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Taxation of Land and Economic Growth

Shulu Che [1], Ronald Ravinesh Kumar [2] and Peter J. Stauvermann [1,*]

[1] Department of Global Business and Economics, Changwon National University, Changwon 51140, Korea; uknowlook@gmail.com
[2] School of Accounting, Finance and Economics, Laucala Campus, The University of the South Pacific, Suva 40302, Fiji; ronald.kumar@usp.ac.fj
* Correspondence: pjsta@changwon.ac.kr; Tel.: +82-55-213-3309

Abstract: In this paper, we theoretically analyze the effects of three types of land taxes on economic growth using an overlapping generation model in which land can be used for production or consumption (housing) purposes. Based on the analyses in which land is used as a factor of production, we can confirm that the taxation of land will lead to an increase in the growth rate of the economy. Particularly, we show that the introduction of a tax on land rents, a tax on the value of land or a stamp duty will cause the net price of land to decline. Further, we show that the nationalization of land and the redistribution of the land rents to the young generation will maximize the growth rate of the economy.

Keywords: taxation of land; land rents; overlapping generation model; land property; endogenous growth

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1. Introduction

In this paper, we use a growth model to theoretically investigate the influence of different types of land tax on economic growth. Further, we investigate how the allocation of the tax revenue influences the growth of the economy.

The idea of taxing land and the subsequent outcomes have a long history and are based on the characteristics that land is fixed in supply and is not mobile. It is widely acknowledged in economics that the fixed supply of land leads to economic rents (Ricardo 1821) and that the existence of economic rents indicates an allocative inefficiency. The economic rent of land is the differential between the productive capacity of the land and the margin of production. Adam Smith ([1776] 1904, p. 142) posited that "[t]he rent of land, therefore, considered as the price paid for the use of the land, is naturally a monopoly price. It is not at all proportioned to what the landlord may have laid out upon the improvement of the land, or to what he can afford to take, but to what the farmer can afford to give".

Henry George ([1789] 1935) was one of the first to investigate the question of how to deal with land property and its taxation. According to George, "Pure Ricardian rent results from growth and change of the society as a whole, not from the sacrifices of the particular individuals who have occupied the land, and therefore ought to accrue to the society as whole." (Whitaker 2001, p. 558).

A primary reason why George's ideas remain popular in scientific (Stiglitz 2015; Kalkuhl et al. 2017) and public (Neklason 2019; *The Economist* 2018) discussions is because the taxation of land does not directly create distortions or welfare losses.

In this paper, a contribution we make in the literature of economic theory is that we consider land both as an input factor of production and as a consumption good for the purpose of housing, whilst analyzing its subsequent impact on the rate of economic growth with three different types of taxation on land. In what follows, we analyze if the main insights and results gained by others (c.f. Tirole 1985; Homburg 1991; Fane 1984; Chamley and Wright 1987; Grossman and Yanagawa 1993; Hashimoto and Sakuragawa 1998; Stauvermann 2002; Koethenbuerger and Poutvaara 2009; Edenhofer et al. 2015;

Dao and Edenhofer 2018) can be confirmed. The novelty of the paper is that it is the first study to consider, in an overlapping generations (OLG) framework, the possibility of using land for production purposes or housing purposes and the subsequent effect of different land taxes and the redistribution of the respective tax revenue to the young generation on economic growth.

The relevance of the study can be underscored by the facts that 50% of the total private investments in the United States are devoted to real estate investments and that the total value of US real estate represents around 60% of the total US wealth (Brito and Pereira 2002; Leung 2004). In absolute numbers, Larson (2015) estimated that the value of land in the United States (7.65 million square km) was approximately $23 trillion in 2009 current prices, where 24% of the land is owned by the federal government. According to Eurostat (2015), the value of land represents 27% of the total national wealth in Italy, 16% in Germany, 21% in the Netherlands and 33% in France in 2012. Further, the value of land represents 53% of the non-financial wealth in Korea, 39% in Australia, 35% in Canada, 7% in the Czech Republic, 44% in France and 42% in Japan in 2012. This indicates that the value of land represents a significant share of the total national wealth and of the national non-financial wealth. Thus, it is pertinent to investigate the role of land in economic growth.

The rest of the paper is organized as follows: In the next section, we provide a literature review on land taxation. In Section 3, we introduce an OLG model with land as a production factor and as a resource for housing. In Section 4, we show that private land ownership has a negative impact on growth. In Section 5, we analyze the impact of three different types of land taxation on growth: a tax on land rents, a tax on the value of land and a stamp duty. In Section 6, we analyze the consequences of a tax on land rents with a tax rate of 100% and the impact on growth when the land rents are redistributed to the working generation. In Section 7, we discuss our results, and in the last section, we conclude.

2. Literature Review: Land Taxation

It is argued that in a one-good economy, a tax on land rents will lead to a fall in the net price of land (price after taxation), while the gross price remains constant (Ricardo 1821). This means the burden of the tax has to be borne fully by the landowners. This happens because a tax can only be shifted if the supply of the taxed good or factor can be reduced, but this is not the case because the supply of land is perfectly price inelastic. As noted above, George ([1789] 1935) was the first to propose a tax on the value of land with the intention to redistribute the tax revenue to the poor. However, taking a look at George's work, his policy recommendation is not clear, because once he stated "[w]e must make land common property" (George [1789] 1935, p. 328) and later that "[i]t is not necessary to confiscate land; it is only necessary to confiscate rent" (George [1789] 1935, p. 405). This issue is deeply discussed by Pullen (2001), Whitaker (2001) and Feder (2001). Pullen (2001) argued that George has proposed two inconsistent concepts of reforms. The initial reform was "to make land common property", and the modified reform was to tax land rents. Pullen expressed his doubts if the modified reform is compatible with the initial reform proposal. In a rejoinder on Pullen (2001), Feder (2001) argued that Pullen has misinterpreted the term "common property" in the sense of nationalization of land, but according to Feder, common property and state property are distinct notions. According to Whitaker (1997, 2001), George's principal idea was in fact that the state shall receive the pure land rents. Moreover, to avoid private investment incentives being distorted by the government's appropriation of land rents, and to avoid state ownership of land engendering corruption in the bureaucracy and politics, George proposed a tax on land rents as a compromise, although it was understood that not all the land rents will be appropriated by the state.

Gesell ([1920] 1991) proposed—based on George's ideas—that government should become the only landowner by buying all land at market prices and then receive all land rents by leasing out the land to the private sector. Gesell assumed that the commoditization of land will reduce economic inequality. In contrast to Gesell, George did not propose to compensate the private landowners.

Ricardo (1821) argued that taxation of land will lead to a reduction in the net price of land. However, this was questioned by Feldstein (1977), who presented arguments using a static general equilibrium model. According to Feldstein, an increase in the tax on land rents will lead in the short run to a decline in the value of land, a diversion of savings for capital accumulation and thus an increase in the output per capita. The increase in the capital stock will result in a decrease in the marginal productivity of capital, while marginal productivities of labor and land will increase as a consequence. The effect that an increase in the tax rate leads to a lower marginal productivity of capital and increased marginal productivities of land and labor may lead to the counterintuitive outcome of the price of land rising in the long run. A necessary assumption for this outcome is a negative interest elasticity of savings. Moreover, the outcome implies that at least part of the tax burden is shifted from land to capital owners. The positive effect of the tax (on land rents) on capital accumulation is called the "Feldstein effect", which is grounded in the portfolio choice between investments in land and real capital. However, it should be noted that the assumption of a negative interest elasticity of savings is difficult to justify, because it contradicts the empirics on the interest elasticity of savings (c.f. Gylfason 1993).

In contrast, Calvo et al. (1979) used a Barro–Ramsey growth model with perfect intergenerational altruism to show that a tax on land will not necessarily affect the capital accumulation as derived by Feldstein.

Fane (1984), considering the work of Feldstein (1977) and Calvo et al. (1979), highlighted that the differences of both approaches are due to Calvo et al.'s assumption that individuals are perfectly altruistic. To show that, Fane applied a fully compensated land tax in the context of Feldstein's approach whereby the landowners will be fully compensated for the tax burden. The compensation is achieved by newly issued perpetual government bonds in which the land rents are used to finance the interest payments of the government bonds. Later, Buiter (1989) validated the outcome of Fane in a neoclassical growth model with perfect altruism.

However, Kotlikoff and Summers (1987) showed using Feldstein's framework that Feldstein's outcomes are no longer valid if current consumption and future consumption are perfect substitutes. Chamley and Wright (1987) derived from a dynamic extension of Feldstein (1977) that in the long run the value of land can be positively or negatively affected by tax on land.

Eaton (1987, 1988), using a neoclassical OLG model in an open economy with land, showed that portfolio choice is no longer between investments in land and capital, but a choice between land and foreign assets. Further, Eaton noted that the capital stock, domestic consumption and all prices, except the land price, remain unaffected by the land tax if the country is small. Hence, the considerations of Feldstein are not valid in a small open economy.

Ihori (1990) used an OLG model with money to show that a tax reform in which lump-sum taxes are substituted by a land tax will lead to an increase in the returns of capital and land. Additionally, he showed that the nominal price of land will decline with a land tax, but the change of the real price of land induced by land tax is ambiguous. The latter outcome validates the outcomes of Chamley and Wright (1987) in an OLG model with money.

Using an overlapping generation model of the Diamond (1965) type, Tirole (1985) showed that the existence of a productive asset such as land lowers the steady-state capital intensity and subsequently the income per capita. The argument is simple: if land and capital are perfect substitutes, arbitrage between the two assets leads to the outcome that part of the savings will be invested in land instead of capital. However, the problem is that, on the one hand, the land is productive even if it is not traded and, on the other hand, the lower capital stock leads to lower incomes. This argument was also used in an OLG model with land and endogenous growth by Grossman and Yanagawa (1993), which was based on Romer (1986) and Rebelo (1991). In their framework, the existence of private land will lower not only the per capita income but also the growth rate of capital and per capita income.

Hashimoto and Sakuragawa (1998) and Stauvermann (2002) used the model of Tirole (1985) and Grossman and Yanagawa (1993) to show that a tax on land rents (even if the tax revenue will be wasted) will increase the growth rate of the economy. Further, Stauvermann (2002) showed that the result still holds if land is not traded but inherited from generation to generation. This outcome is consistent with the study of Hashimoto and Sakuragawa (1998) in which the land tax revenue is transferred to the old generation in a lump-sum fashion. The argument in both papers is that the willingness to save declines if the individuals receive additional income or wealth in the second period of life. However, if the tax revenue is transferred to the young generation, the growth rate of the capital stock and the economy will increase.

Fane (1984) and Buiter (1989) derived the equivalence of government debt and pure rent taxation. Their considerations are based on the assumption that landowners are fully compensated for the land tax by bond-financed government debt. Under these circumstances, the resource allocation will be not affected and the tax on land has no effect. This neutrality of the land tax is no longer valid in an endogenous growth model of the Romer (1986) type because, as shown by Stauvermann (2002), a Pareto improvement is possible if the government internalizes the positive externality of capital accumulation.

Petrucci (2006) considered a continuous OLG model in a small open economy with endogenous labor supply and land. The study shows that the economic consequences of a tax on land depend on how the tax revenue is used by the government. If the revenue is used to lower other distortionary taxes such as labor taxes, the wealth accumulation will be spurred. Similarly, Koethenbuerger and Poutvaara (2009), using a standard OLG model with endogenous labor supply, showed that a tax on land may lead to a Pareto improvement, given that the tax on land substitutes a sufficiently high tax on labor.

Further, Edenhofer et al. (2015) investigated the welfare effects of taxation of land in a continuous OLG model and concluded that a redistribution of the tax revenue to the newly born generation leads to an increase in aggregate welfare and the achievement of the social optimum. Dao and Edenhofer (2018) extended the analysis by considering environmental aspects. The study notes that if the revenue of the land tax is used to finance emission mitigation, higher capital intensity and consumption per capita will result. A general survey about the relationship between the taxation of land and sustainable development was provided by Kalkuhl et al. (2017).

In a recent paper, Petrucci (2020) extended the work of Petrucci (2006) by using a two-sector model in a small open economy. In this setting, growth will only be spurred if the land tax substitutes an existing distortionary tax. In a recent paper, Schwerhoff et al. (2020) provided a survey on the taxation of economic rents and economic inequality. They provided reasoning as to why the taxation of rents is an appropriate policy measure to reduce inequality without creating deadweight losses.

While all these studies treat land as an input factor of production, Deaton and Laroque (2001) treated land as a provider of housing services for the young generation in a standard OLG model. They concluded that to achieve or maintain a social optimum, land should be nationalized. Similarly, Skinner (1996) showed that the costs of existing housing subsidies offered by many governments are much higher than usually estimated and that it would be preferable to tax land.

In contrast to the studies above, Bosi and Pham (2016) applied Barro's (1990) endogenous growth model. Based on Barro's assumption that public infrastructure is an important driver of economic growth, they concluded that a rational bubble increases economic growth if the rents of a rational bubble are taxed to finance government investments.

It should be noted that the results generated in models with infinitely living agents and continuous time, such as those of Brito and Pereira (2002), Leung (2003, 2004), Mattauch et al. (2013), Kalkuhl and Edenhofer (2017) and Borri and Reichlin (2021), are not directly comparable with the results derived from a standard OLG framework without perfect altruism. This is because the models with continuous time and infinitely living agents are only comparable with the outcomes of OLG models with perfect altruism (Barro 1974; Calvo et al. 1979). However, the assumption of intergenerational perfect altruism is a very strong assumption because it implicitly requires that parents perfectly consider the preferences of their children and the preferences of all other descendants.

To analyze the effects of land taxation empirically is a challenge because of restricted data availability of land rents and land prices. Particularly, data of land values are missing and thus can only be estimated. The latter can be problematic when it comes to quantifying the effect of land taxes and huge when appropriately applying a specific type of land tax. As noted by Almy's (2016) study, from a sample of 167 countries, only 7 had implemented a tax on land. Wyatt (2019) and Hughes et al. (2020) presented approaches used to calculate the value of land value in practice in different countries.

Yang (2018) attempted to investigate empirically the effect of land value taxation on the value of land and explored the differential effects across various types of land use. He used panel data for Pennsylvania municipalities in which a two-rate property tax is applied. A two-rate property tax means that the land value and the value of buildings on the land are taxed at different rates. Yang showed that increasing the tax rate on land while lowering the tax rate on buildings leads to an increase in assessed land value per acre. Further, the impact of the tax change differs between residential land and commercial and industrial land. It appears that residential land is more responsive to changes in the tax differential than commercial and industrial land.

Janoušková and Sobotovičová (2019) empirically assessed the impact of legislative changes of land taxes and land value on land tax revenues in the Czech Republic. They concluded that the low tax revenue of Czech municipalities in comparison to other municipalities in the European Union is due to the method used by the tax administration to calculate the value of land.

Nassios et al. (2019) investigated the allocative efficiency of the land tax system in Australia and particularly New South Wales using simulations. They used a multiregional computable general equilibrium (CGE) model, which was calibrated using a discrete choice model of housing tenure choice. With this simulation, they were able to calculate the effects of a specific land tax reform on the different sectors of the Australian economy.

Based on the above studies, the theoretical literature using OLG models can be separated based on the assumption of perfect altruism in the sense of Barro (1974) (neoclassical growth models with infinitely living agents belong to this class of models) and without this assumption. Generally, it can be argued that in a world where individuals are perfectly altruistic with respect to their children, the beneficial effects of land taxation are more difficult to derive. To derive a positive effect of a land tax in this class of models, it is necessary that the land tax substitute another distorting tax, that the land tax revenue is used to alleviate negative externalities such as environmental pollution or that the land tax revenue is used to provide public infrastructure.

In OLG models without intergenerational altruism, the steady-state welfare in neoclassical models with exogenous growth can be increased by a tax on land, and in models with endogenous growth, the long-run welfare can be increased by a land tax.

In the following sections, we extend the analysis of land taxes in an OLG model without intergenerational altruism and endogenous growth. We integrate the assumptions of Skinner (1996) and Deaton and Laroque (2001) in the framework of Stauvermann (2002), Hashimoto and Sakuragawa (1998) and Grossman and Yanagawa (1993).

3. Model

To model the consumption side of the economy, we use Diamond's (1965) OLG model where we take into account two generations. A representative member of the young generation supplies labor inelastically, earns a wage rate w_t, consumes c_t^1 of it, rents an apartment or house of size h_t and saves the remaining part of her income. In the second period of life, the consumption c_{t+1}^2 equals the interest payment plus her savings. Without loss of generality, we assume that housing is only demanded by the young generation.

We assume that all individuals have a log-linear utility function as proposed by Skinner (1996) or Deaton and Laroque (2001):

$$U_t\left(c_t^1, c_{t+1}^2,\ h_t\right) = lnc_t^1 + qlnc_{t+1}^2 + vlnh_t \tag{1}$$

The parameter $q > 0$ is the subjective discount factor, and $v > 0$ is the preference parameter for housing. Consequently, the variable h_t reflects the quantity of housing, such as the size of an apartment or house. Different from most models known in the literature, land has a multiple-use character. On the one hand, it can be used as a factor of production, and on the other, it can be used as a durable consumption good called housing. Because of the fact that the construction of houses requires land, we assume for simplicity that construction costs of houses, office buildings and factories are zero. We justify this assumption based on the findings of Knoll et al. (2017), empirically showed that the price development of housing is driven by 80% through the development of land prices. Knoll et al. (2017) showed that relatively stable housing prices in the late 19th century and the first half of the 20th century were a result of the sharp drop in the transportation costs in these periods caused by the dissemination of cars and improvements in the public transport and showed that land and buildings are complements.

We assume each generation consists of N individuals, where $N > 0$ is constant, and consider that the representative agent is equipped with the average productivity. The rental rate per unit of housing equals r_t^h in period t and the market interest factor is R_{t+1} in period $t + 1$. The periodical budget constraints of the representative worker have the following forms:

$$c_t^1 + r_t^h h_t = w_t - s_t \tag{2}$$

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

This means that the individual has to rent a house only in the first period of life, and in the second period of life, the old stay in the house of their child or live in their own house. Maximizing (1) by considering the budget constraints (2) and (3) leads to the following:

$$\max_{s_t, h_t} ln\left(w_t - s_t - r_t^h h_t\right) + qln(R_{t+1}s_t) + vlnh_t \tag{4}$$

Maximization (4) delivers the following first-order conditions:

$$\frac{1}{w_t - s_t - r_t^h h_t} - \frac{q}{s_t} = 0 \tag{5}$$

$$\frac{1}{w_t - s_t - r_t^h h_t} - \frac{v}{h_t} = 0 \tag{6}$$

Using (5) and (6), we determine the optimal amounts of savings and housing of the representative individual as follows:

$$s_t^* = \frac{q}{(1+q+v)} w_t \tag{7}$$

$$h_t^* = \frac{v}{r_t^h(1+q+v)} w_t \tag{8}$$

The consumption in the first period of life and expenditure are linear in the income. In addition, the demand for housing depends negatively on the rental rate r_t^h. The aggregate demand for housing L_t^h becomes

$$L_t^h = Nh_t^* = \frac{vN}{r_t^h(1+q+v)}w_t \tag{9}$$

On the production side of this economy, the function of an individual firm j is given by

$$Y_{t,j} = AF\left(K_{t,j}, \bar{k}_t N_{t,j}, K_t L_{t,j}^p\right) \tag{10}$$

where A is a positive constant and $L_{t,j}^p$ represents the stock of land used by firm j. The variable K_t represents the economy-wide capital stock, $N_{t,j}$ represents the hired labor force working for firm j, $K_{t,j}$ represents the firm-specific capital stock and $\bar{k}_t$ represents the economy-wide capital intensity. The use of the capital intensity guarantees that the growth rate will not increase with an increasing population. The variables with the subscript j are specific to firm j; the other variables are exogenous from the view of a single firm. The production function is linear and homogenous in the firm-specific variables $\left\{K_{t,j}, N_{t,j}, L_{t,j}^p\right\}$. In addition, the production function has the following properties:

$$F_i > 0,\ F_{ii} < 0,\ F(i,0,0) = 0,\ \ \forall i \epsilon \left\{K_{t,j}, N_{t,j}, L_{t,j}^p\right\} \tag{11}$$

$$K_t = \sum\nolimits_j^m K_{t,j},\ L_t^p = \sum\nolimits_j^m L_{t,j}^p,\ N = \sum\nolimits_j^m N_{t,j} \text{ and } \bar{k}_t = \frac{K_t}{N} \tag{12}$$

In addition, we assume that the corresponding Inada conditions hold. The idea of this production function goes back in general to Frankel (1962), Romer (1986), Rebelo (1991) and Stauvermann (1997), and specifically to Grossman and Yanagawa (1993). This production function exhibits two positive externalities. The first is related to the economy-wide capital intensity, which positively affects the labor productivity. Differently from Romer (1986) and Rebelo (1991), we do not assume that aggregate capital stock creates a positive externality for the labor productivity. Instead, we assume that the economy-wide capital intensity creates a positive spillover for the labor productivity. The second positive externality is created by the economy-wide capital stock and affects the productivity of land. Intuitively, this externality is obvious in that the more agglomerated an industry, the more productive is each parcel of land in use. Assuming symmetry of all firms and perfectly competitive factor markets, aggregating the production of all m firms gives

$$Y_t = \sum_j^m Y_{t,j} = AF\left(1, 1, L_t^p\right)K_t \tag{13}$$

For simplicity, we assume the following explicit production function:

$$Y_{t,j} = A\left(K_{t,j}\right)^{\alpha}\left(\bar{k}_t N_{t,j}\right)^{1-\alpha-\sigma}\left(K_t L_{t,j}^p\right)^{\sigma} \tag{14}$$

where $0 < \sigma + \alpha < 1$.

Each firm j maximizes (14) under the restriction that the costs TC_t are given by

$$TC_t = w_t N_{t,j} + R_t K_t + r_t^p L_{t,j}^p, \tag{15}$$

where r_t^p represents the rental price for land used for production $L_{t,j}^p$. We also note that the final good is taken as numeraire and that the depreciation rate per period is 100%. Maximizing the profits of all firms and aggregation leads to the following factor prices:

$$w_t = (1-\alpha-\sigma)A\left(L_t^p\right)^{\sigma}\frac{K_t}{N} \tag{16}$$

$$R_t = \alpha A\left(L_t^p\right)^{\sigma} \tag{17}$$

$$r_t^p = \sigma A \left(L_t^p\right)^{\sigma-1} K_t \tag{18}$$

Since land can either be used for housing or for the production of goods, the land used for production is determined by the no-arbitrage condition that the rental rates of the housing and production sector have to be equal. Thus, the following holds:

$$r_t^p = \sigma A \left(L_t^p\right)^{\sigma-1} K_t = \frac{v}{L_t^h(1+q+v)} w_t N = r_t^h \tag{19}$$

Assuming the total available land L is given, substituting $L_t^h = L - L_t^p$ in (19) and solving the resulting equation for L_t^p gives

$$L_t^{p*} = \frac{\sigma(1+q+v)}{(1+q)\sigma + (1-\alpha)v} L \tag{20}$$

Accordingly, the optimal amount of land for housing L_t^h is given by

$$L_t^{h*} = \frac{v(1-\alpha-\sigma)}{(1+q)\sigma + (1-\alpha)v} L \tag{21}$$

In this model, the allocation of land is time-invariant and depends on the preference and production parameters. A rise in the preference for housing v leads to the effect that relatively more land is devoted to housing. If the capital income share α or the production elasticity of land σ increases, more land is being allocated to production. The same holds if the subjective time preference q will increase. Since the allocation of land is constant, the interest factor of capital R is also constant:

$$R = \alpha A \left(L_t^p\right)^{\sigma} = \alpha A \left(\frac{\sigma(1+q+v)}{(1+q)\sigma + (1-\alpha)v} L\right)^{\sigma} \tag{22}$$

Equation (22) conveys that an increase in the preference for housing v lowers the marginal product of capital because the change of the preferences results in an increase in the land devoted to housing. Simultaneously, the rental rates for both kinds of land increase. If the total amount of land increases, the consequence is a rise in the interest rate and wage rate and a decline in the rental rates. Inserting (20) in (21) results in the equilibrium rental rate of land, given as follows:

$$r_t^p = r_t^h = \sigma A \left(\frac{\sigma(1+q+v)}{(1+q)\sigma + (1-\alpha)v} L\right)^{\sigma-1} K_t \tag{23}$$

Notably, the land rents are increasing in the capital stock and decreasing in the total amount of land.

At the end of the working period, the individuals have two possibilities: they invest their savings to buy land or in physical capital. The capital market-clearing condition is obtained by using (7), (16) and (20), where p_t is the price of a unit of land measured in consumption goods:

$$N s_t = \frac{q(1-\alpha-\sigma)}{(1+q+v)} A \left(L_t^{p*}\right)^{\sigma} K_t - p_t L = K_{t+1} \tag{24}$$

The capital stock in period t + 1 equals the aggregate savings minus the total expenditures for land purchases. Defining the savings rate as $s = \dfrac{q}{(1+q+v)}$ and dividing both sides of (21) by K_t, the growth factor of capital $1 + g_t$ is computed as follows:

$$1 + g_t = s(1-\alpha-\sigma) A \left(L_t^{p*}\right)^{\sigma} - \frac{p_t}{K_t} L \tag{25}$$

Because of the fact that the total amount of land is fixed in supply, the price of land depends on the real interest rate and the rental rate of land. The intertemporal no-arbitrage condition between investing in real capital and land only holds if an investor is indifferent regarding both assets. The second no-arbitrage condition, which is an intertemporal one, is fulfilled if the following holds:

$$Rp_t = r_{t+1}^p + p_{t+1} = r_{t+1}^h + p_{t+1} \tag{26}$$

We define $\varphi_t = \frac{p_t}{K_t}$, which is the land price measured in capital units. Substituting φ_t in (26) and additionally inserting (17), (23) and (25) in (26), we obtain

$$\begin{aligned} \alpha A\left(L_t^{p*}\right)^{\sigma}\varphi_t = \sigma A\left(L_t^{p*}\right)^{\sigma-1} \\ +\varphi_{t+1}\left(\frac{q(1-\alpha-\sigma)}{(1+q+v)}A\left(L_t^{p*}\right)^{\sigma} - \varphi_t\frac{(1+q)\sigma+(1-\alpha)v}{\sigma(1+q+v)}L_t^{p*}\right) \end{aligned} \tag{27}$$

This no-arbitrage condition can be written as an implicit function $\Omega(\varphi_t, \varphi_{t+1}) = 0$. A dynamic long-run equilibrium will only be realized if there exists a unique $\varphi^* = \varphi_t = \varphi_{t+1}$. That means the price of land related to the capital stock must be constant. Solving Equation (27) for φ^* gives the following:

$$\begin{aligned} \varphi^* = \frac{A\sigma^{\sigma}(1+q+v)^{\sigma-1}L^{\sigma-1}}{(v(1-\alpha)+\sigma(1+q))^{\sigma}}\Bigg[\sqrt{\frac{2q(1-\alpha-\sigma)(\sigma(1+q)+v(1-\alpha))}{2}+\left(\frac{(\sigma+\alpha)(2q-1)-q+v}{2}\right)^2}- \\ \left[\frac{\sigma(2q+1)+q(2\alpha-1)+v+\alpha}{2}\right]\Bigg]. \end{aligned} \tag{28}$$

To derive the equilibrium growth factor of capital we insert (28) in (25) to obtain:

$$1 + g(\varphi^*) = s(1-\alpha-\sigma)A\left(\frac{\sigma(1+q+v)}{(1+q)\sigma+(1-\alpha)v}L\right)^{\sigma} - \varphi^* L \tag{29}$$

Before we go further, we show that the long-run equilibrium is always efficient in the sense of Diamond (1965). Notably, in the long-run equilibrium, the interest factor always exceeds the growth factor of the economy.

Proposition 1. *In the long run, the equilibrium interest factor always exceeds the growth factor of capital and of the economy: $R > 1 + g(\varphi^*)$. That means this economy is always dynamically efficient.*

Proof. Inserting $\varphi^* = \varphi_t = \varphi_{t+1}$ in (26) and simplifying, we obtain the following:

$$(R - (1 + g(\varphi^*)))\varphi^* = \sigma A\left(L_t^{p*}\right)^{\sigma-1}. \tag{30}$$

On the RHS, we have the rental rate for land, which is always positive; on the LHS, we have the difference between the interest factor of capital and the growth factor of capital times the price of land in terms of capital goods, which is always non-negative. Because of the fact that the equality holds, necessarily $R > (1 + g(\varphi^*))$ holds in the equilibrium. Q.E.D. □

The proposition is in line with the outcomes of Homburg (1991) and Nichols (1970), who showed for an economy with a neoclassical standard production function, the existence of land guarantees that the long-run equilibrium is always dynamically efficient. In other words, they prove that the interest rate always exceeds the (exogenous) growth rate in the equilibrium. Thus, an over-accumulation of capital like in models with only human-made capital is not feasible in the equilibrium.

We know from Hahn (1966) and Shell and Stiglitz (1967) that a market equilibrium of an economy with heterogeneous capital goods in the absence of a full set of futures markets extending infinitely far into the future or without perfect foresight is always dynamically unstable. The respective equilibrium steady state is a saddle point. Therefore, it is not surprising that the same is true in our model. Note that the land market equilibrium is locally stable if $\left|\frac{d\varphi_{t+1}}{d\varphi_t}\right| < 1$ in the equilibrium, but this is here. Using the implicit function $\Omega(\varphi_t, \varphi_{t+1}) = 0$, the derivative is calculated as follows:

$$\frac{d\varphi_{t+1}}{d\varphi_t} = \frac{\alpha A\left(L_t^{p*}\right)^{\sigma} + L\left[\sigma A\left(L_t^{p*}\right)^{\sigma-1} + \varphi^*\right]}{1+g(\varphi^*)} = \frac{R^* + L\left[\sigma A\left(L_t^{p*}\right)^{\sigma-1} + \varphi^*\right]}{1+g(\varphi^*)} > 1 \quad (31)$$

To analyze the dynamics of the model, it is, therefore, necessary to assume that the individuals are equipped with perfect foresight, that is, the individuals in this economy are always capable of calculating the correct equilibrium price of land. However, this is a strong assumption, but common in the literature (Tirole 1985; Eaton 1987, 1988; Drazen and Eckstein 1988; Chamley and Wright 1987; Stauvermann 2002; Homburg 2019, as well as Chow (2011), who provided a statistical reason and strong econometric evidence in favor of the adaptive expectation hypothesis).

It should be noted that the equilibrium is not intertemporal efficient. The inefficiency is caused by the positive externality of capital (c.f. Grossman and Yanagawa 1993; Stauvermann 2002). In what follows, we ignore the inefficiency caused by the positive externality of the capital intensity because it is shown elsewhere how to internalize this positive externality without harming any generation (Stauvermann 1997, 2002), and we focus on the second inefficiency caused by the private land ownership.

4. Private Land Ownership Creates Inefficiency

In the long-run equilibrium, the land price evolves proportionally to the capital stock and income, and the value of land to capital is constant.

Because a part of the savings is used for land purchases instead of being invested in productive capital, the capital accumulation process is negatively affected, and hence, the growth rates of capital and income are adversely affected. Thus, we derive the following proposition:

Proposition 2. *The growth rate of an economy in which land is privately owned and traded is lower than the growth rate of an economy in which land is state-owned and in which the government wastes the land rents.*

Proof. Let us assume that the government owns all of the land and that it rents out the land at competitive prices for housing and production purposes. From the view of individuals and firms, the situation is the same as that described by the model above, except that it is no longer possible to trade in land. Thus, all savings must be invested in the capital stock. Therefore, the corresponding growth factor $1 + g^G$ of an economy is as described above, and since land cannot be bought or sold by individuals, $1 + g^G$ becomes

$$1 + g^G = s(1-\alpha-\sigma)A\left(\frac{\sigma(1+q+v)}{(1+q)\sigma + (1-\alpha)v}\right)^{\sigma} L^{\sigma} \quad (32)$$

If we compare the growth factors of the economy with private ownership of land (29) and state-owned land (32), the latter exceeds the former growth factor by $\varphi^* L$ as shown in the following equation:

$$1 + g^G - (1 + g(\varphi^*)) = \varphi^* L > 0 \quad (33)$$

Thus, the growth rate of an economy with state-owned land and in which the land rents will be wasted is higher than the growth of an identical economy in which land is traded privately and in which the land rents are part of the individuals' income. Q.E.D. □

According to this model (and to most models in the literature), private land ownership is a curse from the view of economic development. The simple reason is that land is productive, even if it is not owned by private agents. If individuals own the land and trade in land, this trade withdraws resources from investments in capital and thus lowers the growth rate.

5. Taxation of Land

In this section, we analyze how different taxes on land affect the growth rate of the economy. Throughout this section, we maintain an emphasis on the pure tax effects, i.e., that the government wastes the tax revenue or spends it for purposes that leave the utility of individuals unaffected. However, we relax this assumption in later sections.

In reality, different jurisdictions apply different taxes on land. For example, Russia, Denmark, Estonia, Singapore and Taiwan apply a land value tax. For our study, this means that the sellers of the land (the old generation) have to pay a tax that is subtracted from the value of land in the case that it will be sold. Other countries such as the United Kingdom, Germany, Korea and Australia apply a stamp duty, which would be a tax on the buyer of land in the model presented in this study. Thus, the buyer of land has to pay the price of the land and a tax levied on the value of the land. Moreover, most European countries apply a rental income tax on land rents; in this case, the land rents are taxed.

5.1. Tax on Land Rents

In this section, we assume that the government taxes the land rents with a tax rate $1 \geq \tau_r \geq 0$. The allocation of land regarding its use for housing or production remains unaffected because the tax is levied on both rents from households and rents from firms. Because of the fact that interest incomes of capital remain untaxed, the no-arbitrage condition (26) has to be adjusted accordingly:

$$Rp_t = (1-\tau_r)r^p_{t+1} + p_{t+1} = (1-\tau_r)r^h_{t+1} + p_{t+1} \tag{34}$$

In the equilibrium, (34) becomes

$$\alpha A\left(L_t^{p*}\right)^{\sigma}\varphi^*_{\tau_r} = \left((1-\tau_r)\sigma A\left(L_t^{p*}\right)^{\sigma-1} + \varphi^*_{\tau_r}\right)\left(1+g\left(\varphi^*_{\tau_r}\right)\right) \tag{35}$$

Total differentiation of (35) leads to

$$\frac{d\varphi^*_{\tau_r}}{d\tau_r} = -\frac{\sigma A\left(L_t^{p*}\right)^{\sigma-1}\left(1+g\left(\varphi^*_{\tau_r}\right)\right)}{\underbrace{\underbrace{\alpha A\left(L_t^{p*}\right)^{\sigma}}_{R} - \left(1+g\left(\varphi^*_{\tau_r}\right)\right)}_{>0} + \left((1-\tau_r)\sigma A\left(L_t^{p*}\right)^{\sigma-1} + \varphi^*_{\tau_r}\right)L} < 0 \tag{36}$$

The derivative is negative because the numerator is positive and the denominator is also positive because of the fact that $R > \left(1+g\left(\varphi^*_{\tau_r}\right)\right)$ (Proposition 1). Thus, the taxation of land rents negatively affects the equilibrium price of land measured in capital units, and the consequence is a decline in the price of land. Accordingly, the total amount of resources that are invested in the purchase of land will also decline because the total amount of land is fixed in supply. As a consequence, the share of savings that is invested in capital will increase, and therefore, the growth factor of the capital stock and the economy will also increase. The growth factor is given by

$$1+g\left(\varphi^*_{\tau_r}\right) = s(1-\alpha-\sigma)A\left(\frac{\sigma(1+q+v)}{(1+q)\sigma+(1-\alpha)v}L\right)^{\sigma} - \varphi^*_{\tau_r}L \tag{37}$$

If we differentiate (37) with respect to the tax rate τ_r, we obtain

$$\frac{\partial g(\varphi^*_{\tau_r})}{\partial \tau_r} = -L\frac{\partial \varphi^*_{\tau_r}}{\partial \tau_r} > 0 \tag{38}$$

The results can be presented in the following proposition:

Proposition 3. *The introduction of or increase in a tax on land rents will cause a decline in the equilibrium price of land and as a consequence lead to an increase in the growth rate of the capital stock and the economy.*

The incidence of this tax has to be fully borne by the landowners. The reasoning is that the equilibrium price of land $\varphi^*_{\tau_r}$ will adjust immediately at the moment when the government announces the introduction or an increase in tax on land rents. Even if the tax revenue will be fully transferred to the landowners, they will suffer from the fact that price of land will decline. All individuals born after the introduction of or increase in the tax are better off because of the increased growth rate of the economy.

5.2. Taxation of Land Value

Now we are considering a land value tax $0 \leq \tau_{LV} \leq 1$, which is levied on the sales of land. The no-arbitrage condition has to be adjusted accordingly:

$$Rp_t = r^p_{t+1} + (1-\tau_{LV})p_{t+1} = r^h_{t+1} + (1-\tau_{LV})p_{t+1} \tag{39}$$

In the equilibrium, arbitrage condition (39) becomes

$$\alpha A\left(L^{p*}_t\right)^{\sigma}\varphi^*_{\tau_{LV}} = \left(\sigma A\left(L^{p*}_t\right)^{\sigma-1} + (1-\tau_{LV})\varphi^*_{\tau_{LV}}\right)(1+g(\varphi^*_{\tau_{LV}})) \tag{40}$$

Total differentiation of (40) delivers

$$\frac{d\varphi^*_{\tau_{LV}}}{d\tau_{LV}} = -\frac{\varphi^*_{\tau_{LV}}(1+g(\varphi^*_{\tau_{LV}}))}{\underbrace{R-(1+g(\varphi^*_{\tau_{LV}}))}_{>0}(1-\tau_{LV}) + \left(\sigma A\left(L^{p*}_t\right)^{\sigma-1} + (1-\tau_{LV})\varphi^*_{\tau_{LV}}\right)L} < 0 \tag{41}$$

Again, the value of land measured in capital units and accordingly the price of land will decline as a consequence of the land value tax. Moreover, a decline in the expenditures for land will raise the investments in capital, and hence, the growth rate of the economy will increase. If we differentiate (37) with respect to the tax rate τ_{LV}, we obtain

$$\frac{\partial g(\varphi^*_{\tau_{LV}})}{\partial \tau_{LV}} = -L\frac{d\varphi^*_{\tau_{LV}}}{d\tau_{LV}} > 0 \tag{42}$$

Hence, we present the following proposition:

Proposition 4. *The introduction of or increase in a land value tax will cause a decrease in the equilibrium price of land and consequently lead to an increase in the growth rate of the capital stock and the economy.*

The tax burden of the land value tax has to be borne by the owners of the land because if a land value tax is introduced, the equilibrium price will fall immediately and the owners will be harmed. The welfare of all others remains unaffected.

5.3. Stamp Duty

Here we are considering a stamp duty $\tau_{SD} \geq 0$, which is levied on the purchase of land. As with the two taxes above, the allocation of land regarding its use for housing or production remains unaffected because the tax is levied on land purchases. Further, the no-arbitrage condition (26) has to be adjusted to account for stamp duty or tax:

$$Rp_t(1+\tau_{SD}) = r^p_{t+1} + p_{t+1} = r^h_{t+1} + p_{t+1} \tag{43}$$

The equation for the growth rate is adjusted for the stamp duty as follows:

$$1+g\left(\varphi^*_{\tau_{SD}}\right) = s(1-\alpha-\sigma)A\left(\frac{\sigma(1+q+v)}{(1+q)\sigma+(1-\alpha)v}L\right)^{\sigma} - (1+\tau_{SD})\varphi^*_{\tau_{SD}}L \tag{44}$$

In the equilibrium, arbitrage condition (43) becomes

$$\alpha A\left(L^{p*}_t\right)^{\sigma}(1+\tau_{SD})\varphi^*_{\tau_{SD}} = \left(\sigma A\left(L^{p*}_t\right)^{\sigma-1} + \varphi^*_{\tau_{SD}}\right)\left(1+g\left(\varphi^*_{\tau_{SD}}\right)\right) \tag{45}$$

Again, we use total differentiation to calculate the derivative of the relative land price $\varphi^*_{\tau_{SD}}$ with respect to the stamp duty τ_{SD} as follows:

$$\frac{d\varphi^*_{\tau_{SD}}}{d\tau_{SD}} = -\frac{R\varphi^*_{\tau_{SD}} + \left(\sigma A\left(L^{p*}_t\right)^{\sigma-1} + \varphi^*_{\tau_{SD}}\right)\varphi^*_{\tau_{SD}}L}{\left(R(1+\tau_{SD}) - \left(1+g\left(\varphi^*_{\tau_{SD}}\right)\right) + \left(\sigma A\left(L^{p*}_t\right)^{\sigma-1} + \varphi^*_{\tau_{SD}}\right)(1+\tau_{SD})L\right)} < 0 \tag{46}$$

As with the tax on land rents and tax on the land value, the introduction of a stamp duty lowers the price of land, and hence, the growth rate has a positive relationship with the stamp duty.

Differentiation of (44) with respect to the stamp duty leads to

$$\frac{\partial g\left(\varphi^*_{\tau_{SD}}\right)}{\partial \tau_{SD}} = -\left(1 + \frac{d\varphi^*_{\tau_{SD}}}{d\tau_{SD}}\frac{(1+\tau_{SD})}{\varphi^*_{\tau_{SD}}}\right)\varphi^*_{\tau_{SD}}L > 0 \tag{47}$$

if the absolute value of $\frac{d\varphi^*_{\tau_{SD}}}{d\tau_{SD}}\frac{(1+\tau_{SD})}{\varphi^*_{\tau_{SD}}}$ exceeds 1. A sufficient condition is that elasticity of the relative land price with respect to the tax rate is $\left|\frac{d\varphi^*_{\tau_{SD}}}{d\tau_{SD}}\frac{\tau_{SD}}{\varphi^*_{\tau_{SD}}}\right| > 1$. This condition implies that the total expenditures for land $(1+\tau_{SD})\varphi^*_{\tau_{SD}}L$ decline with an increasing tax rate. In other words, the relative increase in the tax rate must be weaker than the relative decline in the relative price of land $\varphi^*_{\tau_{SD}}$.

Proposition 5. *The introduction of or increase in a stamp duty will cause a decline in the expenditures for land and an increase in the growth rate of the capital stock and the economy, if* $\left|\frac{d\varphi^*_{\tau_{SD}}}{d\tau_{SD}}\frac{\tau_{SD}}{\varphi^*_{\tau_{SD}}}\right| > 1$.

From the investigations of the different taxes, it is clear that the growth rate of the economy will increase if land will be taxed in some way. The intuition behind this result is that a tax on land will incentivize the investment in capital, which has a positive impact on economic growth. In this section, we have assumed that the tax revenue is used for the provision of public goods that do not affect the utility of individuals or that the tax revenue is wasted every period. However, the owners of land in the period when the tax is introduced or increased will suffer from the tax.

6. A 100% Tax on Land Rent

In this section, we assume that the government taxes the land in such a way that the market for land will vanish. This can be done by introducing a tax on land rents with a tax rate of 100%. As a consequence, the first summand of the RHS of (35) vanishes, and it becomes immediately clear that the unique equilibrium has the characteristic that $\varphi^* = p_t = p_{t+1} = 0$. It is intuitively clear that if the government announces the appropriation of all land rents by taxation, the value of land will become immediately nil because the incentive to purchase land vanishes. It should be noted that land with a 100% tax on land rents has the same characteristics as worthless assets. This is important because Tirole (1985) has shown that bubbles with worthless assets may exist, but only if the economy is dynamically inefficient ($1 + g > R$). However, this is not the case in our study because of Proposition 1; the interest factor will always exceed the growth factor. If the interest rate exceeds the growth rate of the economy, the total value of bubbles grows faster than the total amount of savings, hence a contradiction. As a consequence of this policy measure, the land becomes automatically state-owned, because typically all abandoned land is state-owned land, and the capital stock and growth rate of the economy will increase. In the following periods, the government can lease all land to the individuals and firms who have the highest willingness to pay. Additionally, this proposal has the advantage that the landlords will not lose the land rent in the current period and realize only the loss from not being able to sell the land. Alternatively to the 100% tax on land rents, the government could also nationalize the land. In both cases, the government receives all land rents, which consists of the rental revenues from firms $\sigma A \left(L_t^p\right)^\sigma K_t$ and rental revenues from leasing land for housing. Hence, the government's revenue R_t^G is the sum of the contribution of land to the production and the aggregated rent payments of households. Because of the fact that it is not efficient to waste this revenue, it has to be considered what the government should do with the revenue. If the revenue is distributed to the old generation, the problem arises that an additional income in the second period of life will reduce the incentive to save given that the second period consumption is a normal good. Hence, savings will decline if the individuals receive a form of income such as a transfer or pension in the second period of life. Thus, it is not recommended to provide a transfer to the old generation. If the government transfers the revenue to the young generation, the outcome is also not as obvious; for example, Hashimoto and Sakuragawa (1998), like most authors, assumed that land is only useful for production but not used for housing.

Hence, we consider the case that the government owns all land and that it organizes a competitive market for land services and distributes the land rents equally to the working generation as a lump-sum transfer. These assumptions lead to a new individual budget constraint in the first period of life:

$$c_t^1 + r_t^h h_t = w_t + \phi tr_t - s_t \tag{48}$$

where $tr_t = \frac{R_t^G}{N} = \frac{r_t^p L}{N} = \frac{r_t^h L}{N}$ and $0 \le \phi \le 1$. This means ϕ is the share of government revenue that is paid out to the young generation. Utility maximization with the modified budget constraint (48) leads to the following optimal savings and housing demand:

$$s_t = \frac{q}{(1+q+v)}(w_t + \phi tr_t) \tag{49}$$

$$r_t^h = \frac{v}{h_t(1+q+v)}(w_t + \phi tr_t) \tag{50}$$

The problem with the transfer is that not only the savings but also the demand for housing increase with income. To calculate the allocation of land, we calculate the government revenue, where the equations for factor prices remain unaffected by the fact that the government owns the land:

$$R_t^G = \sigma A \left(L_t^p\right)^\sigma K_t + \frac{v}{(1+q+v)}(w_t + \phi tr_t)N \tag{51}$$

Using the fact that $w_t N = (1 - \alpha - \sigma) A \left(L_t^p\right)^\sigma K_t$, we obtain

$$R_t^G = \frac{(v(1-\alpha)+\sigma(1+q))A\left(L_t^p\right)^{\sigma}K_t}{1+q+(1-\phi)v} \tag{52}$$

Inserting (52) in (50) and inserting in the no-arbitrage condition regarding the optimal allocation of land (18) delivers the optimal amount of land for production:

$$L_t^{p**} = \frac{\sigma(1+q+(1-\phi)v)}{(1+q)\sigma+(1-\alpha)v}L \tag{53}$$

Proposition 6. *If the young generation receives a lump-sum transfer, the share of the total land allocated for production will decline and the share of the total land used for housing will increase. Accordingly, the total production, the wage rate and the interest rate will decrease, whereas the rental rate of land will increase.*

Proof. We differentiate (53) with respect to the share ϕ:

$$\frac{\partial L_t^p}{\partial\phi} = -\frac{v\sigma L}{(1+q)\sigma+(1-\alpha)v} < 0 \tag{54}$$

It is obvious from (14) and (16) to (18) that the production, the wage rate and the interest rate will decline with a smaller amount of land for production purposes and that the rental rate of land will increase. Q.E.D. □

However, it should be noted that the total income of the young will increase, even if the wage rate declines, because of the lump-sum transfer.

The total savings become

$$Ns_t = \frac{s(1+q+v)(1-\alpha-(1-\phi)\sigma)A\left(\frac{\sigma(1+q+(1-\phi)v)}{(1+q)\sigma+(1-\alpha)v}L\right)^{\sigma}K_t}{(1+q+v(1-\phi))} \tag{55}$$

Dividing (51) by the capital stock delivers the respective growth factor $1+g^{tr}$:

$$1+g^{tr} = \frac{s(1+q+v)(1-\alpha-(1-\phi)\sigma)A\left(\frac{\sigma(1+q+(1-\phi)v)}{(1+q)\sigma+(1-\alpha)v}L\right)^{\sigma}}{(1+q+v(1-\phi))} \tag{56}$$

If we set $\phi = 0$, the growth factor without a transfer will result:

$$1+g^{tr}\big|_{\phi=0} = s(1-\alpha-\sigma)A\left(\frac{\sigma(1+q+v)}{(1+q)\sigma+(1-\alpha)v}L\right)^{\sigma} \tag{57}$$

We recognize that this growth factor equals the growth factor in Equation (32). Differentiating the growth factor with respect to the share ϕ, we obtain

$$\frac{\partial(1+g^{tr})}{\partial\phi} = \frac{s(1+q+v)\left((\sigma^2(1-\phi)+(1-\sigma)(1-\alpha))\gamma+\sigma(1+q)\right)}{\left((1+q+v(1-\phi))\right)^2}A\left(L_t^{p**}\right)^{\sigma} > 0. \tag{58}$$

Because the derivative is positive, the maximal growth factor is realized when ϕ is 1, that is, when all government revenue generated by land rents is transferred as lump-sum payments to the young.

$$1+g^{tr}\big|_{\phi=1} = 1+g^{max} = \frac{s(1+q+v)(1-\alpha)A\left(\frac{\sigma(1+q)}{(1+q)\sigma+(1-\alpha)v}L\right)^{\sigma}}{(1+q)} \tag{59}$$

Proposition 7. *The growth factor of this economy is maximized if all land is nationalized and the land rents are transferred as lump-sum payments to the young generation.*

The outcome of the analyses presented in this section is that the government will become the owner of the land after it has introduced a tax on land rents with a tax rate of 100% because land then loses its characteristic as an asset in which savers can invest. If the government introduces a lump-sum transfer to the young financed through land rents, the income of this generation increases, and this has two important consequences. First, the demand for housing increases, and this will drive up the rental rate of land, so less land is used for production. Although the reduction in the amount of input factor (land) has a negative impact on the production, wage rate and interest rate, the growth rate of capital will increase with the lump-sum transfer. Second, as a result of the lump-sum transfer, the total savings will increase, and hence, the economy will grow faster.

7. Discussion

Now we can discuss the main outcomes of this paper. In Section 4, we have derived that private ownership of land is inefficient because the savings devoted to buying land are no longer available for capital accumulation, which is the driver of growth in this model. This result is in principle very common, and this feature of land makes it attractive to tax land. This result is also derived implicitly or explicitly in almost all models from Ricardo to the most recent literature. In this paper, we have shown that even if land is partly used for housing, the results remain valid.

Further, in Section 5, we analyzed the effects of three kinds of taxes and showed that the growth rate will increase even if the tax revenue is wasted. Particularly, these outcomes indicate that the government could use the tax revenue to finance other useful expenditures, such as environmental protection (Dao and Edenhofer 2018; Kalkuhl et al. 2017), reduction in income and wealth inequality (Koethenbuerger and Poutvaara 2009; Schwerhoff et al. 2020) or public infrastructure (Bosi and Pham 2016). Additionally, in our model, the whole tax incidence falls to the landowners because the marginal productivity of capital remains constant.

In Section 6, we showed that the growth rate can be maximized if the state becomes the owner of the land and distributes all land rents to the young generation. If the land rents are transferred to the young generation, the income of the current young generation will increase and this generation will be also better off. The higher income of the young generation will induce them to increase the demand for housing with the consequence that the share of land devoted for production will decline, resulting in a decrease in wage and interest rates. The lower interest rate will again harm the current old generation. However, to avoid the increase in demand for land used for housing, the government could introduce zoning laws. This policy proposal coincides fully with the arguments of Deaton and Laroque (2001), who considered land only for housing purposes. In general, based on the analyses presented, it can be stated that it does not matter if land is used as a production factor, for housing or for both purposes because land markets are inimical to economic growth. Regarding the taxation of agricultural land in developing countries, Skinner (1991) argued that the administrative costs of taxing land are too high to tax land accurately. In a recent study, Schwerhoff et al. (2020, p. 20) argued "that mass valuation (McCluskey et al. 2013; Almy 2014) and comprehensive international support for land administration (Enemark et al. 2014) have been developed, so that it may be time to reconsider using land rent taxation." If policymakers would go a step further to nationalize the land, the cost argument would vanish, but then the opponents of this proposal would argue probably similar to de Soto (1989, 2000) and Deininger (2003), who based their work on Alchian and Demsetz (1973), Demsetz (1967) and Coase (1960). These studies support the superiority of private land ownership over all other forms of land tenure. For example, according to Deininger (2003, p. xxviii), "[i]f leases awarded by state institutions are not credible, . . . , full privatization, will be required to give users sufficient security of tenure and associated benefits. An indicator for limited credibility of leases is that even where there is strong, effective demand for credit, financial institutions will not accept long-term leases as collateral." However, it can be questioned that if state-guaranteed leases are not credible, then why should other tenure titles of the same government be credible? Under these circumstances, it is more a general credibility problem of the government than the form of property right. Particularly, if we consider counterexamples such as China or Vietnam, the two countries in which all land is state-owned, and their economic developments, then the arguments of de Soto (1989, 2000) or Deininger (2003) become weak. As noted by Ho (2001, 2015), China is an example where property rights in the sense of Coase are obviously not a precondition for the development of a prospering market economy. However, considering the development of China and Vietnam in the last 40 years, the arguments of Ho cannot be ignored. We may ask the question analogous to Skinner (1991): if land taxation is so efficient, why is it so weakly used? Even Ali et al. (2017) estimate that the tax revenue of property taxes makes up only less than 1% of the GDP in developing countries, and in many African countries, the revenue is below 0.5% of GDP. Fjeldstad et al. (2017) explained that poor revenue collection from land tax is mainly caused by inefficient and corrupt institutions. From the view of real-world politics, the growth effects, which are derived not only in this study but also in the majority of related publications, should raise the attention of policymakers, particularly in developing countries and countries in transition.

8. Conclusions

We have shown in an OLG model with endogenous growth and land as production and consumption good that the equilibrium growth path generated by a pure market system is inferior to an equilibrium growth path in which land cannot be traded and the land rents are wasted. Although this is not new and is a very general result that has been derived earlier, we have extended the analysis to show that the value of the land declines when the land rents are taxed, when the value of land is taxed or if the buyer of land has to pay a stamp duty. Moreover, a lower price for land leads to a higher growth rate of the economy, and in all cases, the landowners have to bear the whole tax burden because the marginal productivity of capital remains unchanged. All other generations will be better off because the higher growth rate guarantees a higher income for all unborn (future) generations. The current young generation will not benefit from a land tax, but they also will not suffer. It is important to highlight that these outcomes are derived under the assumption that the land rents will be wasted or used for purposes that do not affect the utility of individuals. As analytically shown in the model, the old generation would suffer from the nationalization or taxation of land.

However, in reality, land ownership is mostly in the hands of the relatively rich members of the economy, and as such, the taxation or nationalization of land would probably contribute to reducing the wealth and income inequality in the respective countries. Most economists believe that a tax on land is a progressive tax because, in most developed countries, the poorest 50% of the society own little or no wealth and usually do not hold land in their portfolios.

Therefore, an interesting theoretical question for future research is to examine if the results presented in this paper hold when considering an open and/or a small economy. It must be noted that Petrucci (2006, 2020) found the results not to hold for the case of a small open economy. Additionally, it also would be useful to empirically investigate the relationship between the taxation of land and economic growth, provided consistent data on land values are available. Moreover, the availability of accurate data on land values becomes extremely necessary if we wish to compute and tax pure land rents accurately. While this study falls short on empirical estimations due to these reasons, we have provided theoretical insights of interest to policymakers and a framework for investigating the issues empirically. Additionally, we have underscored some recent studies such as those of Wyatt (2019) and Hughes et al. (2020) which offer promising proposals on tackling data constraints.

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