Economics Letters 247 (2025) 112149

Contents lists available at ScienceDirect

Economics Letters

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

Green investors and the return on capital in general equilibrium

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ARTICLE INFO

JEL classification:
D58
Q5
Q54

Keywords:
Carbon abatement
Environmental economics
Impact investing
OLG model

ABSTRACT

We study how "green" preferences affect the return on capital in a general equilibrium model with overlapping generations and two types of investors. The "brown" type only cares about financial returns, while the "green" type also cares about climate damages from emissions. Based on the preferences of their owners, firms make an endogenous emission abatement choice. We find that the return on capital of green firms increases in the share of green investors, and that the return differential between green and brown firms decreases in the share of green investors. In general equilibrium, the labor demand of green firms can negatively impact the return on capital of brown firms. We show that a carbon tax curbs the return on capital differential as the behavior of the two types of investors converges.

1. Introduction

There has been a growing interest in sustainable investment in the last decade. Two motives for holding sustainable assets have been identified, the diversification motive, i.e., risk management (e.g., Hambel et al., 2024), and the responsible investment motive, i.e., investor preferences (e.g., Pedersen et al., 2021). Our focus is on the responsible investment motive with respect to environmental sustainability.

We develop an overlapping generations (OLG) model where green and brown investors co-exist in equilibrium, and each type owns and manages a firm. Brown investors care only about the financial return of their firm, whereas green investors invest in a firm that internalizes the negative externality of CO_2 emissions. Although the green and the brown firm are ex-ante the same, they behave differently in accordance with their owners' preferences.

Our model extends the existing literature on (environmentally) responsible investors with a combination of an endogenous abatement decision, general equilibrium effects, climate damages as in the seminal DICE model (Nordhaus, 1992, 2017), and heterogeneous agents. We find that these mechanisms can have a significant effect on the return on capital (ROC)—the net profit per unit of capital—contrasting some results found in the partial equilibrium literature, e.g., Pedersen et al. (2021) and Pástor et al. (2021).

The endogenous abatement decision is important because costly abatement lowers returns (ceteris paribus). General equilibrium effects are important, because green and brown firms influence each other's ROC through their labor demand. In particular, a high labor demand by green firms to reduce emissions can negatively impact the ROC of brown firms. Climate damages are important as they directly affect production, and therewith the return on capital. An indirect effect is the interaction between aggregate emissions and green investors. On the one hand, aggregate emissions depend on the number of green firms and investors. On the other hand, the level of abatement by green firms is determined by climate damages, which depends on aggregate emissions. Heterogeneous agents are important because they allows us to extend the closely related papers of Dam and Heijdra (2011) and Renström et al. (2019) with the interaction between green and brown agents.

We obtain the following results. First, the ROC of green firms increases in the number of green firms. This contrasts with results obtained in partial equilibrium frameworks with assets as in Pedersen et al. (2021) and Pástor et al. (2021). In these papers a positive sustainability score gives responsible investors utility, which drives up the price of sustainable assets, and lowers their return. In our model, more green investors imply lower climate damages, which reduces abatement by individual green firms. The associated cost reduction increases their ROC. Second, the ROC differential between brown and green firms decreases in the number of green investors. Third, the ROC of brown firms is adversely affected by the labor demand for abatement by green firms when climate change damages are high. Fourth, higher climate damages increase the ROC differential between brown and green. Fifth, a carbon tax reduces the ROC differential between brown and green firms.

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https://doi.org/10.1016/j.econlet.2024.112149
Received 14 October 2024; Received in revised form 8 December 2024; Accepted 24 December 2024
Available online 1 January 2025

2. Model

We consider the steady state of an OLG model, where each generation lives for two periods. Households maximize their discounted utility from consumption over these periods. In the first period, referred to as y for young, they only earn labor income. Each household supplies the same amount of labor $\bar{l}$ to the aggregate labor market at wage W. The young can save part of their labor income as (sector-specific) capital k_i, which yields a sector-specific rental rate of capital R_i in the next period, when they are old (o). Moreover, in the second period households get a lump sum transfer equivalent to the sector-specific profit π_i plus a lump sum rebate of the carbon tax revenue from the government. The household optimization problem yields a standard Euler equation (see (A.2) in Appendix A).

There are two household types, green (g) and brown (b). Each type $i = \{b, g\}$ supplies capital to firms of the same type. Each type of firm operates in accordance with the preferences of the households of this type. Brown households and firms only care about their own profits, while green households and firms internalize the negative externality of CO_2 emissions, which result from production, i.e., climate damages to output resulting from CO_2 emissions. The decentralized market economy is presented in Appendix A.

The profit π_i of firm type i is:

$$\pi_i = \left[\left(1 - D(E)\right)\left(1 - \Gamma\left(a_i\right)\right) - \tau\gamma\left(1 - a_i\right)\right] F\left(k_i, l_i\right) - R_i k_i - W l_i \tag{1}$$

where $D(E) = 1 - \exp(-\frac{\eta}{2}(\kappa E)^2)$ are climate damages stemming from aggregate emissions E,[1] $\Gamma\left(a_i\right)$ are abatement costs as a fraction of output, given fraction a_i of emissions is abated, τ denotes the levied carbon tax and γ emission intensity. The production function is $F\left(k_i, l_i\right)$ with (firm-specific) inputs capital k_i and labor l_i. The sector-specific rental rate is R_i with $i = \{b, g\}$, and the aggregate wage W.

The first-order condition with respect to a firm's abatement strategy a_i yields

$$\chi_i = \frac{\left(1 - D(E)\right)\Gamma'\left(a_i\right)}{\gamma}. \tag{2}$$

It equates the (firm-specific) internal carbon price χ_i with the marginal abatement costs. The internal carbon price χ_i reflects how the firm values emission reductions:

$$\chi_b = \tau, \qquad \chi_g = D'(E)\sum_i \omega_i\left[\left(1 - \Gamma(a_i)\right)\right]F(k_i, l_i).$$

For the brown firm the internal carbon price χ_b is the carbon tax τ, while for the green firm the internal carbon price χ_g reflects the internalization of the emission externality, which is the weighted sum of the marginal damages to all firms,[2] where ω_i denotes the weight of each type.

Proposition 1. *If the carbon tax is less than the total marginal damage, green firms abate more than brown firms.*

Proof. See Appendix B.1. □

The proposition implies that green firms abate more than brown firms if carbon is underpriced, i.e., if the levied carbon tax is less than the optimal Pigouvian tax.

The first-order conditions with respect to capital and labor result in

$$\Psi_i F_k\left(k_i, l_i\right) = R_i, \tag{3}$$

$$\Psi_i F_l\left(k_i, l_i\right) = W. \tag{4}$$

These equations equate the factor price of capital and labor to the respective marginal productivity times the wedge variable Ψ_i given by

$$\Psi_i = \left(1 - D(E)\right)\left(1 - \Gamma(a_i)\right) - \chi_i\gamma(1 - a_i). \tag{5}$$

The first component reflects the difference between gross and net output, i.e., output corrected for climate damages $\left(1 - D(E)\right)$ and firm level abatement costs $\left(1 - \Gamma(a_i)\right)$. The second component reflects the firm-specific internal carbon price χ_i times the emissions per unit of output $\gamma(1 - a_i)$.

Proposition 2. *If the carbon tax is less than the marginal damage and abatement is between 0% and 100%, i.e., $0 < a_i \leq 1$,*

(i) the wedge variable of green firms as defined in (5) is smaller than that of brown firms ($\Psi_g < \Psi_b$).

(ii) green firms produce more capital intensive than brown firms.

Proof. See Appendix B.2. □

The focal point of our analysis is the ROC defined as the profit (excluding the rental of capital) per unit of capital,[3]

$$\text{ROC}_i = \left[(1 - D(E))\left(1 - \Gamma\left(a_i\right)\right) - \tau\gamma\left(1 - a_i\right)\right]\frac{F\left(k_i, l_i\right)}{k_i} - W\frac{l_i}{k_i}. \tag{6}$$

An important determinant of the ROC is the capital-labor ratio, since it appears in the first term as $\frac{F(k_i,l_i)}{k_i} = Z\left(\frac{k_i}{l_i}\right)^{\alpha-1}$ and in the labor costs as $\frac{l_i}{k_i}$. When a firm produces more capital intensive, i.e., the green firm in most cases as shown in Proposition 2, the marginal productivity of capital $\frac{F_k(k_i,l_i)}{k_i}$ is reduced, and this negatively affects the ROC.

3. Laissez-faire equilibrium

In this section we numerically analyze how the ROC for the brown and green, and the difference between them depends on the fraction of green households for different values of the damage parameter. Our results are based on the calibration discussed in Appendix C. When the damage parameter is set to the benchmark value ($\eta = 0.01$) or lower, the ROC of the brown firm increases in the fraction of green investors, see Fig. 1(a). As green firms abate more, increasing the fraction of green firms reduces aggregate emissions resulting in less climate damage and higher ROC.

This effect is also present for higher values of the damage parameter, but as the damage parameter increases the relation between the ROC of the brown and the fraction of green agents becomes non-monotonic. In that case the ROC of the brown initially falls with the fraction of green agents due to the high labor demand of green firms. With a high damage parameter and few green firms the emissions and the marginal damage are high. This results in a high level of abatement by the green as in (2), which reduces profits and consumption for the old green households. As capital income is the only source of income for the old, the green sharply increase their investment when young to smooth consumption. The resulting high capital level of the green drives up their labor demand, see Fig. 2. The high labor demand by the green pushes up the aggregate wage, which increases labor costs, but also increases the capital-labor ratio of brown firms as determined by labor demand (4). A higher capital-labor ratio of the brown firms reduces their marginal productivity of capital, and drives down their ROC further.

The ROC of the green increases in the number of green firms, see Fig. 1(b). The explanation is that a higher number of green firms reduces aggregate emissions, and lowers (marginal) damages. This has

[1] η is the damage parameter, and κ converts emissions to temperature. To keep the model tractable, we abstract from other types of climate externalities such as tipping points or climate disasters as studied in e.g., Cai and Lontzek (2019), Hambel et al. (2024), among others.

[2] For simplicity we abstract from carbon taxes in excess of the total marginal damage. We also abstract from public abatement, meaning only firms abate emissions.

[3] Since there are no investment adjustment costs in our model, the market clearing conditions imply that Tobin's Q is equal to 1, e.g., Pindyck and Wang (2013). Thus, the return on equity equals the return on capital.

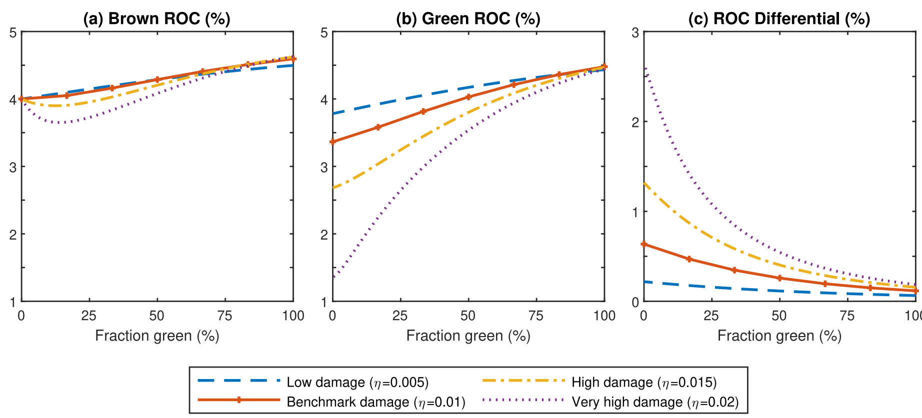

Fig. 1. Laissez-faire equilibrium: Return on capital. The figure illustrates how the return on capital as defined in (6) depends on the fraction of green investors in the model for four different damage parameters. Panel (a) depicts the ROC of the brown firm, Panel (b) the ROC of the green firm, and Panel (c) the ROC differential defined as the ROC of the brown firm minus the ROC of the green firm. Generally, the ROC of brown firms is higher than for green firms and the differential declines in the fraction of green investors. If this fraction is high, both firms can generate higher ROCs.

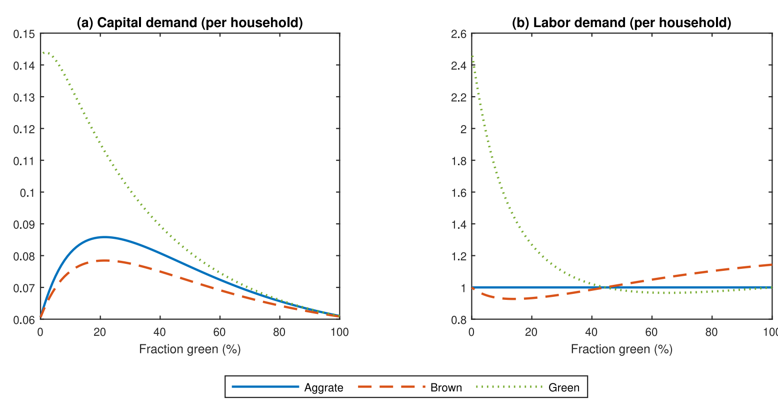

Fig. 2. Laissez-faire equilibrium: Capital and labor demand with very high damage (τ = 0.02). The figure illustrates how the capital and labor demand depends on the fraction of green investors for each household type, and the (weighted) average. Panel (a) depicts the capital demand and Panel (b) the labor demand.

two positive effects on the ROC of green firms. First, lower damages increase output, and the ROC directly. Second, lower marginal damages reduce abatement (costs) by individual green firms, and therewith increases their ROC. When the damage parameter is higher, the change in the ROC of the green is larger since these two effects are stronger.

The ROC differential between brown and green firms is positive and decreases in the fraction of green investors, see Fig. 1(c). The change in the ROC differential is mostly driven by changes in the ROC of green firms, which responds much stronger because only the green lower their abatement level with an increasing fraction of green as described above. This effect is stronger when climate damages are higher. This result provides a theoretical explanation for the carbon premium as empirically found by Bolton and Kacperczyk (2021, 2023), among others.[4] Most authors explain the carbon premium by transition risk that has a stronger effect on the brown firms than the green firms and leads to an asymmetry in the risk premiums, e.g., Hsu et al. (2023). In our model, however, the return differential is driven by investors' preferences and general equilibrium effects and emerges even in the absence of risk especially if there are only few green investors in the economy.

4. Policy equilibrium

In this section, we investigate the ROC in the presence of a carbon tax, which is rebated lump sum to the households. The Pigouvian tax equals the marginal damage,

$$\tau = D'(E) \sum_i \omega_i \left(1 - \Gamma(a_i)\right) F\left(k_i, l_i\right)$$

and achieves the Pareto optimum as it internalizes the negative externality from emissions. Note that this Pareto optimum is also attained when there are only green households, and the government does not levy a carbon tax. With the Pigouvian tax the ROC for the brown and green firms are identical since both face the same internal carbon price. For taxes below the Pigouvian level, we get two results.[5] First, for a

[4] Others have found mixed or even contrary evidence and thus challenge the existence of a carbon premiums, e.g. Pástor et al. (2021, 2022), Bauer et al. (2022), Aswani et al. (2024), Zhang (2024).

[5] For these numerical results the damage parameter is set to the benchmark value (η = 0.01).

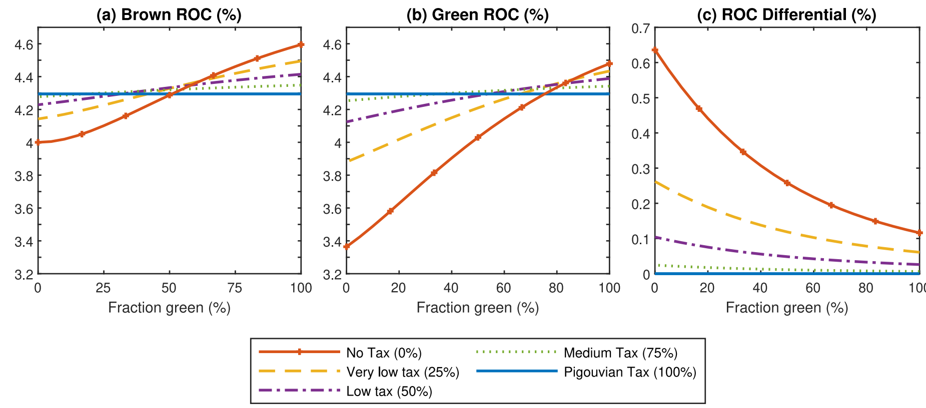

Fig. 3. Policy equilibrium: Return on capital. The figure illustrates how the return on capital as defined in (6) depends on the fraction of green investors in the model for five different levels of the carbon tax ranging between zero and the optimal Pigouvian tax. Panel (a) depicts the ROC of brown firms, Panel (b) the ROC of green firms, and Panel (c) the ROC differential defined as the ROC of brown firm minus the ROC of green firm. Generally, the ROC differential declines in the fraction of green investors and in the levied carbon tax. If the Pigouvian tax is charged, the ROC differential vanishes.

given tax level the ROC of both types increases in the fraction of green agents, see Figs. 3(a) and 3(b). Second, the ROC differential decreases in the level of the carbon tax, see Fig. 3(c). Both results are driven by the same mechanisms as described in the previous section. With a suboptimal carbon tax, marginal damages decrease with the number of green firms. This reduces climate damages, and increases the ROC for both firms. Furthermore, due to lower marginal damages, individual green firms reduce their abatement effort, which improves their ROC even more. Another effect of these two mechanisms is that for both types the difference in the return between an economy without green investors and an economy with only green investors decreases in the tax level, meaning the slope of the curves decreases in the tax level.

5. Conclusion

Our study shows that general equilibrium effects, endogenous abatement choices, and climate damages can strongly affect the return on capital of green and brown investors, and the difference between these two returns. Therefore it seems important to include these three aspects when analyzing the impact of environmentally responsible investors. As for further research, we intend to extend the model to climate transition risk such as uncertainties about future climate policies and sudden shocks to investor's beliefs and preferences. These additional layers of complexity can lead to the stranding of financial assets and explain the transition risk premium, e.g., Engle et al. (2020). Although our model provides a simple mechanism to generate a positive carbon premium, climate transition risks may help match the empirical magnitude of the carbon premium, e.g., Bolton and Kacperczyk (2021, 2023), Hsu et al. (2023).

Acknowledgments

Kai Lessmann acknowledges project funding from the German Federal Ministry of Education and Research (BMBF) (Grant Number 01LA2212C). We thank Mariano Croce (the editor), Rick van der Ploeg, Beatriz Gaitan, Ibrahim Tahri, one anonymous reviewer, and participants of the Berlin Climate Workshop (May 2024), the Sustainable Finance and Climate Protection (SFCP) PhD & PostDoc Workshop (April 2024) and the Climvest Stakeholder Meeting (April 2023) for helpful comments and suggestions.

Appendix A. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.econlet.2024.112149.

Data availability

Code available upon request.

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