeconomic effects of financial shocks. *American Economic Review* 102, 238–271.

Jorgenson, Dale W. and Kazuyuki Motohashi (2005) Information technology and the Japanese economy. *Journal of Japanese and International Economics* 19, 460–481.

Kashyap, Anil K., Jeremy C. Stein, and David W. Wilcox (1993) Monetary policy and credit constraints: Evidence from the composition of external finance. *American Economic Review* 83, 78–98.

Kim, Kyung-Hwan and Seong Hwan Suh (2005) Speculation and price bubbles in the Korean and Japanese real estate markets. *Journal of Real Estate Finance and Economics* 6, 73–87.

King, Robert G., Charles I. Plosser, and Sergio T. Rebelo (1988) Production, growth and business cycles: I. The basic neoclassical model. *Journal of Monetary Economics* 21, 195–232.

Kiyotaki, Nobuhiro and John H. Moore (1997) Credit cycles. *Journal of Political Economy* 105, 211–248.

Kocherlakota, Naryana (2000) Creating business cycles through credit constraints. *Federal Reserve Bank of Minneapolis Quarterly Review* 2431, 1–10.

Krishnamurthy, Arvind (2010) Amplification mechanisms in liquidity crisis. *American Economic Journal—Macroeconomics* 2, 1–30.

Liu, Zheng, Pengfei Wang, and Tao Zha (2013) Land-price dynamics and macroeconomic fluctuations. *Econometrica* 81, 1147–1184.

Martin, Alberto and Jaume Ventura (2012) Economic growth with bubbles. *American Economic Review* 102, 3033–3058.

McGrattan, Ellen R. (2012) Capital taxation during US great depression. *Quarterly Journal of Economics* 127, 1515–1550.

McGrattan, Ellen R. and Lee E. Ohanian (2010) Does neoclassical theory account for the effects of big fiscal shocks? Evidence from World War II. *International Economic Review* 51, 509–532.

Mendoza, Enrique G. and Katherine A. Smith. (2006) Quantitative implications of a debt–deflation theory of sudden stops and asset prices. *Journal of International Economics* 70, 82–114.

Mera, Koichi (2000) Land price ascent and government response in Japan. In K. Mera and B. Renaud (eds.), *Asia's Financial Crisis and the Role of Real Estate*, pp. 27–63. London: M.E. Sharp.

Miao, Jianjun, Pengfei Wang, and Zhiwei Xu (2012) A Bayesian DSGE Model of Stock Market Bubbles and Business Cycles. Boston University working paper.

Miao, Jianjun, Pengfei Wang, and Jing Zhou (2013) Housing Bubbles and Policy Analysis. Boston University working paper.

Miao, Jianjun, Pengfei Wang, and Tao Zha (2014) Liquidity Premia, Price–Rent Dynamics, and Business Cycles. Boston University working paper.

Peek, Joe and Eric S. Rosengren (2005) Unnatural selection: Perverse incentives and the misallocation of credit in Japan. *American Economic Review* 95, 1144–1166.

Stone, Douglas and William T. Ziemba (1993) Land and stock prices in Japan. *Journal of Economic Perspectives* 7, 149–165.

Tortorice, Daniel L. (2014) Credit constraints, learning, and aggregate consumption volatility. *Macroeconomic Dynamics* 18, 338–368.

APPENDIX: PROOF OF PROPOSITION 1

Proof. In the steady state (ignoring growth for the moment and setting $g_z = 0$), the first-order conditions related to lending and borrowing can be written as[30]

$$\beta\lambda^{w}[1 + r(1 - \tau_a)] = \lambda^{w} \quad \textbf{(A.1)}$$

and

$$\beta\lambda^{e}(1 + r(1 - \tau_y)) = \lambda^{e} - \mu, \quad \textbf{(A.2)}$$

where the variables without the time subscripts denote the steady state. λ^{w} and λ^{e} are the steady state Lagrange multipliers associated with the representative worker's and the entrepreneur's budget constraint, respectively. Equation (A.1) yields the steady state rate of interest r as

$$r = \frac{\left(\frac{1}{\beta} - 1\right)}{1 - \tau_a}. \quad \textbf{(A.3)}$$

Substituting the value of r into equation (A.2), we can express μ, the steady state value of the Lagrange multiplier associated with the borrowing constraint, as

$$\frac{\mu}{\lambda^{e}} = (1 - \beta)\frac{(\tau_y - \tau_a)}{1 - \tau_a}. \quad \textbf{(A.4)}$$

Note that the standard assumption of nonsatiation of preferences implies that $\lambda^{e} > 0$. Given that $0 < \beta < 1$ and $0 < \tau_a < 1$, if $\tau_y > \tau_a$, then μ is strictly positive. This implies that the borrowing constraint holds with equality (binds). If $\tau_y = \tau_a$, then $\mu = 0$ and the borrowing constraint no longer binds. ■