Asset bubble and endogenous labor supply: a clarification

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Abstract

This paper analyzes the link between asset bubbles, endogenous labor and capital. The question is whether endogenous labor, per se, can explain a crowding-in effect of the bubble, i.e. higher levels of capital and labor. With respect to the existing literature, our contribution is twofold. First, we explicitly and theoretically derive the conditions to have a crowding-in effect of the bubble. Second, the utility function we consider allows us to show that this result does not require an arbitrarily high elasticity of intertemporal substitution in consumption. Our result still holds for a unit value of this elascticity (Cobb-Douglas utility).

JEL classification: E22, E44, J22

Keywords: Asset bubbles, crowding-in effect, endogenous labor, overlapping generations.

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1 Introduction

Some recent episodes of asset bubbles, measured by the difference between the market price and the market fundamental, are characterized by the sharp increase of asset prices followed by a contraction, causing a great recession of economic activity and waves of job destructions. Many countries have witnessed this phenomenon, for instance, the United States during 2000-2007 and Japan during 1980-1990. Asset bubble periods are associated to high levels of employment and capital stock, and boom in economic activity (Martin and Ventura (2012), Miao and Wang (2016), Hashimoto and Im (2019)). After the collapse of housing and asset prices in the U.S in 2007, the average annual labor hours recorded a decline of 1.83% in 2009 (OECD database). Despite these observations, the relationship between rational bubbles and employment has not been extensively investigated in macroeconomics. The purpose of this paper is to address this relationship.

In their seminal studies, Tirole (1985) and Weil (1987) show that deterministic and stochastic bubbles have a recessionary effect on GDP, by absorbing a share of over-saving which leads to lower capital and increase the interest rate. This is the so-called crowding-out effect of bubble, but is hard to reconcile with the observations. Thus, recent works exhibit different mechanisms explaining that bubbly episodes are characterized by the boom of productive capital and its bursting causes depression, meaning that there is a crowding-in effect of the bubble. For instance, Martin and Ventura (2012) or Hirano and Yanagawa (2016) rely on the existence of heterogeneous investment projects, Fahri and Tirole (2012) focus on the liquidity role of bubbles, Kocherlakota (2009) assumes that the bubble plays the role of collateral in the credit constraint, while Raurich and Seegmuller (2019) make a distinction between liquid bubbles and illiquid capital. However, these studies are not interested in the link between asset bubbles and employment.

Our paper contributes to the few literature that investigates the relationship between bubbles and employment provided some mechanism explaining that asset bubbles raise employment. Among the others, Miao *et al.* (2016) incorporate endogenous credit constraints. Under optimistic beliefs, the firms can borrow more because their value used as a collateral is higher. In that case, they are hiring more. Kunieda *et al.* (2017) rely on the existence of heterogeneous investment projects. The mechanism is close to the one introduced in Martin and Ventura (2012), but is extended to a model with unemployment. Investors having the projects with the higher return sell the bubble to those which have projects with lower returns to increase their investment, capital and employment. Finally, Kocherlakota (2011) combines overlapping generations to a matching model on the labor market. Following a crash of the bubble, the increase of unemployment is due to the zero lower bound of the interest rate imposed by the monetary authority, which restricts the liquidity in periods of recession. Hence, in all these papers, the positive link between the bubble and employment is driven by some form of credit or liquidity constraint.

Shi and Suen (2014) adopt another strategy, which does not rely on the existence of a credit constraint. They extend the Tirole (1985) model to endogenous labor and highlight that asset bubbles can promote capital and labor. A higher interest rate at the bubbly steady state may be in accordance with higher capital when labor is higher too. The main mechanism goes through the labor supply. It should strongly increase with respect to the interest rate. Considering a separable utility function over consumptions, Shi and Suen (2014) highlight, using a calibration, that it requires a high elasticity of intertemporal substitution in consumption. However, the empirical estimations show that realistic values of this elasticity are between 1 and 2 (Gruber (2013), Mulligan (2002), Vissing-Jorgensen and Attanasio (2003)), while Shi and Suen (2014) calibration is 6.66. In addition, they don't provide an explicit and theoretical proof of their result.[1]

This paper fills these gaps. We consider an overlapping generations model with a non-separable utility function over consumptions, that allows to disentangle the elasticity of intertemporal substitution in consumption and the degree of homogeneity over consumptions when young and old, and endogenous labor. Of course, our utility function admits as a particular case the Shi and Suen (2014) specification. At the first period of life, each agent works, consumes and saves, and at the second period, she only consumes. There is a portfolio choice between the investment in productive capital and in a purely speculative asset.

Comparing the bubbleless and bubbly steady states, we theoretically show that the bubble may have a crowding-in effect on capital and labor, i.e. the levels of capital and labor are higher when there is a positive bubble. The main idea is the following. When there is a bubble, the interest rate is higher because the bubble compensates the shortage of asset and reduces over-savings. In that case, capital can increase only if labor increases too. This happens when the labor supply is positively correlated with the interest rate. Under a separable utility function, Shi and Suen (2014) emphasizes that this requires a high elasticity of intertemporal substitution in consumption. We theoretically show that this is no more the case when one considers a more general family of non-separable utility functions. A bubble has a crowding-in effect on labor and capital for a realistic interval of elasticities of intertemporal substitution in consumption, which encompasses the Cobb-Douglas case. Therefore, we show that under realistic parameterizations, endogenous labor per se is a channel which may explain the crowding-in effect of bubbles.

Our paper is organized as follows. Next section presents the model and defines an intertemporal equilibrium. Sections 3 describes the steady state equilibrium with and without bubble and determines the condition for the existence of asset bubble. Section 4 figures out the condition under which the asset bubble has a crowding-in effect, i.e. raises employment and capital. The last section concludes.

[1]In fact, the reader does not know if the condition in their Proposition 3 is satisfied or not.

2 Model

We consider an economy with two types of agents, households and firms. Time is discrete, $t = 0, 1, 2... + \infty$. We describe the behavior of this two types of agents and, finally, define an intertemporal equilibrium.

2.1 Households

We consider an overlapping generations (OLG) model in which consumers live two periods: young and old ages. In each period of time $t \geq 0$, a new generation of identical consumers is born with a population size $N_t = (1+n)^t$ growing at the rate $n > -1$. Each young households supplies elastically labor (l_t). At the first period of life, each household works and earns a wage income w_t, consumes c_{1t} and saves through two types of assets. Each saver makes a portfolio choice between investing in productive capital, s_t, and holding m_t units of an intrinsically useless paper asset, for instance "money", which has a positive value $P_t \geqslant 0$. In the second period, the household consumes c_{2t+1}, that is, the returns on productive investment $(R_{t+1}s_t)$ and useless asset $(P_{t+1}m_t)$, where R_{t+1} and P_{t+1} denote the interest factor on capital and the price of the intrinsically useless asset at time $t+1$, respectively.[2]

The utility over the life-cycle is given by:

$$U(c_{1t}, c_{2t+1}, l_t) = \frac{1}{\pi}\left[c_{1t}^{\frac{\theta-1}{\theta}} + \gamma c_{2t+1}^{\frac{\theta-1}{\theta}}\right]^{\frac{\pi\theta}{\theta-1}} - V\frac{l_t^{1+\mu}}{1+\mu} \tag{1}$$

where $\pi \in (0,1]$ denotes the degree of homogeneity of the utility for consumption, $V > 0$ a constant parameter of disutility of work, $\mu \geq 0$ the inverse of the Frisch elasticity of labor supply, $\gamma \in (0,1)$ the subjective discount factor and $\theta \geqslant 1$ the intertemporal elasticity of substitution in consumption. Note that we restrict our attention to configurations where θ is not lower than 1 to focus on saving functions which do not decrease with the interest factor R_{t+1}.

This utility function allows us to consider several well-known utilities as particular cases. Especially, when $\pi = (\theta-1)/\theta$, the utility is separable between consumption in both periods, with an elasticity of intertemporal substitution of consumption equal to θ. This is the specification considered in Shi and Suen (2014). When $\pi = 1$, the utility over consumptions is CES. It is Cobb-Douglas if in addition $\theta = 1$.

Taking $(w_t, P_t, P_{t+1}, R_{t+1})$ as given, the consumer's problem is to choose an allocation $(c_{1t}, c_{2t+1}, s_t, m_t, l_t)$ that maximizes her lifetime utility (1) subject to the budget constraints:

$$c_{1t} + s_t + P_t m_t = w_t l_t \tag{2}$$

$$c_{2t+1} = R_{t+1}s_t + P_{t+1}m_t \tag{3}$$

[2]As it is often assumed in overlapping generations economy where the period is long, we assume complete depreciation of capital after one period of use, which means that R_{t+1} represents equivalently the gross return of capital or the interest rate.

The first-order conditions for this problem are given by:

$$c_{1t}^{\frac{-1}{\theta}} = \gamma R_{t+1} c_{2t+1}^{\frac{-1}{\theta}} \quad \text{and} \quad V l_t^{\mu} = c_{1t}^{\frac{-1}{\theta}} w_t \left[c_{1t}^{\frac{\theta-1}{\theta}} + \gamma c_{2t+1}^{\frac{\theta-1}{\theta}} \right]^{\frac{\pi\theta}{\theta-1}-1} \tag{4}$$

and the no arbitrage condition between capital and the useless asset:

$$P_t R_{t+1} = P_{t+1} \tag{5}$$

When there is a bubble on the useless asset, $P_t > 0$ and the returns on productive capital is equal to the returns of holding the speculative bubble. In other words, the bubble must grow at the rate of interest. Using these equations, we obtain:

$$c_{1t} = \frac{w_t l_t}{1+\gamma^{\theta} R_{t+1}^{\theta-1}} \quad , \quad c_{2t+1} = \frac{\gamma^{\theta} R_{t+1}^{\theta} w_t l_t}{1+\gamma^{\theta} R_{t+1}^{\theta-1}}, \tag{6}$$

$$s_t + P_t m_t = \frac{\gamma^{\theta} R_{t+1}^{\theta-1}}{1+\gamma^{\theta} R_{t+1}^{\theta-1}} w_t l_t \tag{7}$$

and, substituting (6) into (4), we get:

$$l_t = [V^{-\frac{1}{\pi}} w_t (1+\gamma^{\theta} R_{t+1}^{\theta-1})^{\frac{1}{\theta-1}}]^{\frac{\pi}{1+\mu-\pi}} \tag{8}$$

Note that the second order condition for the labor choice requires $1+\mu > \pi$, which implies that the labor supply is increasing with the wage w_t and the interest factor R_{t+1}.

2.2 Firms

In the economy, there is a continuum of identical and competitive firms of unit mass. Each firm rents capital K_t and hires labor L_t at interest rate R_t and wage w_t, respectively. Production is given by the following Cobb Douglas technology:

$$Y_t = A K_t^{\beta} L_t^{1-\beta}$$

with $A > 0$ and $0 < \beta < 1$. Profit maximization yields:

$$w_t = (1-\beta) K_t^{\beta} L_t^{-\beta} \quad \text{and} \quad R_t = \beta K_t^{\beta-1} L_t^{1-\beta} \tag{9}$$

2.3 Intertemporal equilibrium

Labor marker clears in each period, so that $l_t = L_t / N_t$. Using (9), the equilibrium wage and interest rate can be expressed as:

$$w_t = (1-\beta) k_t^{\beta} l_t^{-\beta} \quad \text{and} \quad R_t = \beta k_t^{\beta-1} l_t^{1-\beta} \tag{10}$$

where $k_t = K_t / N_t$ denotes the capital stock per worker.

Equilibrium on the asset market requires that aggregate savings of young households is used to buy the useless bubble and the future capital stock.[3]

$$K_{t+1} + P_t m_t N_t = N_t S_t \tag{11}$$

The total supply of the intrinsically useless asset is constant over time and is denoted by $M > 0$. Since this asset has no fundamental value, it is a (pure) bubble when its price is strictly positive, i.e. $P_t > 0$. Each young household buy m_t units of asset bubbles, meaning that at equilibrium,

$$N_t m_t = M \tag{12}$$

Let $b_t = P_t m_t$ be the value of financial asset at time t hold by an household. Using the no-arbitrage condition between bubble and capital stock (5), we have:

$$b_{t+1} = \frac{R_{t+1}}{(1+n)} b_t \tag{13}$$

where $b_t > 0$ if there is a bubble. Using equations (7) and (10), the equilibrium on the asset market (11) rewrites:

$$(1+n)k_{t+1} = (1-\beta)\left(\frac{\gamma^\theta R_{t+1}^{\theta-1}}{1+\gamma^\theta R_{t+1}^{\theta-1}}\right)\left(\frac{k_t}{l_t}\right)^\beta l_t - b_t \tag{14}$$

while using equations (8) and (10), we get:

$$l_t = \left[V^{-\frac{1}{\pi}}(1-\beta)\left(\frac{k_t}{l_t}\right)^\beta (1+\gamma^\theta R_{t+1}^{\theta-1})^{\frac{1}{\theta-1}}\right]^{\frac{\pi}{1+\mu-\pi}} \tag{15}$$

Definition 1 *Given the initial capital stock $k_0 = K_0/N_0 > 0$, an intertemporal equilibrium is a sequence $(k_t, l_t, R_t, b_t) \in \mathbb{R}^4_{++}$ satisfying (10), (13), (14) and (15)*

3 Stationary equilibria

A steady state is a solution $k_t = k$, $l_t = l$, $R_t = R$ and $b_t = b$ for all $t \geq 0$ satisfying:

$$l = \left[V^{-\frac{1}{\pi}}(1-\beta)\left(\frac{\beta}{R}\right)^{\frac{\beta}{1-\beta}} (1+\gamma^\theta R^{\theta-1})^{\frac{1}{\theta-1}}\right]^{\frac{\pi}{1+\mu-\pi}} \tag{16}$$

$$k = l\left(\frac{\beta}{R}\right)^{\frac{1}{1-\beta}} \tag{17}$$

$$b = k\left[\frac{1-\beta}{\beta}\frac{\gamma^\theta R^\theta}{1+\gamma^\theta R^{\theta-1}} - (1+n)\right] \tag{18}$$

$$b = \frac{R}{(1+n)} b \tag{19}$$

[3] At time 0, all assets are owned by a generation of "initial-old" consumers, which sell these assets to young households born at this period.

There are two types of stationary equilibria, the bubbleless ones with $b = 0$ and the bubbly ones with $b > 0$.

We first study the existence and uniqueness of a bubbleless steady state. Using equation (18), the value of the interest rate at such a steady state $\tilde{R}$ is determined by:

$$\delta(\tilde{R}) \equiv \frac{\gamma^\theta \tilde{R}^\theta}{1 + \gamma^\theta \tilde{R}^{\theta-1}} = \frac{\beta(1+n)}{1-\beta} \tag{20}$$

where the function $\delta(R)$ is strictly increasing with $\delta(0) = 0$ and $\lim_{R\to+\infty} \delta(R) = +\infty$. We easily deduce that there exists a unique $\tilde{R} > 0$ that solves (20). The following proposition summarizes this result:

Proposition 1 *There exists a unique bubbleless steady state given by* $(k, l, R, b) = (\tilde{k}, \tilde{l}, \tilde{R}, 0)$.

The stationary values $\tilde{l}$ and $\tilde{k}$ are determined by substituting $\tilde{R}$ in (16) and (17).

We switch now to the bubbly steady state where $b > 0$. When there is a bubble, $b > 0$, equation (19) implies that $R^* = (1+n)$, where R^* represents the interest rate at a bubbly steady state. Substituting this last expression in (18), a positive bubble $b > 0$ means:

$$\frac{\gamma^\theta (1+n)^\theta}{1 + \gamma^\theta (1+n)^{\theta-1}} > \frac{\beta(1+n)}{1-\beta} \tag{21}$$

which is equivalent to $\delta(1+n) > \delta(\tilde{R})$ using equation (20), i.e. $1 + n > \tilde{R}$.

Proposition 2 *There exists a unique bubbly steady state* $(k, l, R, b) = (k^*, l^*, 1+n, b^*)$ *if* $\tilde{R} < (1+n)$ *or equivalently:*

$$\frac{\gamma^\theta (1+n)^{\theta-1}}{1 + \gamma^\theta (1+n)^{\theta-1}} > \frac{\beta}{1-\beta} \tag{22}$$

By inspection of inequality (22), we see that Proposition 2 will be satisfied if β is low enough, γ and n are sufficiently high. In that case, equations (16)-(18) give the stationary values l^*, k^* and b^* substituting R by $1 + n$.

The bubble exists if the interest rate at the bubbleless steady state $\tilde{R}$ is lower than the sum of the population growth rate and the depreciation of capital $1+n$, which is also the return of capital at the bubbly steady state. The increase of the capital return occurs because the bubble compensates the shortage of asset and over-saving. When labor is exogenous, this means a lower capital stock at the bubbly than at the bubbleless steady state (Tirole (1985)). When labor is endogenous, it is the capital-labor ratio which is lower at the bubbly steady state. Therefore, as we will see, if labor is higher, capital can be higher too at the bubbly steady state, which means that there is a crowding-in effect of the bubble.

4 Labor supply and crowding-in effect of bubbles

We now examine whether the existence of asset bubble raises employment and capital comparing the bubbly and and bubbleless steady states.[4] By assessing the elasticity of labor supply and capital with respect to the interest rate, we will be able to deduce whether the bubbly steady state is characterized by higher levels of capital and labor supply.

When the bubble exists, the interest rate increases from $\tilde{R}$ to R^*. Such an increase will push up employment. Indeed, using equation (16), the elasticity of l with respect to R, $\xi_{l,R}$, is determined by:

$$\xi_{l,R} = \frac{\pi}{1+\mu-\pi}\left(\frac{\gamma^\theta R^{\theta-1}}{1+\gamma^\theta R^{\theta-1}} - \frac{\beta}{1-\beta}\right) \tag{23}$$

Using (18), $b \geqslant 0$ implies:

$$\xi_{l,R} \geqslant \frac{\pi}{1+\mu-\pi}\frac{\beta}{1-\beta}\left(\frac{1+n}{R}-1\right) \geqslant 0 \tag{24}$$

because all the steady states we consider are characterized by $R \leqslant 1+n$. This means that $l^* > \tilde{l}$.

The capital stock per worker depends positively on the labor supply and negatively on the interest rate. According to equation (17), the elasticity of k with respect to R, $\xi_{k,R}$, is given by:

$$\xi_{k,R} = \xi_{l,R} - \frac{1}{1-\beta} = \frac{\pi}{1+\mu-\pi}\left(\frac{\gamma^\theta R^{\theta-1}}{1+\gamma^\theta R^{\theta-1}} - \Omega\right) \tag{25}$$

where $\Omega \equiv \frac{1+\mu-\pi(1-\beta)}{\pi(1-\beta)} > 0$. We note that $\Omega < 1$ if and only if:

$$\pi > \frac{1+\mu}{2(1-\beta)} \tag{26}$$

which is satisfied for μ and β low, and π sufficiently close to 1. Using equation (25), $\xi_{k,R} > 0$ if and only if:

$$R > \left[\frac{\Omega}{\gamma^\theta(1-\Omega)}\right]^{\frac{1}{\theta-1}} = \left[\frac{1+\mu-\pi(1-\beta)}{\gamma^\theta(2\pi(1-\beta)-(1+\mu))}\right]^{\frac{1}{\theta-1}} \equiv \underline{R} \tag{27}$$

We will have $k^* > \tilde{k}$ if $R^* > \widetilde{R} > \underline{R}$. Using (20), it requires $\delta(\underline{R}) < (1+n)\beta/(1-\beta)$, which is equivalent to:

$$\frac{[1+\mu-\pi(1-\beta)]^{\frac{\theta}{\theta-1}}}{\pi\beta\left[\gamma^\theta(2\pi(1-\beta)-(1+\mu))\right]^{\frac{1}{\theta-1}}} < 1+n \tag{28}$$

This last inequality is satisfied for μ and β low, π sufficiently close to 1, γ and n high enough. This result is summarized in the following proposition:

[4]For the sake of brevity, we do not analyze dynamics, which have been incidentally studied in previous papers with or without bubbles (Benhabib and Laroque (1988), Nourry (2001)).

Proposition 3 *Assume that inequality (22) holds.*

1. *Labor is higher at the bubbly steady state, i.e.* $l^* > \widetilde{l}$.
2. *Capital is higher at the bubbly steady state, i.e.* $k^* > \widetilde{k}$, *if inequalities (26) and (28) are satisfied, which requires* μ *and* β *low,* π *sufficiently close to 1,* γ *and* n *high enough.*

When there is a bubble, the return of capital raises. Despite the decrease of the wage it implies, labor supply always increases. This raise allows to generate a higher level of capital in accordance with the higher interest and, therefore, the lower level of capital-labor ratio. In such a case, the bubble is productive and has a crowding-in effect. Of course, this implies a higher level of production (per capita).

Our model generalizes the result obtained by Shi and Suen (2014). They consider the particular case of a separable utility function between consumptions when young and old. In our setting, it corresponds to the particular case where $\pi = \frac{\theta-1}{\theta}$. Using a calibration, they explain that the bubble has a crowding-in effect if the elasticity of intertemporal substitution in consumption θ is sufficiently high. They calibrate the value of θ to 6.66. This result is inconsistent with the empirical estimates that show that the value of θ is rather between 1 and 2 (Gruber (2013), Mulligan (2002), Vissing-Jorgensen and Attanasio (2003)).

In contrast to Shi and Suen (2014), we explicitly and theoretically prove that the bubble may have a crowding-in effect on capital and labor. The utility function we consider is more general than their and disentangles the degree of homogeneity π from the elacticity of intertemporal substitution in consumption θ. This degree of homogeneity should be sufficiently close to one, but the bubble may have a crowding-in effect for smaller and more realistic values of the elacticity of intertemporal substitution in consumption than in Shi and Suen (2014).

To reinforce our argument, let us consider the case of a Cobb-Douglas utility over the consumptions in both periods. We obtain this case for $\pi = 1$ and $\theta = 1$. Then, the utility function (1) writes $c_{1t}c_{2t+1}^{\gamma} - V\frac{l_t^{1+\mu}}{1+\mu}$. According to Proposition 2, equations (23) and (25), the bubble exists and has a crowding-in effect on labor and capital, i.e. $k^* > \tilde{k}$ and $l^* > \tilde{l}$, if:

$$\frac{\gamma}{1+\gamma} > \frac{\mu+\beta}{1+\beta}$$

This proves that contrary to what is agued by Shi and Suen (2014), a bubble exists and has a crowding-in effect for an elasticity of intertemporal substitution in consumption not arbitrarily large. As we show, the bubble can enhance capital and labor under a Cobb-Douglas utility over consumptions, which corresponds to a unit value of this elasticity. It requires an elasticity of labor supply $1/\mu$ and a saving rate $\gamma/(1+\gamma)$ sufficiently high, and a share of capital β low enough.

5 Conclusion

In this paper, we have highlighted in a more general way than previous papers the interaction between bubbles, labor and capital. We have thus considered an OLG model with elastic labor supply. Asset bubble can appear if the interest rate at the bubbleless equilibrium is lower than the growth rate of population. We have found some conditions such that the bubble has a crowding-in effect on capital and labor. In contrast to Shi and Suen (2014), our result is theoretically shown and does not require an elasticity of intertemporal substitution in consumption too high. Considering a non-separable utility function between consumptions when young and old, the crowding-in effect of the bubble holds for values of that elasticity close or equal to 1, which are empirically relevant values. Therefore, this paper shows that endogenous labor is a relevant channel that may contribute to explain that bubble episodes are characterized by higher levels of capital and employment.

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