In this paper, I explore the dynamics of real estate market fluctuations and business cycle comovements in a neoclassical setting. Applying a dynamic, stochastic 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 like 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
JEL Codes: E32, E44, E62
INTRODUCTION

The unfolding of the recent US 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 to fluctuations in collateral value eventually resulting in large macroeconomic consequences (Krishnamurthy, 2010).

The chain of events is not unique to the US. Japan, the second largest economy of 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 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 behind the spill-over 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 US crisis, I choose Japan as my laboratory to investigate the 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 in the production process that can also be used as a 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)\textsuperscript{1}. Actual choice of the primary drivers is a more complex issue\textsuperscript{2}. One of the

\textsuperscript{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

\textsuperscript{2}Other studies in this area are by Stone and Ziemba (1993), Mera (2000), Kim and Suh (2005), Barseghyan (2010), Alpanda (2010).
earliest suspects in this regard is monetary policy (Kashyap, Stein and Wilcox, 1993). In addition, the other potential suspects examined are fluctuations in total factor productivity or TFP (Benk, Gillman and Kejak 2005, Jermann and Quadrini 2009), changes in credit availability (Caballero and Krishnamurthy 2001, Peek and Rosengren 2005, Jermann and Quadrini 2009) and fiscal changes (McGrattan and Ohanian 2008, McGrattan 2009). 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 that translates to further macroeconomic fluctuations. While theoretically straightforward, finding quantitative support for the financial accelerator has been a challenge in literature. The third question is an attempt to revisit this rather pesky issue and explore the model dynamics to generate larger amplifications as predicted by theory.

Summary of findings & Connection to current 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, 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, Wei and Zhou (2012) revisits 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 the asset market bubbles in the United States. Miao, Wang and Xu (2013) argue that it is the belief or the "sentiment" of a household (the lender) about the stock market value of the borrower which 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 US asset market bubble to a great extent. Miao, Wang and Zha (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, Wang and Zha (2013) highlight the role of housing demand, a channel supported by Iacoviello and Neri (2010). Liu, Wang and Zha (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, Kehoe and McGrattan (2007), I show that taxes on land holding of households have the same implications as shocks to housing preferences in literature and apply a modified business cycle accounting procedure to evaluate the impact of such preference shocks. In addition, the tax on land holding 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, I find that the benchmark model captures well the fluctuations in output and the real estate dynamics-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

---

3This is in contrast to the previous recent literature that uses Bayesian Vector Autoregression tools.
intrinsically linked to the assumption of persistence of shocks. Assuming temporary shocks compromises the model’s ability to account for price fluctuations while allowing shocks to be permanent markedly improves the match. The role of persistence of shocks is understated in literature. For example, the housing demand shock of Liu, Wang and Zha (2013) that 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 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 that works to increase land value. At the same time, the heterogenous nature of the impact of positive shocks studied, creates a stronger incentive for the constrained agent to hold or dispose off 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 the impact of changes in real estate taxation policies have a greater impact on the businesses than 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) highlights the same and provides us with an explanation. They suggest that the response of output to a shock comes from four channels:

\[ \text{output response} = (\text{productivity gap}) \times (\text{collateral share in production}) \times (\text{production share of constrained agents}) \times (\text{redistribution of collateral between constrained and unconstrained}) \]
So, all or any of these four factors can play an important role in generating amplification. The first three factors are pretty restricted when a production function is concave. The difference comes in the fourth factor - the "redistribution channel". While 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 to 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, while 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 above, income or TFP shocks are not the only primitives we rely on. We introduce land taxes that act as shocks to housing demand (for unconstrained agent) and shocks to investment (for constrained agent) further assisting us in getting better output responses.

The rest of the paper is organized as follows. Section 2 discusses the empirical motivation

---

4In our model, the productivity gap is determined by the household labor share in output, while the total output is contributed by the constrained agent.
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\(^5\)) reveals, 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 since 1991 (Figure 1 & Table 5). This pattern was mirrored in the real estate market (Figures 2 & 3 and Table 5) 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%\(^6\) 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). 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\(^7\).

During the same period, significant land redistributions occurred between the residential and the corporate sector. During the early eighties, the corporate sector held about 12% of the land. However, by the mid-eighties, residential land became more dominant. The variables are detrended with respect to their long-term average growth rate. 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 due to two potential problems of HP detrending (Canova 1998)- firstly, if a series is driven by deterministic trends and we decide to use HP filtering on the series then the results can be spurious; secondly, Canova’s (1998) experiments with HP filtering leads 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)". Since 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, the further decline during 1996 to 2000), I opt for linear detrending.

\(^5\) The variables are detrended with respect to their long-term average growth rate. 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 due to two potential problems of HP detrending (Canova 1998)- firstly, if a series is driven by deterministic trends and we decide to use HP filtering on the series then the results can be spurious; secondly, Canova’s (1998) experiments with HP filtering leads 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)". Since 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, the further decline during 1996 to 2000), I opt for linear detrending.

\(^6\) 3% was the average rate of growth of land prices since the Second World War till the beginning of the eighties.

\(^7\) 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, the 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%.
of the total land (about 13% in the top three metropolitan areas of Tokyo, Nagoya and Osaka), which is almost 52% of their total tangible asset holding. To put these numbers into perspective, the corporate sector in United States owns about 9% of the total land. During the late eighties, land ownership by corporate sector went up by 20% (27% in the top three metropolitan areas) and come the nineties, land held by corporate sector fell by 7% (almost 15% in the top three metropolitan areas) (Figure 4 and Table 5).  

While the real economy and the real estate market were witnessing historic fluctuations, economic fundamentals were also changing. Hayashi and Prescott (2002) found that while during the late eighties TFP grew at 3.7% (the comparable figure for the US being 2.6%), during the nineties, it fell to 0.3%. Jorgenson and Motohashi (2003), while providing less pessimistic numbers found a similar trend. They found that Japan’s TFP growth rate declined from 1.52% in 1975-90 to 0.56% in 1990-95. However, since then it slightly recovered to 0.69% in 1995-2000.

On the policy front, two major changes were noted (amongst 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 the growing economy and provide small and medium sized firms additional collateral to secure investment funds. However, it started to reign in the tax cuts in the nineties and gradually increased the rates back up 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 small scale and real estate sectors during the eighties followed by stricter requirements on bank capital positions since the nineties.

---

8Note that according to the data from Ministry of Land, Infrastructure, Transport and Tourism, while the trend in the eighties was that of an increasing fraction of land being held by the corporate sector, albeit with some intermittent fluctuations, the decline in land holding since early 90s is pretty monotonous.
3. THEORETICAL MODEL

3.1. General setup

I model a closed economy with two groups of heterogenous agents: workers and entre-
preneurs. 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 either born as an entrepreneur or as a worker and
it is not possible to switch types. For simplicity, fraction of workers to entrepreneurs every
period is a constant $\zeta$ such that

(1) $N_1t = \zeta. N_2t$

In my numerical analysis, I assume a constant rate of population growth $\eta$ (same for both
entrepreneurs and workers). 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 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
adds to their utility (similar to Iacoviello (2005))\(^9\).

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\(^10\). Consistent with earlier literature, while the workers derive direct

---

\(^9\)In alternative robustness checks in the online appendix, I also model worker’s demand for land in an
alternative way by introducing a production technology for household services and have land as 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.

\(^10\)In general practice, it is assumed that entrepreneurs do not value leisure (Kiyotaki-Moore (1995), Ia-
coviello (2005), Cordoba and Ripoll (2004)). This seems to be a restrictivte assumption and allowing for
leisure might non-trivially affect the entrepreneurs policy function. We therefore err on the side of caution
by including leisure in our framework.
utility from consumption of land, entrepreneurs hold land exclusively for production and for collateral purposes, not for consumption\footnote{This assumption is guided by data shortcomings. It is not possible to disentangle the fraction of the total land holding that entrepreneurs use towards consumption and fraction they devote to production.}. 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 the wages, interest and finance their own 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?**- 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 for 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.

### 3.2. Workers

The representative worker’s (denoted by a superscript \( w \)) problem 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 

\[
E_0 \sum_{t=0}^{\infty} \beta^t u^w_t(c^w_t, 1 - h^w_t, l^w_t)
\]

where 

- \( E_0 \) is the expectations operator,
- \( \beta \in (0, 1) \) is the discount factor,
- \( c^w_t \) denotes consumption of the worker at time \( t \),
- \( h^w_t \) denotes hours worked,
- \( l^w_t \) denotes land holdings of the worker at time \( t \).

In our numerical analysis, we assume a standard felicity function (log linear...
in consumption, leisure and land-holdings):

\[ u_t^w(c_t^w, 1 - h_t^w, l_t^w) = \log c_t^w + \alpha_1 \log (1 - h_t^w) + \alpha_2 \log (l_t^w) \]

The workers maximize the lifetime utility subject to a budget constraint:

\[ c_t^w + q_t(l_{t+1}^w - l_t^w) + \tau_t^w q_t l_t^w + a_{t+1} \leq w_t h_t^w (1 - \tau_{ht}) + (1 + r_t (1 - \tau_{at})) a_t + t r_t^w \]

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 \( \tau_{ht} \), a tax on their interest earnings at the rate \( \tau_{at} \) and a tax on their land holding at the rate \( \tau_t^w \). The workers also get transfers \( T r_t^w \) 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 \( l_{t+1}^w - l_t^w \)) 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 \( E_0 \sum_{t=0}^{\infty} \beta^t u_t^e(c_t^e, 1 - h_t^e) \) where \( E_0 \) is the expectations operator, \( \beta \in (0, 1) \)\(^{12} \) is the discount factor, \( c_t^e \) denotes consumption of the entrepreneurs at time \( t \) and \( h_t^e \) denotes the hours worked by the entrepreneurs. As distinct from the workers, land does not directly add to the entrepreneur’s utility. The felicity function is log-linear in consumption and leisure:

\[ u_t^e(c_t^e, 1 - h_t^e) = \log c_t^e + \alpha_1 \log (1 - h_t^e) \]

\(^{12} \) In our analysis, in contrast to earlier literature, \( \beta \) is same for the workers and the entrepreneurs.
The entrepreneur’s maximize the lifetime utility subject to a budget constraint:

\[
(5) \quad c_t^e + q_t(l_{t+1}^e - l_t^e) + \tau_{lt}^e q_t l_t^e + (k_{t+1} - (1-\delta)k_t) \leq (1-\tau_{yt})(y_t - y_{t}^{wd} - \delta k_t - r_t b_t) + b_{t+1} - b_t + Tr_t^e
\]

where \( y_t \) is output produced at time \( t \). The entrepreneurs are assessed a tax on their corporate income at the rate \( \tau_{yt} \), and a tax on their land holding at the rate \( \tau_{lt}^e \). They also receive transfers \( Tr_t^e \) from the government every period. In addition, they can claim wage income paid to the workers \( (w_t h_t^{wd}) \), the depreciation on their existing capital stock \( (\delta k_t) \) 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 \( (y_t - w_t h_t^{wd} - \delta k_t - r_t b_t) \). After repaying the loans of last period and the interest incurred on it, the remaining after-tax earnings are used to finance consumption. Any remaining amount is invested in land \( (l_{t+1}^e - l_t^e) \) and capital \( (k_{t+1} - (1-\delta)k_t) \). The entrepreneurs can supplement their retained earnings by borrowings \( (b_{t+1} - b_t) \). However, unlimited borrowing is not allowed and the entrepreneurs face an upper limit on their borrowing:

\[
(6) \quad b_{t+1} \leq B_{t+1}
\]

The constraint can be exogenously set such that \( b_{t+1} \leq \bar{B}_{t+1} \) where \( \bar{B}_{t+1} \) is exogenously determined and is independent of the entrepreneur’s net asset position. In practice, most often it is endogenously determined by the wealth holding of the entrepreneur. In my setup that means the value of capital and land holdings of the entrepreneur 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:

\[
(7) \quad b_{t+1} \leq \phi_t (k_{t+1} + q_t l_{t+1}^e)
\]

\( h_t^{wd} \) denotes the demand of the worker’s labor by the entrepreneur at time \( t \). In equilibrium, the demand for workers’ labor by the entrepreneurs is equal to the supply of labor by the workers.
or the loan to value ratio determines the fraction of the net holdings that can be borrowed. \( \phi_t \) 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 about the market often determines the ease with which the lender can liquidate the collateral in case of non-repayment of loans. Hence for any given amount of collateral pledged by the borrower \((k_{t+1} + q_t l_{t+1}^c)\) in our model, the lender is only left with a fraction of it \((\phi_t(k_{t+1} + q_t l_{t+1}^c))\) in case of delinquency. The rest \(((1 - \phi_t)(k_{t+1} + q_t l_{t+1}^c))\) is spent in administrative expenses of loan recovery. Consequently, the maximum amount the lender brings to the table is determined by net amount that the lender recovers or, \(\phi_t(k_{t+1} + q_t l_{t+1}^c)\).

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

\[
y_t \leq A_t F_t(k_t, l_t^e, h_t^{wd}, h_t^c) = A_t h_t \theta_t \theta_c \theta_h h_t^{wd} h_t^{e1-\theta_c-\theta_h-\theta_h}
\]

\(A_t\) 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 it on consumption. Any remaining amount is transferred back to the entrepreneurs and the workers so as to balance the budget every period. The government’s budget constraint can therefore be summarized by the equation:

\[
N_{1t} (w_t h_t^{wd} \tau_{ht} + r_t \tau_{at} a_t + \tau_t^{wd} q_t l_t^{wd}) + N_{2t} \tau t (y_t - w_t h_t^{wd} - \delta k_t - r_t b_t) + N_{2t} \tau t q_t l_t^{e} \\
\leq g_t + N_{1t} Tr_t^{wd} + N_{2t} Tr_t^{e}
\]
I close the model by summarizing the resource constraints every period. The goods market clearing condition is given by:

\[
N_{1t}c_t^w + N_{2t}(c_t^e + k_{t+1} - (1 - \delta)k_t) + g_t \leq N_{2ty_t}
\]

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

\[
N_{2t}b_t \leq N_{1t}a_t
\]

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

\[
N_{1t}l_t^w + N_{2t}l_t^e \leq 1
\]

and

\[
N_{2t}h_t^{wd} \leq N_{1t}h_t^w
\]

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 is 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 the exogenous productivity \(\{A_t\}\), exogenous loan to value ratio \(\{\phi_t\}\), set of exogenous fiscal policy instruments \(\{\tau_{ht}, \tau_{lt}, \tau_{yt}, \tau_{at}, g_t\}\), and the state of the economy \(\{k_t, l_t^w, l_t^e, b_t, a_t\}\), an equilibrium is given by a sequence of allocations \(\{c_t^w, c_t^e, l_{t+1}^w, l_{t+1}^e\}\).
$k_{t+1}, h_t^w, h_t^{wd}, h_t^e, y_t, b_{t+1}, a_{t+1}, Tr_t^w, Tr_t^e \}^\infty_{t=0}$, and prices $\{w_t, r_t, q_t\}^\infty_{t=0}$ such that:

1. The set of allocation functions $\{c_t^w, l_{t+1}^w, h_t^w, a_{t+1}\}$ solve the worker’s utility maximization problem given the prices $\{w_t, r_t, q_t\}^\infty_{t=0}$

2. The allocation functions $\{c_t^e, l_{t+1}^e, k_{t+1}, h_t^{md}, h_t^e, y_t, b_{t+1}\}$ solve the entrepreneurs’ utility maximization problem\(^{14}\) given the prices $\{w_t, r_t, q_t\}^\infty_{t=0}$

3. The government budget is balanced every period and

4. The resource constraints are satisfied every period.

4. **STEADY STATE PROPOSITIONS**

I first conduct some partial equilibrium analysis (at 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\(^{15}\).

**Balanced growth path**

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

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

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

\(^{14}\)The details of the first order conditions are summarized in the online appendix.

\(^{15}\)Interested readers can refer to the online appendix for the steady state equations.
(3) Price of land $q_t$ and the aggregate amount of government expenditure $g_t$ grows at the constant rate $g_z \eta$ where $g_z$ is the long term growth rate of productivity $A_t$ and $\eta$ is the population growth rate. That is, $x_{t+s} = (1+g_z)\eta x_{t+s-1}, s \in \{0, 1, 2, 3, \ldots \}$ 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 Appendix 1.

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 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 is the difference between $\tau_y$ and $\tau_a$, the tighter is the collateral constraint and 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, steady state capital output ratio is independent of the tax on land holdings.*
Proof: In steady state, the value of land held by the entrepreneur and the capital stock as a share of output can be expressed as:

\[
\frac{q_{le}}{y} = \frac{\theta_k \eta (1 + g_z)}{(\theta_k \frac{y}{k} - \delta - \frac{\eta (1 + g_z)(1 - \tau_{le}) - 1}{1 - \tau_y})}
\]

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

Taking the first derivative of the share of entrepreneurial land holding in output and the capital output ratio with respect to land holding tax \(\tau_{le}\):

\[
\frac{d q_{le}}{d \tau_{le}} = -\frac{\theta_k \eta (1 + g_z)}{(\theta_k \frac{y}{k} - \delta - \frac{\eta (1 + g_z)(1 - \tau_{le}) - 1}{1 - \tau_y})^2} \frac{\eta (1 + g_z)}{1 - \tau_y} < 0
\]

\[
\frac{d k}{d \tau_{le}} = 0
\]

Therefore a decline in the value of \(\tau_{le}\) leads to an increase in 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 an entrepreneur.

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

\[
\frac{b}{y} = \phi \left[ \frac{k}{y} + \frac{q_{le}}{y \eta (1 + g_z)} \right]
\]

where

\[
\frac{q_{le}}{y} = \frac{\theta_k \eta (1 + g_z)}{(\theta_k \frac{y}{k} - \delta - \frac{\eta (1 + g_z)(1 - \tau_{le}) - 1}{1 - \tau_y})}
\]
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 borrowings to output ratio with respect to land holding tax levied on the entrepreneur, we get:

\[
\frac{d^b_y}{d\tau_{le}} = \frac{d^k_y}{d\tau_{le}} + \frac{dq_y^e}{d\tau_{le}}
\]

Given Proposition 2, we can express the above relation as:

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

Proposition 3 establishes that, at least in the steady state, an inverse relationship exists between the 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, Plosser and Rebelo (1988)) to solve for the policy functions. The first step is to calibrate the parameters from data and the steady state equations.
5.1.1. Calibration

The model is calibrated to match the moments of the Japanese data during 1980-1984\textsuperscript{16} in accordance with the National Income Accounting and Balance Sheet concepts\textsuperscript{17}. 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 high at 49.5\%. These mean tax rates are slightly higher than the corresponding mean tax rates in the U.S. during this period\textsuperscript{18}. In terms of real estate taxes, tax levied on land holdings of the corporate sector is 1.67\% and about 0.56\% for the non-corporate 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\textsuperscript{.} 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, depreciation rate of capital stock or $\delta$ 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 $\phi$ to 0.66. In an online appendix, I relax the assumption of a constant $\phi$ and test the effect of evolution of $\phi_t$ on the macroeconomy. Matching the discount factor to an interest rate of 4.25\% prevalent during this period yields a $\beta$ 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 worker’s 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

\begin{itemize}
  \item \textsuperscript{16} A period of relative calm when output per capita was growing at a steady rate of 2.15\%.
  \item \textsuperscript{17} Details of the data outlined in the online appendix.
  \item \textsuperscript{18} Davis and Heathcote (2005) estimates that, in the U.S., the average tax on the capital earnings is 37.9\% while that on labor is 28.9\%.
\end{itemize}
the workers’ consumption. This implies an $\alpha_1 = 1.96$. The elasticity of substitution between consumption and land holding of the worker, $\alpha_2$, is estimated as 0.0471 to match the steady state value of residential stock of housing to output ratio of 272% (in the US, this measure is 140%).

The share of capital in output or $\theta_k = 0.37$, and the share of entrepreneurial land in output or $\theta_{hc} = 0.04$ 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 share of transfer going to the worker, while there is no data that separately provides 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 worker’s share of the aggregate transfer that ensures this is 0.86. The aggregate transfers by Japanese government as a percentage of output is 6.73%. The calibrated parameters are summarized in Table 1 and includes relevant calibrations from Davis and Heathcote (2005) and Iacoviello (2005) for comparison purposes.

5.1.2. Benchmark Analysis

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

**Evolution of TFP:** Given the data, the calibrated share parameters and the Cobb-Douglas production function, TFP is estimated as the Solow residual (Figure 5 & Table 2). While during the mid to late eighties, productivity exceeded expectations growing at an average rate of 1.85% above trend, the downturn since 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)\(^{19}\).

**Land taxes in Japan:** For its part, the land tax system in Japan is a complicated one\(^{20}\). The statutory tax rate on the corporate land during the early eighties stood at 3.1%\(^{19}\)

\(^{19}\)The slight difference in my calculations as compared to Hayashi and Prescott (2002) or Jorgenson and Motohashi (2003) is due to the fact that I include land as a factor of production in contrast to the other studies.

\(^{20}\)Ishi (2001) discusses in detail many features of land taxation in Japan.
with a maximum cap of 3.8%. The residential land holdings were charged a lower statutory tax rate at about 1/3rd of the corporate sector tax rate. However, the effective tax rates for land is much lower since the tax is not assessed on the market value, rather on a certain percentage of the official land value. The formula for the effective tax rate is given by:

\[
\text{Effective land tax rate} = \frac{\text{Statutory tax rate} \times \text{Assessment ratio} \times \text{Official land value}}{\text{Market Value}}
\]

Every year, the National Land Agency of Japan publishes a bulletin (kouji-kakaku) that provides the official land valuation in 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 this statistics, I set the official land value to market value at 80% for all periods. The corporate land statutory tax rate of Japan has remained pretty constant at about 3.1% over time (this comprises of a 1.4% property tax, 0.3% city planning tax and 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 fell 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 they came back up to the early eighties level by 1997 at about 70%. The idea was that an increasing assessment 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 was not 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 back up to pre-1990s value by 1997 (the annual data is collected from Ishi, 2001, for the sample period) (Figure 6 & Table 2). The average effective residential land tax rate stands at about one-third that of 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:

\[
\Phi(t) = P\Phi(t-1) + \epsilon(t)
\]

\[
\Phi(t) = \{\tilde{A}_t, \tilde{\tau}^e_{lt}, \tilde{\tau}^w_{lt}, \tilde{g}_t\} \text{ and } \epsilon(t) = \{\tilde{c}_{At}, \tilde{c}^e_{lt}, \tilde{c}^w_{lt}, \tilde{c}_{gt}\} \text{ where } \tilde{A}_t \text{ and } \tilde{g}_t \text{ denotes the log deviation of productivity and government expenditure from its steady state, and } \tilde{\tau}^i_{lt}, \ i \in \{e, w\} \text{ denotes the deviation of the land taxes from their steady state. Epsilon or the error terms capture the shocks. } P \text{ is a 4x4 matrix that summarizes the parameters underlying the stochastic process. The innovations } \{\tilde{c}_{At}, \tilde{c}^e_{lt}, \tilde{c}^w_{lt}, \tilde{c}_{gt}\} \text{ are serially independent, multivariate normal random variables. The variance-covariance matrix of the innovations is summarized by another 4x4 matrix that we call } Q. \text{ I assume no contemporaneous correlation of the shocks. The matrix values derived from the Japanese data are outlined in Table 3.}

5.1.3. Methodology

Given the exogenous process summarized by a vector \(\Psi(t) = \{A_t, \tau^e_{lt}, \tau^w_{lt}, g_t\}\) and a vector of endogenous state variables \(\Omega(t) = \{k_t, b_t, a_t, l^e_t, l^w_t\}\), I solve for the policy functions determining the evolution of the endogenous control variables summarized by the vector of allocations \(\Xi(t) = \{c^w_t, c^e_t, l^w_{t+1}, h^w_t, h^e_t, y_t, b_{t+1}, a_{t+1}, T_{ret}^w, T_{ret}^e, k_{t+1}\}\) 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

5.2.1. 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 one economy has higher land
taxes (both commercial and residential) than the other and (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 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 (average tax in Japan during 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 the counterpart in the high tax economy by 84.12%. Moreover, the numbers suggest at least in the steady state, the difference between the two economies in terms of output, corporate land holdings 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 price (0.83%) except now the land holdings of the entrepreneur does 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?

5.2.2. 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 borrowings, and consequently output\textsuperscript{21}; (2) in comparison to the impact of changes in land taxes, the effect of TFP shocks are 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 later sections, we test if our findings are robust to assuming more permanent shocks. Note that the external shocks bring about significant shifts in land holding of the entrepreneurs. We term this effect as

\textsuperscript{21}The effect of a decline in TFP or an increase in land holding taxes would be just the opposite
the "redistribution mechanism". An increase (decrease) in TFP or a decline (increase) in land holding taxes increases (decreases) the returns to land and prompts the entrepreneur 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 (both taxes on land holdings of the households as well as 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% increase in output with respect to the long term trend, while the declining TFP of the nineties in our model generate 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 jointly vary in our model, the predicted fluctuations in output overshoot the data.

While 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. While TFP alone predicts an increase of 0.33% during the eighties (as compared to 76% in data), during the nineties, the predicted fall is 1.76% (47% in data). Land taxes perform slightly better, predicting .69% increase in eighties and 3% fall in the nineties. Even feeding in the exogenous shocks 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. While the land holding taxes on the households acts like a shock to housing preferences, a trigger that has the potential to generate large asset price fluctuations (Liu, Wang and Zha, 2013), aided by land taxes on entrepreneurial land holding that acts as investment shocks, a good estimation requires the shocks to be volatile enough. However, in our data, the standard deviation of the land taxes is 0.002 as compared to a standard deviation of 0.0462
noted in housing preference shocks modeled in Liu, Wang and Zha (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 increase by 33.7% (20.2% in data) and in the nineties, land holdings decline by 52% (7% in data). These findings are robust to alternative parameterization\textsuperscript{22}.

Note that our model predictions significantly overshoots the redistribution of land as compared to data, particularly during the decline of the nineties\textsuperscript{23}. 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 into account zoning laws 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 vs. 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 till 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:

\[ b_{t+1} \leq B_{t+1}(1 + g_z)^{t+1} \]

\textsuperscript{22} Results outlined in an online appendix.

\textsuperscript{23} This factor is also responsible for the high degree of correlation between land redistribution and output noted in our results.
where $B_{t+1}$ is the exogenously set borrowing limit$^{24}$. I conduct the same exercise as before and feed in time varying TFP and land holding taxes in unison (numerical results summarized in Table 6-A, 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 as compared to 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 more magnified. 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 generate greater fluctuations than an exogenously fixed collateral limit. The results thus provide us with a quantitative evidence of 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 like monetary policy to generate 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, Wang, and Zha, 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 as in the data are not enough to generate observed land price fluctuations, a contradiction to existing literature. Here, we investigate further this apparent contradiction. 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

\footnote{Note that I assume 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.}
decided by the government, but incorporate broader distortions of the real estate market which influence price volatility, to what extend does our model performance change? This is the classical "Business Cycle Accounting (BCA)" approach developed by Chari, Kehoe and McGrattan (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.

While 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 like Liu, Wang and Zha (2013) is equivalent to the "tax" on household land holding in our benchmark model (called "equivalence" proposition in the BCA literature). Therefore, if we move away from interpreting the tax on household land holding as merely a fiscal policy, but 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. Since 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) secondly, we estimate the time varying housing preference shocks from the data using BCA techniques, 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 in the benchmark model. Then, the BCA estimation results, if it proves 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. A 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.

### 6.1.1. 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:

\[ u^w_t(c^w_t, 1 - h^w_t, l^w_t) = \log c^w_t + \alpha_1 \log (1 - h^w_t) + \varphi_t \log (l^w_t) \]

where \( \varphi_t \) is a shock to household taste for land services (like Liu, Wang and Zha, 2013).

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

\[ c^w_t + q_t(l^w_{t+1} - l^w_t) + a_{t+1} \leq w_t h^w_t (1 - \tau_{ht}) + (1 + r_t(1 - \tau_{at}))a_t + T r^w_t \]

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 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\(^{25}\):

\[ \beta E_t \left( \frac{\alpha_2}{l^w_{t+1}} + \frac{q_t+1}{c^w_{t+1}} (1 - \tau^w_{ht+1}) \right) = \frac{q_t}{c^w_t} \]

\(^{25}\)The details of the first order conditions are in the online appendix.
where the R.H.S denotes the current loss in utility by 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, net of any land holding taxes paid (marginal benefit).

Note that a decline in land holding taxes, $\tau_{lt+1}$, 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:

\[
\beta E_t \left( \frac{\varphi_{l+1}}{t_{l+1}} + \frac{q_{l+1}}{c_{l+1}} \right) = \frac{q_t}{c_t^{aw}}
\]

An increase in preferences for land $\varphi_{l+1}$ also increases the marginal benefit of an unit of land investment, given the marginal cost, and would result in an increased demand for land, therefore land prices as well, much like a decline in land holding taxes.

Note that the first order conditions of the two models are identical where:

\[
E_t \left( \frac{\alpha_2}{l_{l+1}} + \frac{q_{l+1}}{c_{l+1}} (1 - \tau_{lt+1}^l) \right) = E_t \left( \frac{\varphi_{l+1}}{l_{l+1}} + \frac{q_{l+1}}{c_{l+1}} \right)
\]

Since the entrepreneur’s problem as well as all other relevant first order conditions remain the same, the above equality establishes equivalence of the two alternative models.

6.1. 2. 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, Kehoe and McGrattan 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 $\beta$ the same as in our benchmark model. Once we have the housing preference shock thus estimated, we posit an AR1 process for the shock:

$$\ln \varphi_t = (1 - \rho_\varphi) \ln \varphi + \rho_\varphi \ln \varphi_{t-1} + \sigma_\varphi \varepsilon_{\varphi t}$$

where $\rho_\varphi$ is the persistence parameter, $\varphi$ is a constant determined in the steady state, $\sigma_\varphi$ 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, Wang and Zha’s (2013) persistence measure at 0.9997. Our standard deviation measure $\sigma_\varphi = 0.1014$ is higher than Liu, Wang and Zha (2013) who get 0.0462 from U.S. data, and it is also much higher than a standard deviation of 0.002 of the household land holding taxes in the benchmark model.

The results are outlined in Table 6-B. 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, Wang and Zha (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. Since 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 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 of 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 the other (since entire land supply is held either by the household or the entrepreneur). Land price increases as a result. 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 at play.

7. CONCLUSION

Generating asset price volatility along with appropriate macroeconomic fluctuations has been a challenge in applied macroeconomics literature. Recently, a class of models have proved promising by introducing novel features like "sentiment" shocks or changes in consumer preferences for housing in 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 to be highly persistent, or the shocks themselves are very volatile. The financial accelerator in our paper works through redistribution of the collateral asset amongst constrained and unconstrained agents in response to external triggers. 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 simultaneously match asset price volatility without compromising the ability to match changes in output. Introducing housing demand shocks, mimicked by a tax on land holdings prove 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.

References


APPENDIX 1: Proof of Proposition 1

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:

\[
\beta \lambda^w (1 + r (1 - \tau_a)) = \lambda^w
\]

and

\[
\beta \lambda^e (1 + r (1 - \tau_y)) = \lambda^e - \mu
\]

where the variables without the time subscripts denote the steady state. \( \lambda^w \) and \( \lambda^e \) are the steady state lagrange multipliers associated with the representative worker’s and the entrepreneur’s budget constraint respectively. Equation (1) yields the steady state rate of interest \( r \) as:

\[
r = \frac{\frac{1}{\beta} - 1}{1 - \tau_a}
\]

Substituting value of \( r \) in equation (2), we can express \( \mu \), the steady state value of the lagrange multiplier associated with the borrowing constraint as:

\[
\frac{\mu}{\lambda^e} = (1 - \beta) \frac{(\tau_y - \tau_a)}{1 - \tau_a}
\]

Note that the standard assumption of non-satiation of preferences implies that \( \lambda^e > 0 \). Given that \( 0 < \beta < 1 \) and \( 0 < \tau_a < 1 \), if \( \tau_y > \tau_a \), then \( \mu \) 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.

\[\text{Steady state equations are available in the online appendix.}\]
### TABLE 1: CALIBRATED PARAMETERS

<table>
<thead>
<tr>
<th>Parameter description</th>
<th>Parameter symbol</th>
<th>Our model</th>
<th>MI</th>
<th>DH*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Utility function parameters</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elasticity of substitution</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Consumption and leisure</td>
<td>$\alpha_1$</td>
<td>1.96</td>
<td>1.01</td>
<td>2.06</td>
</tr>
<tr>
<td>- Consumption and land</td>
<td>$\alpha_2$</td>
<td>0.0471</td>
<td>0.10</td>
<td>0.13</td>
</tr>
<tr>
<td>Rate of time preference</td>
<td>$\beta$</td>
<td>0.99</td>
<td>0.99</td>
<td>0.95</td>
</tr>
<tr>
<td><strong>Production function parameters</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate of depreciation of capital</td>
<td>$\delta$</td>
<td>0.1002</td>
<td>0.12</td>
<td>0.06</td>
</tr>
<tr>
<td>Share of capital in output</td>
<td>$\theta_k$</td>
<td>0.37</td>
<td>0.30</td>
<td>0.31</td>
</tr>
<tr>
<td>Share of entrepreneurial land in output</td>
<td>$\theta_{le}$</td>
<td>0.04</td>
<td>0.03</td>
<td>0.106**</td>
</tr>
<tr>
<td>Share of aggregate labor in output</td>
<td>$1 - \theta_k - \theta_{le}$</td>
<td>0.59</td>
<td>0.66</td>
<td>0.594</td>
</tr>
<tr>
<td><strong>Borrowing constraint parameter</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loan to value ratio</td>
<td>$\phi$</td>
<td>0.66</td>
<td>0.89</td>
<td></td>
</tr>
</tbody>
</table>

**Note for Table 1:** 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) & Davis & Heathcote (2005) to provide a comparison with our calculations. Note that MI and DH calibrate their models to match the US data.

* DH model differs from ours and focuses on mortgage markets.

**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.

**Data Source:** The calibration is based on the data collected from the Japan Statistical Yearbooks. TFP is based on author’s calculations from the raw data and data on land taxes is from Ishi (2001).
TABLE 2: TRENDS IN TFP AND TAXES ON LAND HOLDINGS

<table>
<thead>
<tr>
<th>Year</th>
<th>TFP Undetrended</th>
<th>TFP Detrended</th>
<th>Land Holding Taxes</th>
<th>Residential</th>
<th>Corporate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980:1991</td>
<td>1.85%</td>
<td>0.48%</td>
<td>-2.96%</td>
<td>-2.34%</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>1.10%</td>
<td>1.08%</td>
<td>12.56%</td>
<td>10.89%</td>
<td></td>
</tr>
<tr>
<td>Standard deviation</td>
<td>1.85%</td>
<td>1.24%</td>
<td>10.70%</td>
<td>10.20%</td>
<td></td>
</tr>
<tr>
<td>1991:2000</td>
<td>0.21%</td>
<td>-1.10%</td>
<td>12.19%</td>
<td>12.14%</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>1.85%</td>
<td>1.24%</td>
<td>10.70%</td>
<td>10.20%</td>
<td></td>
</tr>
</tbody>
</table>

Note for Table 2: 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 as well as detrended with a long term rate of 2.15%. Land holding taxes are the "effective taxes". The change figures reported above 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 of the effective corporate land taxes on average, hence the mean and standard deviations of the percentage changes in land taxes are very similar for residential and corporate land.

Data Source: TFP is based on the author’s calculations. The data on land taxes are from Ishi (2001).

TABLE 3: PARAMETERS OF THE SHOCK PROCESS

\[ P = \begin{pmatrix} 0.51 & 0 & 0 & 0 \\ 0 & 0.91 & 0 & 0 \\ 0 & 0 & 0.91 & 0 \\ 0 & 0 & 0 & 0.95 \end{pmatrix} \]

\[ Q = \begin{pmatrix} 0.007^2 & 0 & 0 & 0 \\ 0 & 0.002^2 & 0 & 0 \\ 0 & 0 & 0.002^2 & 0 \\ 0 & 0 & 0 & 0.004^2 \end{pmatrix} \]

Note for Table 3: 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 of the results: The matrices are determined based on the author’s calculations.
### TABLE 4: STEADY STATE COMPARISON

<table>
<thead>
<tr>
<th>Variable</th>
<th>Symbol</th>
<th>Percentage Change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Model with collateral constraint</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Endogenous</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Exogenous</td>
</tr>
<tr>
<td>Economy with high versus low</td>
<td></td>
<td>land holding taxes, all other factors are same</td>
</tr>
<tr>
<td>Output per capita</td>
<td>$y$</td>
<td>Higher by 1.01% in the economy with low taxes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Higher by 0.34% in the economy with low taxes</td>
</tr>
<tr>
<td>Land price</td>
<td>$q$</td>
<td>Higher by 29.27% in the economy with low taxes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Higher by 5.66% in the economy with low taxes</td>
</tr>
<tr>
<td>Per capita land holding</td>
<td>$l^e$</td>
<td>Higher by 84.12% in the economy with low taxes</td>
</tr>
<tr>
<td>of the entrepreneur</td>
<td></td>
<td>Higher by 67.60% in the economy with low taxes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Economy with high versus low</td>
<td></td>
<td>TFP, all other factors are same</td>
</tr>
<tr>
<td>Output per capita</td>
<td>$y$</td>
<td>Higher by 0.83% in the economy with high TFP</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Higher by 0.80% in the economy with high TFP</td>
</tr>
<tr>
<td>Land price</td>
<td>$q$</td>
<td>Higher by 0.83% in the economy with high TFP</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Higher by 0.80% in the economy with high TFP</td>
</tr>
<tr>
<td>Per capita land holding</td>
<td>$l^e$</td>
<td>No change</td>
</tr>
<tr>
<td>of the entrepreneur</td>
<td></td>
<td>No change</td>
</tr>
</tbody>
</table>

**Note for Table 4:** Implications on macro variables for 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 in the high tax economy is 1.67% 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 differ by 1.00%.

**Source of the results:** Author’s calculations
### TABLE 5: BUSINESS CYCLE IMPLICATIONS

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

**Note:** The data is 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.
TABLE 6-A: EVIDENCE OF AMPLIFICATION

<table>
<thead>
<tr>
<th></th>
<th>Data Model (TFP and land taxes jointly)</th>
<th>Credit Constraint</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Exogenous</td>
</tr>
<tr>
<td><strong>1980:1991</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentage change</td>
<td>9.29%</td>
<td>4.30%</td>
</tr>
<tr>
<td>Mean growth rate</td>
<td>0.82%</td>
<td>0.39%</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>1.04%</td>
<td>0.68%</td>
</tr>
<tr>
<td><strong>Land Price</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentage change</td>
<td>76.25%</td>
<td>0.29%</td>
</tr>
<tr>
<td>Mean growth rate</td>
<td>5.67%</td>
<td>0.03%</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>9.32%</td>
<td>0.06%</td>
</tr>
<tr>
<td><strong>Entrepreneur’s land holding</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentage change</td>
<td>20.17%</td>
<td>2.58%</td>
</tr>
<tr>
<td>Mean growth rate</td>
<td>1.83%</td>
<td>0.23%</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>5.92%</td>
<td>0.26%</td>
</tr>
<tr>
<td><strong>1991:2000</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentage change</td>
<td>-15.46%</td>
<td>-4.51%</td>
</tr>
<tr>
<td>Mean growth rate</td>
<td>-1.59%</td>
<td>-0.47%</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>2.07%</td>
<td>0.54%</td>
</tr>
<tr>
<td><strong>Land Price</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentage change</td>
<td>-47.00%</td>
<td>-1.38%</td>
</tr>
<tr>
<td>Mean growth rate</td>
<td>-7.33%</td>
<td>-0.35%</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>3.18%</td>
<td>0.20%</td>
</tr>
<tr>
<td><strong>Entrepreneur’s land holding</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentage change</td>
<td>-6.45%</td>
<td>-3.50%</td>
</tr>
<tr>
<td>Mean growth rate</td>
<td>-0.13%</td>
<td>-0.29%</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>1.98%</td>
<td>0.67%</td>
</tr>
<tr>
<td><strong>Correlations</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output and Land price</td>
<td>0.85</td>
<td>0.52</td>
</tr>
<tr>
<td>Output and Entrepreneur’s land holding</td>
<td>0.35</td>
<td>0.90</td>
</tr>
</tbody>
</table>

**Note:** The data is 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 borrowings is set exogenously.
# TABLE 6-B: IMPACT OF HOUSING PREFERENCE SHOCKS

<table>
<thead>
<tr>
<th>Shocks</th>
<th>Data</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Housing</td>
<td>All shocks</td>
</tr>
<tr>
<td></td>
<td>Preference</td>
<td>jointly</td>
</tr>
<tr>
<td><strong>output</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentage change</td>
<td>9.29%</td>
<td>2.03%</td>
</tr>
<tr>
<td>Mean growth rate</td>
<td>0.82%</td>
<td>0.21%</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>1.04%</td>
<td>0.15%</td>
</tr>
<tr>
<td><strong>land price</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentage change</td>
<td>76.25%</td>
<td>32.89%</td>
</tr>
<tr>
<td>Mean growth rate</td>
<td>5.67%</td>
<td>1.73%</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>9.32%</td>
<td>2.16%</td>
</tr>
<tr>
<td><strong>Entrepreneur's land holding</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentage change</td>
<td>20.17%</td>
<td>-2.13%</td>
</tr>
<tr>
<td>Mean growth rate</td>
<td>1.83%</td>
<td>-0.03%</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>5.92%</td>
<td>0.23%</td>
</tr>
<tr>
<td><strong>1991:2000</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>output</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentage change</td>
<td>-15.46%</td>
<td>-3.16%</td>
</tr>
<tr>
<td>Mean growth rate</td>
<td>-1.59%</td>
<td>-0.97%</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>2.07%</td>
<td>0.84%</td>
</tr>
<tr>
<td><strong>land price</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentage change</td>
<td>-47.00%</td>
<td>-18.38%</td>
</tr>
<tr>
<td>Mean growth rate</td>
<td>-7.33%</td>
<td>-0.85%</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>3.18%</td>
<td>0.82%</td>
</tr>
<tr>
<td><strong>Entrepreneur's land holding</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentage change</td>
<td>-6.45%</td>
<td>2.98%</td>
</tr>
<tr>
<td>Mean growth rate</td>
<td>-1.13%</td>
<td>0.09%</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>1.98%</td>
<td>0.17%</td>
</tr>
<tr>
<td><strong>correlations</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output and land price</td>
<td>0.85</td>
<td>0.82</td>
</tr>
<tr>
<td>Output and Entrepreneur's land holding</td>
<td>0.35</td>
<td>-0.01</td>
</tr>
</tbody>
</table>

**Note:** The data is 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.
Note: In Figure 1, we measure GDP per capita during the period 1980 to 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. In Figures 2 and 3, we plot average land price index for all of Japan (total land, residential land and commercial land) and the six major cities also known as the \textit{ku}-areas (Tokyo, Nagoya, Osaka, Yokohama, Kyoto and Kobe) during 1980 to 2000.

Data Source: The data is from Japan Statistical Yearbooks provided by the Statistical Bureau of Japan.
FIGURE 4: SHARE OF CORPORATE LAND HOLDING

FIGURE 5: DETRENDED TFP

FIGURE 6: EFFECTIVE LAND HOLDING TAXES

Note: Figure 4 plots corporate land holding during 1980 to 2000 as a percentage of total land where total land is the sum of residential and commercial land underlying buildings. In Figure 5, TFP is measured as the Solow residual and is detrended by the long term rate of technological progress, 2.15%. The effective land tax rate is plotted for the corporate sector (blue line - entrepreneurs in the model) and the residential sector (pink line - households in the model) in Figure 6. 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.

Data Source: The data on land holding is available from Japan Statistical Yearbooks provided by the Statistical Bureau of Japan. The TFP is calculated by the author based on the data compiled from the Japan Statistical Yearbooks provided by the Statistical Bureau of Japan. The data on land taxes is from Ishi (2001).
FIGURE 7: IMPULSE RESPONSES

1% positive shock to TFP & 1% negative shock to land holding taxes - residential and corporate

Note: In Figure 7, we plot the response of output per capita, land price, borrowing of the entrepreneur and capital & 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.