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A New Keynesian Model to Assess the Role of Government Preferences over Climate Investments

Ioannis Kalientzidis* Amélie Barbier-Gauchard* Moise Sidiropoulos*

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Abstract

This paper develops a New Keynesian Environmental Dynamic Stochastic General Equilibrium (E-DSGE) model to analyze the role of government investment in facilitating the transition to a green economy. We extend the standard framework by incorporating two types of capital—polluting (brown) and non-polluting (green)—both used in production. Firms choose their capital mix while subject to carbon taxation, and the government directly invests in capital formation, favoring green and brown investments. The model includes adjustment costs for producing green capital, capturing the frictions associated with its deployment and the slow adaptation of firms to green alternatives. Our analysis explores the macroeconomic and environmental effects of fiscal policy under varying government investment preferences. We find that when the government invests solely in brown capital, the crowding-out effect on private investment leads to lower output, reduced consumption, and increased emissions. In contrast, when the government prioritizes green capital, economic growth accelerates while emissions decline, despite the presence of a private investment crowd-out effect. A mixed investment strategy, where the government allocates resources to both types of capital but still favors brown investment, yields results similar to the green-focused scenario but with more moderate effects.

Keywords: Green Public Capital, New Keynesian Model, Environmental DSGE, Climate Change Policy, Fiscal Policy, Carbon Tax, Emission Reduction, Green Public Investments

JEL Codes: E62, H23, Q52, Q58, Q54

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1 Introduction

The transition of the economy to a "greener" and sustainable future requires governments to invest a substantial number of funds for this cause. This has been stressed in many international agreements for climate change (Paris Agreement, here others). The reason why government intervention plays a crucial role in the transition lies in the inability of the private sector to follow the new standards as fast as they should have. There are many reasons why this is the case. For example, new and green technologies require both time and higher costs than conventional and polluting technologies. In addition, new technologies, green or not, are riskier since there is no guarantee that they will succeed in their goal of offering an alternative solution to the market. Another and more serious obstacle is the inability of market participants, both firms and consumers, to internalize the long-term benefits of the green transition. As a result, government policies that promote the green transition are required to mobilize the private sector and support new technologies. Various policies have been proposed in these agreements. Direct financing of firms in the RnD sector that develop green technologies, subsidies to firms to reduce their energy intensity, investments in renewable energy, etc.

The issue of climate change and the impact it has on the economy and society are numerous and have been highlighted by many researchers. The direct and indirect impacts of climate change forced governments to take to matter under serious consideration. The Intergovernmental Panel for Climate Change (IPCC) which the United Nations established, provides government reports that they can use in the drafting of climate policies. The IPCC reports showcase what are the negative effects of climate change on the economy and society. In their analysis, they found the impacts are numerous and cover different sectors, such as loss of labor productivity due to extreme heat, loss of agricultural yields, increased frequency of extreme events, rise of sea levels, etc. Even though the reports showcase what are some potential effects of climate change the true magnitude remains uncertain, due to the complexity of the matter. Due to the severity of the matter, international agreements have been signed that coordinate common actions of countries to reduce their emissions and promote the green transition of the economy.

The stickiness that is associated with the creation of green alternatives in the economy motivates this work. More in detail, our research question focuses on the role of the government in promoting the use of non-polluting alternatives through direct investments in capital formation. We construct a theoretical model that contributes to the debate regarding the role of the government in navigating the economy to a sustainable future. To do so we develop a New Keynesian (NK) model which belongs to the so-called Environmental Dynamic Stochastic General Equilibrium Model (E-DSGE). We extend the standard NK model by including capital producers which are responsible for the creation of capital in the economy. There are two forms of

capital in the economy. which are used by the real sector in the production function, a polluting (brown) and a non-polluting (green) capital. The real sector combines those two into a single unit to produce. As it is common in this literature, we are not focusing on the process of innovation for the creation of green capital. There is a strain of the literature that deals with this issue but our work does not belong in that[1]. Our model incorporates permanent adjustment costs in the creation of green capital in the economy. By doing so, we include frictions that constrain the availability of green capital which leaves no option for firms but to continue to produce with polluting capital and thus increase their emissions. In our specification, we also include carbon taxes, which are paid by the firm based on the level of their emissions. Carbon taxes, as any other form of firm taxes can be viewed as a negative supply shock in the economy. By including carbon taxes and government investments we explore the interactions between a negative and a positive supply shock in the economy to analyse the promotion of green capital in the production function.

The key feature of our model is the role of government investments in the creation of capital in the economy. Government investments are subject to the preferences of the policy maker, who influences how funds are allocated between green and brown capital investments. This can be viewed as direct financing to green firms, subsidies, or funds for energy efficiency, among others. We do not distinguish between the different policies but rather have a more general approach to the topic. We assume that no matter what type of financing policy the government uses, it leads to the creation of new capital in the economy. In our policy evaluation, we show the results under different governmental preferences to test if preferences have an impact but also to see the reaction of the private sector. In a second step, we also show the results after an increase in carbon taxes, to evaluate if the private sector will be more willing to purchase larger quantities of green than brown capital. At the same time, we evaluate the new tax rates under different governmental preference levels.

The policy analysis provides some interesting insights regarding government preferences' role in climate change. In the extreme scenario, when the government has no preference for green investments, the crowd-out effect of private investments has negative consequences for the economy. Both output and consumption decrease on impact and for the whole analysis period. In addition, the decline of green capital in the economy leads to a decrease in its price and an increase in emissions. Private investments in both types of capital decrease, with a larger impact on green capital, but the stock of brown capital increases thanks to government investments. In the other extreme scenario, where the government prefers only green investments, the effects on the economy are positive. Still, the crowd-out effect of private investments is present, but both output and consumption react positively, on average, to the fiscal expansion. Furthermore, emissions are reduced for the whole period of the analysis. The stock of green capital is increasing while the stock of brown capital

[1]For more information about the literature of endogenous growth DSGE model refer to Boehl et al. (2024)

is decreasing.

In a more realistic scenario, in which the government distributes its preferences over the two types of investments, we observe similar patterns than in the only green scenario. Our benchmark analysis assumes a 30% share of green public investments, in which the crowd-out effect is still present. However, output even though it declines on impact, quickly returns to positive values and remains positive for the period of the analysis. The stock of green capital increases, driven by government investments, but brown capital, even though that is preferred by the government, the crowd-out effect on the brown sector leads to a decrease of the brown capital. Emissions are declining since the share of green capital increases, but brown capital decreases. This result provides some interesting policy implications, at least for the economy that we have developed. The result highlights that the government can achieve two goals at the same time. Firstly, it can invest in brown capital, which is dominant in the economy, but if it also invests in green capital, the crowd-out effect benefits both the economy and the environment. Secondly, a substitution effect is taking place among green public and private investments, which can help in shaping environmental policies in key sectors.

Our work is attached to the fast-growing literature that assesses the effect of climate change on the economy. Following the works of Nordhaus (2008) here and Heutel (2012), a new branch of the DSGE models has been developed to include the laws of climate change in the economy. Since the creation of E-DSGE, various researchers have assessed the role of climate change and evaluated proposed climate policies. For example, Economides and Xepapadeas (2025) identified that climate change, when its impact is taken into consideration, disrupts the traditional role of the Monetary Policy. Our work is closely related to the work of Annicchiarico and Di Dio (2015), in which the authors evaluate the role of carbon taxes and caps on emissions. However, we distinguish from them in the following. First of all, we allow firms to have access to two forms of capital, green and brown, while in their specification, firms have access to one type of capital, but they can invest in abatement technologies. Second of all, the role of the government in their model is only to enforce carbon taxes or cap policy. Our model also adds the role of public investments in the formation of capital. The work of Ferrari and Pagliari (2021) is closely related to our work. In their research, the authors investigate the dynamic interplay between two countries, the EU and the USA, and the importance of international cooperation on the issue of climate change. In their model, they assume two different types of firms, green and brown, for each country, and they assess the validity of climate policies. Their analysis showcases the role of fiscal policies, especially taxation,and the coordination that is required between the fiscal and the monetary authorities. Our work shares some common ideas with their own but differs in others. Our model is focused only on one economy a,nd we do not distinguish between two types of firms, since we believe that even polluting firms have access to green capital. However, our work and the

authors coincide in the evaluation of fiscal policies.

This research is also attached to another branch of the literature that explores the role of government investments in the economy. The idea that public spending can be used in periods of crisis follows the ideas of Keynes, who argued that fiscal policies can be used pro-cyclical to business cycles, through fiscal multipliers. Since the late 80s, there has been an effort to identify the true effect of public spending on the economy through, an increase in demand and accumulation of capital for the private sector. Ilzetzki et al. (2013) argued that the true effect of fiscal multipliers depends on country characteristics. The authors found that the state of development, developed or developing countries, plays a crucial role in determining the effect of fiscal spending. In addition, the exchange rate regime also plays an important role, as well as, the monetary policy stance. Similarly, Di Giorgio et al. (2018) found that a fiscal expansion depreciates domestic currency in a DSGE set-up close in line with empirical evidence. On the issue of how to finance fiscal packages, Leeper et al. (2013) found that if fiscal packages are financed through distortionary taxes, then the multiplier is weak. This literature is of extreme importance for our work but also, for the future of green fiscal packages. It highlights the fact that the government should meticulously design fiscal policies to achieve its targets. In addition, it highlights that the true effect of these policies depends on both endogenous and exogenous characteristics. Furthermore, as Andersson et al. (2020) highlights, issues of debt sustainability need to be taken into consideration by both researchers and policymakers.

The remainder of the paper is organized as follows. Section 2 presents the theoretical model. Section 3 presents the policy evaluations, and Section 4 concludes.

2 The Model

This section presents the baseline NK model on which we base our analysis. The model builds on a standard E-DSGE model augmented in two aspects: first, capital producers are responsible for the available capital in the economy, and second, government preferences decide the allocation of public investments. The remaining blocks of the model follow the standard DSGE literature. For the remainder of this section, variables that appear without a time index represent steady-state values.

2.1 Households

The representative household maximizes its lifetime utility function under an income constraint. Households consume a final product, supply labor, and earn wages, while their labor income is taxed at a constant rate by the government. In addition, households buy risk-free government bonds which yields a nominal interest from the holding of bonds from the previous period. The representative household's problem can be

described as follows:

$$\max_{\{c_t,h_t,b_t\}_{t=0}^{\infty}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{c_t^{1-\sigma}}{1-\sigma} - \frac{h_t^{1+\varphi}}{1+\varphi} \right) \tag{1}$$

subject to the income constraint:

$$c_t + b_t = \frac{r_{t-1}}{\pi_t} b_{t-1} + w_t h_t (1 - \tau^h) + \Gamma_t \tag{2}$$

c_t denotes consumption, h_t hours worked, and b_t is the risk-free one-year governmental bond, which yields a nominal interest rate, r_t. w_t is the real wage and τ^h is the labor income tax rate, which is assumed to be constant. Parameters σ and ϕ capture the risk aversion of households and the inverse of Frisch's elasticity, respectively. Finally, Γ_t are profits from the ownership of firms. The maximization problem of the household yields the following:

$$h^{\phi} = (1 - \tau_h) w_t \tag{3}$$

and

$$c_t^{-\sigma} = \beta \mathbb{E}_t \left(c_{t+1}^{-\sigma} \frac{r_t}{\pi_{t+1}} \right) \tag{4}$$

λ_t represents the household's langragian multiplier. Equations (3) and (4) describe the labor supply and the Euler Equation in the economy.

2.2 Final-good Firms

The representative final-good firm employs a CES aggregator to produce the final product consumed by households. The final output is being produced as follows:

$$y_t = \left[\int_0^1 y_t(i)^{\frac{\epsilon}{\epsilon-1}} \, di \right]^{\frac{\epsilon}{\epsilon-1}} \tag{5}$$

where $y_t(i)$ is the output of the intermediate firm i and ϵ the elasticity of substitution between the product of intermediate firms.

The problem of the final-good firm yields the following demand function for the intermediate firm:

$$y_t(i) = y_t \left(\frac{p_t(i)}{p_t} \right)^{-\epsilon} \tag{6}$$

where $p_t(i)$ is the price of the product of firm's i and p_t is general level of prices, which evolves as:

$$p_t = \left[\int_0^1 p_t(i)^{\frac{\epsilon}{\epsilon-1}} \, di \right]^{\frac{\epsilon}{\epsilon-1}} \tag{7}$$

Combining the above yields the real profits for the final-good firm which are zero in the equilibrium, $\Gamma_t^F = 0$

2.3 Real Sector

The representative firm follows a standard Cobb-Douglas function, combining labor and capital to produce the intermediate product. There are two forms of capital in the economy: green and brown. The firm rents the two types of capital, combines them into a final unit, and pays different rental rates to capital producers. We assume that the two forms of capital are perfect substitutes[2]. Firms also pay a carbon tax based on the level of their emissions, which is a by-product of the production in the economy [3]. Lastly, the firms are subject to a quadratic adjustment cost à la Rotemberg when resetting their prices and the demand of the economy.

The production function of the representative intermediate firm i follows a Cobb-Douglas function as:

$$y_t(i) = Ak_t(i)^{\alpha} h_t(i)^{(1-\alpha)} \tag{8}$$

Where A_t represents the productivity of intermediate firms, k_t is the level of capital and l_t the labor used for the production and parameter α captures the share of capital in the production function. Firms combine both forms of capital into a single unit. Total capital, which enters the production function of the representative firm,m can be described as follows:

$$k_t = k_t^G + k_t^B \tag{9}$$

The representative firm's profit maximization problem is the following when taking the demand from households as given, the production function, and the evolution of emissions:

$$\max_{\{p(i)_t, h(i)_t, k(i)_t, y(i)_t\}_{t=0}^{\infty}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{\lambda_t}{\lambda_0} \left[\frac{p(i)_t}{p_t} y(i)_t - w_t h(i)_t - r_t^{kB} k^B(i)_t - r_t^{kG} k^G(i)_t(i) - \tau^e e(i)_t - \frac{\kappa_P}{2} \left(\frac{p(i)_t}{p(i)_{t-1}} - \overline{\pi} \right)^2 y_t \right]$$

$$\text{s.t.} \begin{cases} y_t(i) = y_t \left(\frac{p_t(i)}{p_t} \right)^{-\epsilon}, \\ y_t(i) = A_t k_t(i)^{\alpha} h_t(i)^{(1-\alpha)}, \\ e_t(i) = (1 - \frac{k_t^G}{k_t}) \gamma_1 y_t^{1-\gamma_2} \end{cases}$$

$y(i)_t$ is the output of firm i, where y_t is the total output in the economy. w_t is the countrywide wage paid to households and $h(i)_t$ is labor employed by a firm. r_t^{kB} and r_t^{kB} are the rental rates for brown and green capital that the firm pays to the capital producers of the economy, and k_t^B and k_t^G are the levels of green and

[2] In the following section, we present the frictions associated with the production of capital that capital producers face. Thus, we decided to assume perfect substitution rather than a CES function

[3] We analyze the environmental dynamics of the model in the following subsection.

brown capital, respectively. τ^e is the carbon tax that firms pay for the level of their respective emissions $e(i)_t$. Finally, A_t denotes the productivity of the firms. As it is standard in the EDSGE literature, productivity is considered exogenous to firms and is negatively affected by climate change through a damage function. We analyse the evolution of A_t in the following subsection.

The representative firm's maximization problem yields the following conditions in a symmetric equilibrium: For labor:

$$h_t w_t = (1-\alpha) mc_t y_t \tag{10}$$

For Brown Capital:

$$r_t^{kB} = mc_t \alpha A_t k_t^{\alpha-1} h_t^{1-\alpha} - \tau^e \gamma_1 y^{-\gamma_2} \frac{k_t^G}{k_t} \tag{11}$$

For Green Capital:

$$r_t^{kG} = mc_t \alpha A_t k_t^{\alpha-1} h_t^{1-\alpha} + \tau^e \gamma_1 y^{-\gamma_2} \frac{k_t^B}{k_t} \tag{12}$$

For Prices:

$$\pi_t(\pi_t - \pi) = \beta \mathbb{E}_t \left(\frac{\lambda_{t+1}}{\lambda_t} \pi_{t+1}(\pi_{t+1} - \pi) \frac{y_{t+1}}{y_t} \right) + \frac{\epsilon}{\kappa_P} \left(mc_t + (1-\gamma_2)(1 - \frac{k_t^G}{k_t}) \gamma_1 \tau^e y^{1-\gamma_2} - \frac{\epsilon - 1}{\epsilon} \right) \tag{13}$$

mc_t represents the marginal costs of the firm. Equation (10) represents the demand for labor in the economy, while Equations (11) and (12) are the demand for brown and green capital, respectively. Equation (13) is the standard non-linear Phillips Curve (PC). Key insights of our specification arise from the maximization problem of the firm. Firstly, firms internalize the carbon tax in the decision of green and brown capital in the production function. The reason lies in the fact that firms have perfect foresight. This result is in line with economic theory, which indicates that green capital will be more expensive since it is associated with no emissions relative to brown capital. Secondly, the Phillips Curve, which links the evolution of inflation in the economy with inflation expectations output gap and markup, is augmented, rather than the standard PC, to include environmental dynamics that arise due to carbon taxation, similar to Annicchiarico and Di Dio (2015). In the absence of carbon taxes, $\tau^e = 0$, the PC decreases to the standard New Keynesian PC, and firms are indifferent between green and brown capital since they are not penalized for the use of brown capital. The latter holds since we have assumed that both forms of capital yield the same marginal productivity.

2.4 Capital Producers

Capital producers are responsible for creating capital in the economy. They rent capital, both green and brown, to firms, and they receive different rental rates based on the type of capital. In addition, capital producers decide the level of investments in the two forms of capital, which maximizes their profits. For the reasons we have explained before, formulating green capital is subject to adjustment costs, making the accumulation of green capital "harder" than the accumulation of brown capital. The introduction of adjustment costs for the creation of green capital is two-fold. Firstly, we would like to reflect on real-world dynamics, where green capital is only a share of brown capital in the total economy. Secondly, based on the optimization problem of the intermediate firms, we would like to exclude cases where firms invest solely in green capital, leading to no brown capital utilized in their production function. We assume a specific type of adjustment cost, which has short-term and long-term effects in the dynamics of our model. Finally, we assume that capital producers benefit from governmental policies by government investments in capital. The government invests in both types of capital, but the distribution between the two forms of capital is subject to preferences, which we explain later how they evolve.

The representative capital producer maximizes the following profit function:

$$\max_{\{k_t^B, k_t^G, i_t^B, i_t^G\}_{t=0}^{\infty}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{\lambda_t}{\lambda_0} \left[r_t^{kG} k_t^G + r_t^{kB} k_t^B - i_t^B - i_t^G \right]$$

The stock of brown capital evolves as:

$$k_t^B = (1-\delta) k_{t-1}^B + i_t^B + g_t^{IB} \tag{14}$$

and green capital:

$$k_t^G = (1-\delta) k_{t-1}^G + i_t^G + g_t^{IG} - \frac{\kappa_I}{2} \left(\frac{i_t^G}{i_t} \right)^2 i_t^G \tag{15}$$

Where g_t^{IB} and g_t^{IG} represent the government investments for capital accumulation and i_t is total investments in the economy [4] and parameter δ the depreciation rate of capita, which we assume is identical for both types of capital. The last part of green capital accumulation is the long-term adjustment cost that capital producers pay to increase the stock of green capital. This specification makes green capital scarce and more expensive than brown capital in the economy, both on the demand and the supply side of the economy. This feature can be justified by the existence of carbon taxation in the economy. Our analysis does not include any endogenous growth features that lead to smaller production costs of green capital in the future. Furthermore, the friction in the formulation of green capital highlights the importance of government intervention to support green

[4] Total investments can be expressed as $i_t = i_t^B + i_t^G$

investments. Any increase in government investments will lead to more green capital in the economy, which will help smooth the rental rate of green capital.

The maximization problem of the representative capital producer yields the following conditions:

For Brown Capital:

$$r_t^{kB} = \mu_t^B - \beta \mathbb{E}_t \left(\frac{\lambda_{t+1}}{\lambda_t} (1-\delta) \mu_{t+1}^B \right) \tag{16}$$

For Green Capital:

$$r_t^{kG} = \mu_t^G - \beta \mathbb{E}_t \left(\frac{\lambda_{t+1}}{\lambda_t} (1-\delta) \mu_{t+1}^G \right) \tag{17}$$

For Brown Investments:

$$\mu_t^B + 2\kappa_I \mu_t^G \left(\frac{i_t^G}{i_t}^3 \right) = 1 \tag{18}$$

For Green Investments

$$\mu_t^G \left(1 - \kappa_I \left(\frac{i_t^G}{i} \right)^2 - 2\kappa_I \frac{(i_t^G)^2 i_t^B}{i_t^3} \right) = 1 \tag{19}$$

μ_t^B and μ_t^G can be interpreted as the shadow price of brown and green capital, respectively. Because of the friction that we introduced, it holds that in the steady state $\mu^G > \mu^B$, which leads to the same inequality for the rental rates of capital, $r^{kG} > r^{kB}$, δ is the depreciation rate of capital in the economy, which is assumed to be homogenous over the two forms of capital. Finally, λ_t is the langragian multiplier from the household's maximization problem.

2.5 Environment

The Environmental block follows the standard literature of environmental DSGE models but for the evolution of emissions. GHG emissions, domestic and from the rest of the world, accumulate pollution in the atmosphere, which, in turn, negatively affects the private sector's productivity. The specification and parameterization of the environmental block follows the work of Annicchiarico and Di Dio (2015).

The total productivity of the private sector is as such:

$$A_t = (1 - D_t) a_t \tag{20}$$

where D_t is the damage function caused by pollution and a_t is a productivity shock that follows an AR(1) process, as such:

$$log(a_t) = (1 - \rho_a)\overline{a} + \rho_a log(a_{t-1}) + \epsilon_t^a \tag{21}$$

where $\overline{a}$ is the steady state value of the productivity shock, ρ_a is the persistence parameter of the shock and ϵ_t^a is an exogenous shock. The damage function follows a non-linear relation with the stock of pollution, and it can be expressed as such:

$$D_t = d_3(d_0 + d_1 x_t + d_2 x_t^2) \tag{22}$$

x_t, the stock of pollution in the atmosphere, depends on domestic and international emissions and its past value, recreating the slow decay of pollution.

$$x_t = \eta x_{t-1} + e^{row} + e_t \tag{23}$$

where η is the decay parameter and e^{row} and e_t international and domestic emissions. In our benchmark scenario, we follow the literature and keep international emissions constant. In a later analysis, we assume that emissions from the rest of the world are time-varying to analyze their dynamics on our economy. Finally, domestic emissions evolve accordingly:

$$e_t = (1 - \frac{k_t^G}{k_t})\gamma_1 y_t^{-\gamma_2} \tag{24}$$

Emissions are a by-product of production, as it has been introduced in the literature. In our model, we do not distinguish between two types of firms, polluting and non-polluting, thus, we need to account for the beneficial role of green capital. Green capital does not emit; thus, its share of total capital is needed to adjust emissions due to the utilization of brown capital in the production function. Our correction provides some interesting results; for example, in the absence of any green capital,$k_t^G = 0$, emissions are as in Annicchiarico and Di Dio (2015). If brown capital is zero $k_t^B = 0$, then the economy does not emit. For any other combination of green and brown capital, emissions are positive but lower than in the no-green capital scenario.

2.6 The Central Bank

The Monetary Authority is independent from the government and follows a standard Taylor Rule. She focuses on setting the interest rate in the economy. We chose to assign independence to the CB to validate the potential trade-offs due to climate change and fiscal policies. The Taylor Rule that she follows evolves as such: :

$$\frac{r_t}{r} = \left(\frac{r_{t-1}}{r}\right)^{\rho_r} \left[\left(\frac{\pi_t}{\pi}\right)^{\phi_\pi} \left(\frac{y_t}{y}\right)^{\phi_y}\right]^{1-\rho_r} \exp(\upsilon_t^m) \tag{25}$$

Parameters ϕ_π and ϕ_y measure the weights of inflation and output gap accordingly, on the CB's mandate. In the baseline scenario, we assume the CB to focus only on inflation deviations. In a later stage of this

analysis, we relax this assumption and assume that the CB also accommodates output deviation.[5]

2.7 The Government

The government plays a crucial role in our analysis as its policies can facilitate the economy's green transition. In our framework, the government directly influences capital formation, a role grounded in both economic theory and international climate policy. Economic theory highlights the productive impact of public investment, while global climate agreements emphasize the importance of fiscal measures in addressing environmental challenges. Thus, the government serves a dual function. First, it promotes capital accumulation and economic growth. Second, prioritizing investment in green capital contributes to emission reduction. Additionally, increased public investment in green capital can incentivize private sector participation by lowering capital costs, further accelerating the transition to a greener economy.

The government runs a balanced budget constraint, which is the following:

$$\tau_e e_t + \tau_h w_t h_t = g_t^I \tag{26}$$

Taxes on emissions and labor income finance government investments. We assume that there are no other types of government spending in the economy. The government decides on the allocation of investments to brown or green capital based on the following rule:

$$g_t^I = \theta g_t^{IG} + (1-\theta) g_t^{IB} \tag{27}$$

θ is a parameter that captures the governmental preferences over green and brown capital. In our benchmark analysis, we assume that $\theta = 0.37$, which means that the government prefers polluting capital over green capital. The value of θ has been chosen based on the new regulations of the European Commission for the share of green investments over total public investments. However, we relax this assumption and evaluate the results for different values of the parameter. Finally, we assume that governmental investments follow an AR(1) process:

$$g_t^I = (1-\rho_g) g^I + \rho_g g_{t-1}^I + \upsilon_t^G \tag{28}$$

where υ_t^G is an exogenous shock.

[5] Variables without time-script denote steady state values.

3 Policy Evaluation

In this section, we present the results of our analysis. We begin by outlining the model's market-clearing conditions. Next, we discuss the calibration of parameter values and the computation of the steady state. Finally, we examine the model's dynamic behavior under different scenarios.

3.1 Market Clearing

We assume that government bonds are zero in net supply, $b_t = 0$. Clearing in the good market implies:

$$y_t = c_t + i_t^T + \frac{\kappa_P}{2}(\pi_t - \pi)^2 + \frac{\kappa_I}{2}\left(\frac{i_t^G}{i_t}\right)^2 i_t^G \tag{29}$$

where i_t^T are the total investments in the economy.

$$i_t^T = i_t^B + i_t^G + g_t^{IB} + g_t^{IG} \tag{30}$$

3.2 Calibration

The table below reports the model's baseline calibration. The calibration of the model follows standard findings from the DSGE literature. Household parameters are calibrated similarly to Smets and Wouters (2007). The discount factor, β to 0.99, risk aversion σ to 1 and the inverse of Frisch elasticity, ϕ to 1. Labor income taxation, τ_h is set to 0.2 following the empirical results from the literature. On the real sector of the economy, we set the elasticity of substitution between capital and labor $\alpha = 0.33$ and the depreciation rate δ to 0.025. Price adjustment costs, κ_P is set to 26.86, similar to Ferrari and Landi (2024). Lastly, the capital adjustment cost between green and brown investments, κ_I, is set to 2.48.

Environmental variables are calibrated based on the existing literature on E-DSGE. Concerning domestic emissions, parameters γ_1 and γ_2, which capture the shifter in the emission function and the concavity of the emission function, respectively, are calibrated as in Annicchiarico and Di Dio (2015). Emissions from the rest of the world, e^{row}, are set to 1.3653, and carbon taxation, τ^e, to 0.0512. The initial pollution level is set to 800 gigatons of atmospheric carbon, similar to Heutel (2012).

Table 1: Calibration

Parameter	Value	Description	Reference
β	0.99	Discount Rate	Ferrari and Landi (2024)

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Parameter	Value	Description	Reference
σ	1	Risk Aversion	Ferrari and Landi (2024)
ϕ	1	Frisch's Elasticity	Ferrari and Landi (2024)
τ^h	0.052	Labor Tax	Ferrari and Landi (2024)
α	0.3	Elasticity of Production with respect to Capital	Ferrari and Landi (2024)
δ	0.025	Depreciation Rate	Ferrari and Landi (2024)
κ^I	2.48	Investments Adjustment Costs	Ferrari and Landi (2024)
κ^P	26.8638	Price Adjustment Costs	Ferrari and Landi (2024)
ϵ	6	Elasticity of Substitution between Differentiated Goods	Ferrari and Landi (2024)
η	0.9979	Pollution Decay	Annicchiarico and Di Dio (2015)
γ_1	0.45	Shifter in the emission function	Annicchiarico and Di Dio (2015)
γ_2	0	Concavity of emission function	Annicchiarico and Di Dio (2015)
d_o	1.3950e-3	Constant in damage function	Ferrari and Landi (2024)
d_1	-6.6722e-6	1st order coefficient term in damage function	Ferrari and Landi (2024)
d_2	1.4647e-8	2nd order coefficient term in damage function	Ferrari and Landi (2024)
d_3	1	Damage function shifter	Ferrari and Landi (2024)
e^{row}	1.3653	Emissions RTW	Ferrari and Landi (2024)
τ^e	0.052	Carbon Tax	Ferrari and Landi (2024)

3.3 Policy Evaluation

We start by presenting the results following a fiscal expansion of 1% in our baseline specification. We explore the dynamics of our system under three scenarios. In the two extreme scenarios, the government prefers only polluting capital, and in the other, only green, $\theta = 0$ and $\theta = 1$, respectively. Finally, we perform a more realistic approach where we assign a conservative value of 37% to government preferences. In this scenario, the government still prefers brown to green investments, similar to empirical data (here to find a citation for it). We start by presenting the two extreme scenarios, and then we continue with the more realistic approach.

Figure 1 and Figure 2 illustrates the response of core variables to a positive increase of 1% of governmental investments. In this scenario, we assume that government preferences favor only polluting capital, $\theta = 0$. Following the increase in government investments, since the government prefers only polluting capital, we

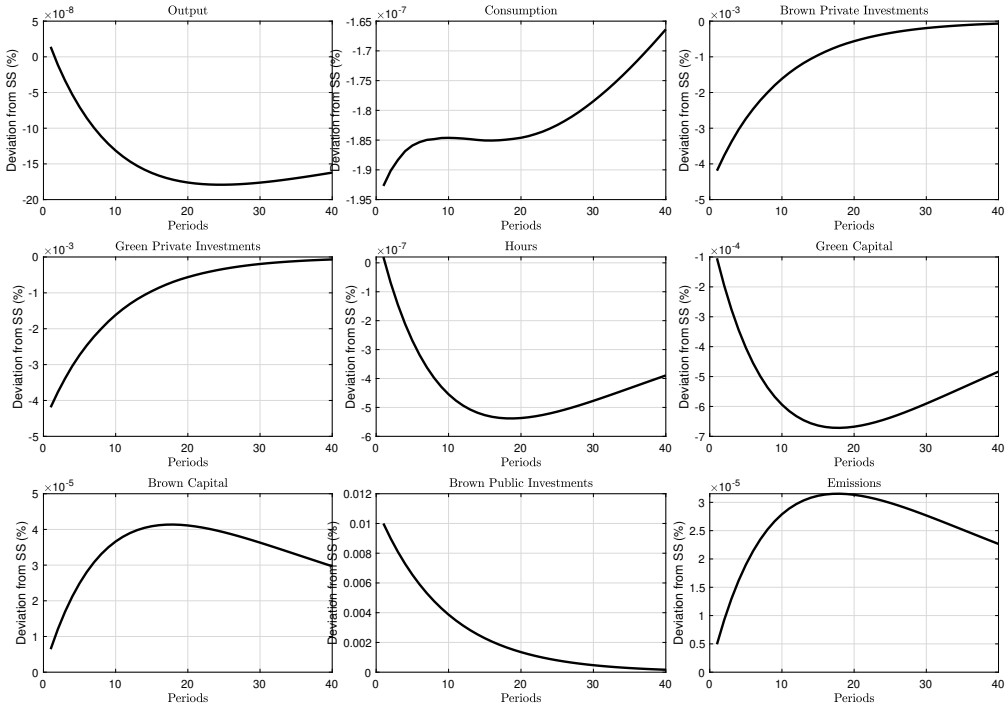

Figure 1: Impulse Response Functions - Real Variables - $\theta = 0$

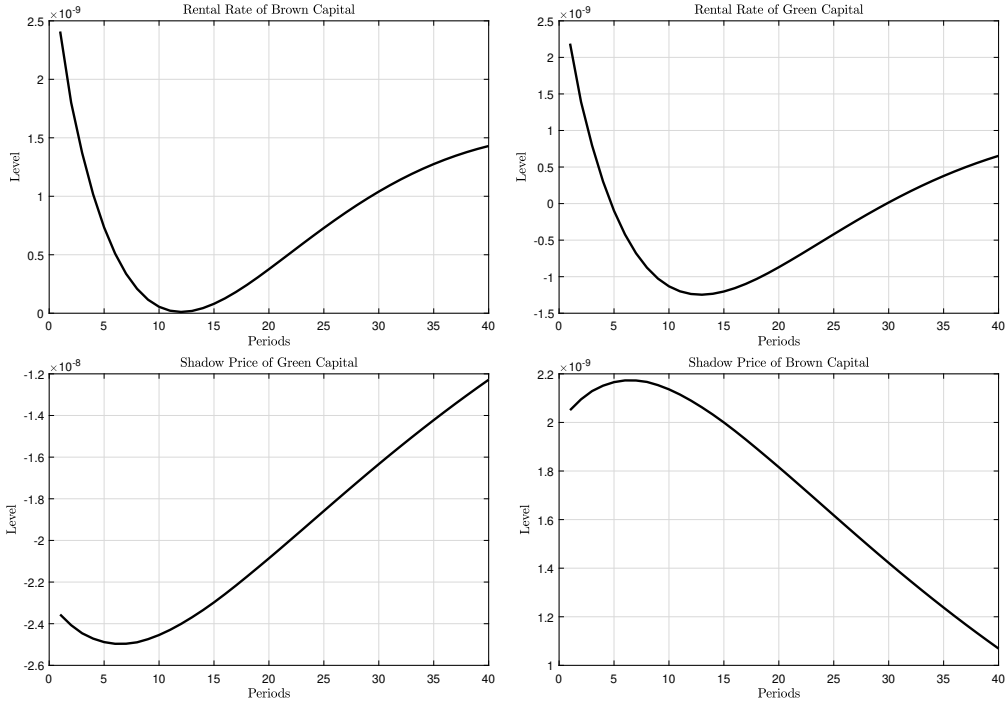

Figure 2: Impulse Response Functions - Price Variables - $\theta = 0$

observe an increase in the stock of polluting capital and a decline in green capital. Due to this interaction, emissions increase and remain positive for the whole period of the analysis. In addition, the fiscal expansion leads to a crowd-out effector private investments in the economy. Both green and brown investments from

the private sector decline. The increase in the stock of polluting capital is attributed to the fiscal expansion. We also observe that output and consumption decline and do not return to their steady-state values. The increased demand for brown capital drives the price of brown capital to increase, while the opposite is true for green capital. Thus, we observe a long-lasting negative impact on both real and financial variables and an increase in emissions.

Figure 3 and Figure 4 showcases the effect of fiscal expansion when the government only invests in green

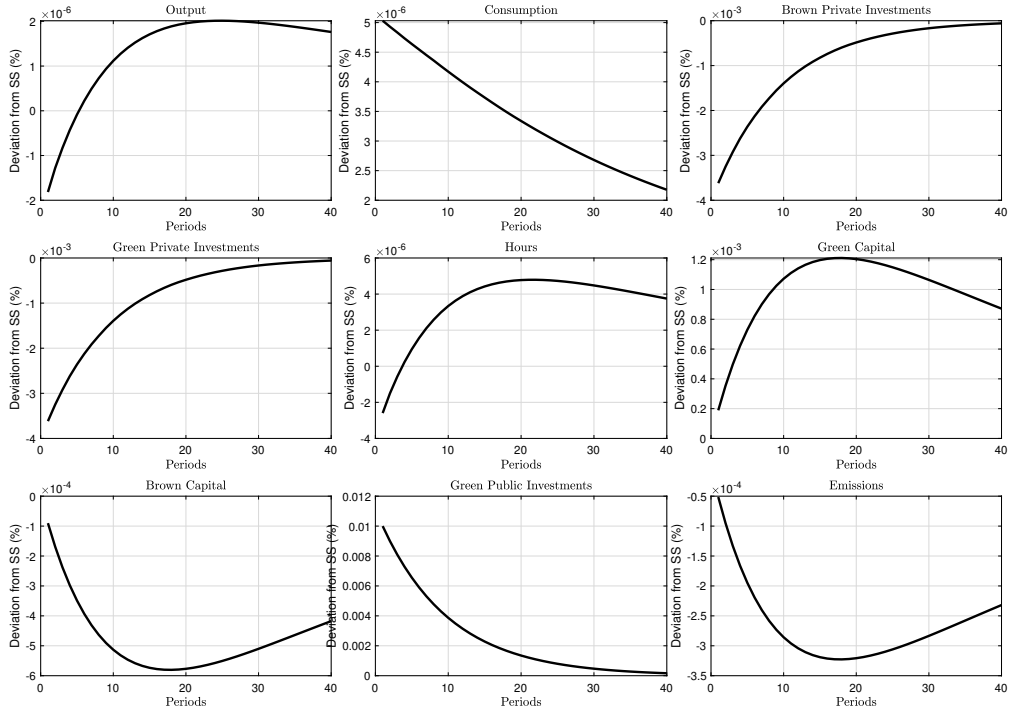

Figure 3: Impulse Response Functions - Real Variables - $\theta = 1$

capital. Following the fiscal expansion, green capital accumulates in the economy while brown capital declines. The crowd-out effect of private investments is still present in both types of capital, indicating a substitution effect between green private and public investments. Unlike in the only brown capital scenario, output decreases on impact but quickly increases, leading to economic growth. Consumption seems to react positively to the green fiscal expansion. The reason this is taking place is due to the positive effect of green capital on the economy. On the one hand, it helps reduce emissions since green capital increases and brown decreases; on the other hand, it helps reduce productivity losses. In addition, the quick return of economic growth along with the reduction of private investments and fuel consumption in the economy. Finally, due to the increased demand for green capital, the price of green capital increases, and the opposite is true for brown capital.

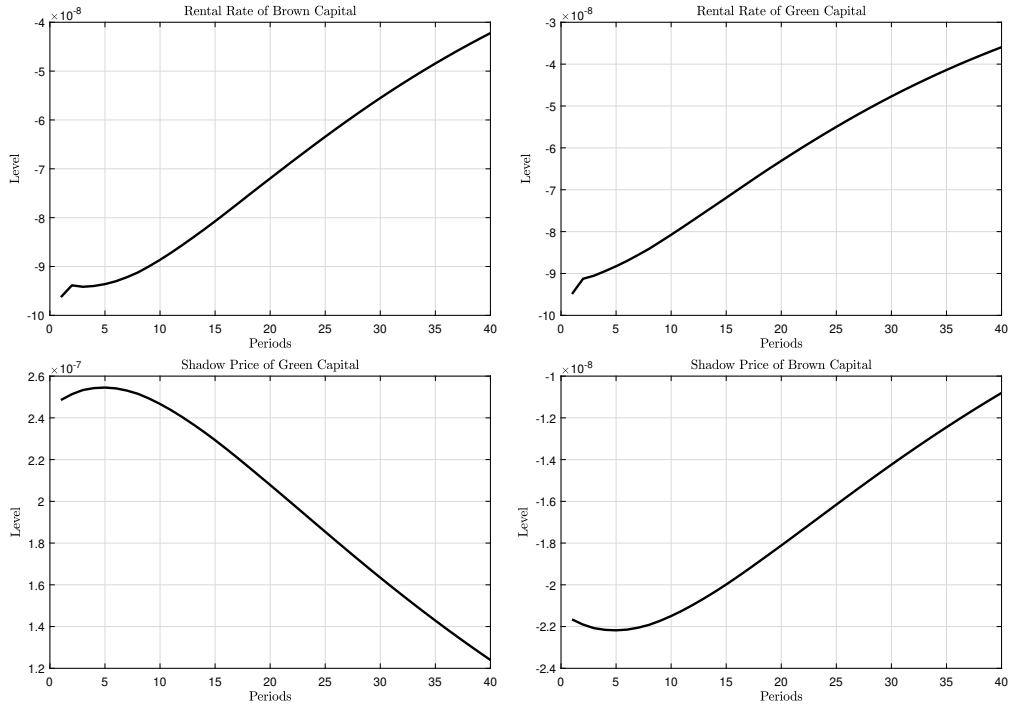

Figure 4: Impulse Response Functions - Price Variables - $\theta = 1$

Figure 5 and Figure 6 illustrates the scenario under which the government invests in both types of capital. However, it prefers more brown than green capital, supported by empirical data. In this analysis, the preference parameter takes the value of 37%, $\theta = 0.37$. Following the fiscal expansion, we observe an increase in the stock of green capital but a decrease in brown capital. The reason lies in the crowd-out of private investments in brown capital, which are higher than government investments. However, even though private investments in green capital fall, the stock of green capital increases. The substitution between green private and public investments is still present with a low level of the preference parameter. We observe the same results as in the full green scenario for output and consumption. Finally, emissions are falling due to the increase of green capital and the decrease of brown capital.

The reaction of the systems to the different levels of government preferences reveals some interesting results and policy implications. First of all, in the scenario where the government invests only in brown capital, the effects on both the economy and the environment are negative throughout the whole period of the analysis due to the crowd-out effect of private investments and the increase in emissions and, as a result, pollution in the economy. The scenario in which the government focuses only on green capital appears to be the most beneficial of the three. Despite the crowd-out effect of private investments, the increase in green capital drives economic growth. At the same time, emissions are decreasing and slightly the stock of pollution.

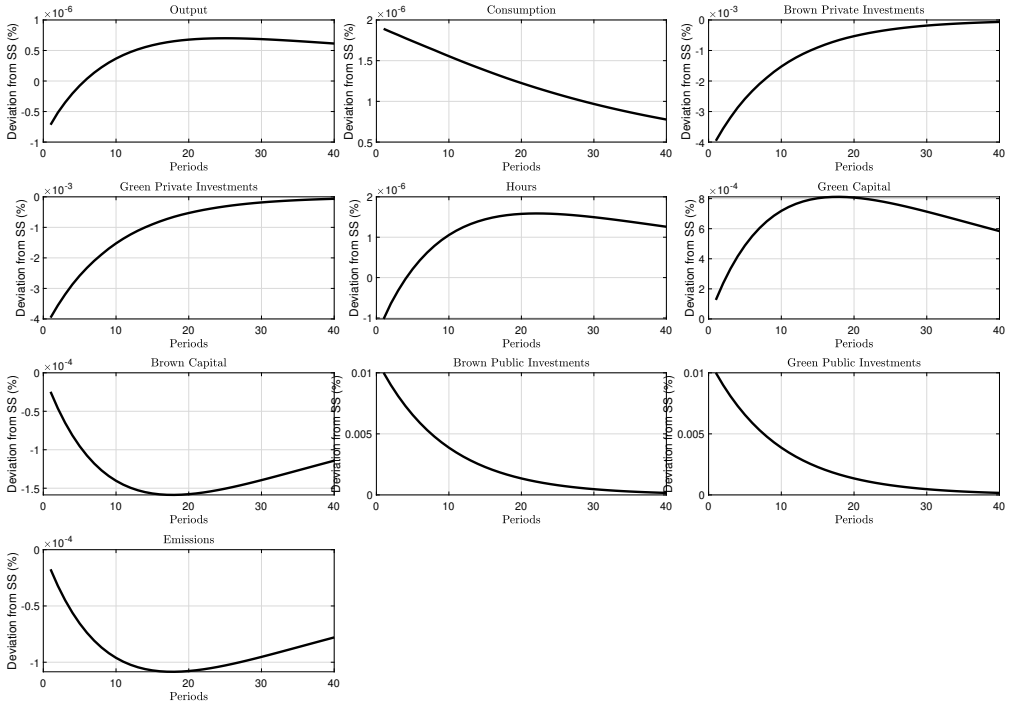

Figure 5: Impulse Response Functions - Real Variables - $\theta = 0.37$

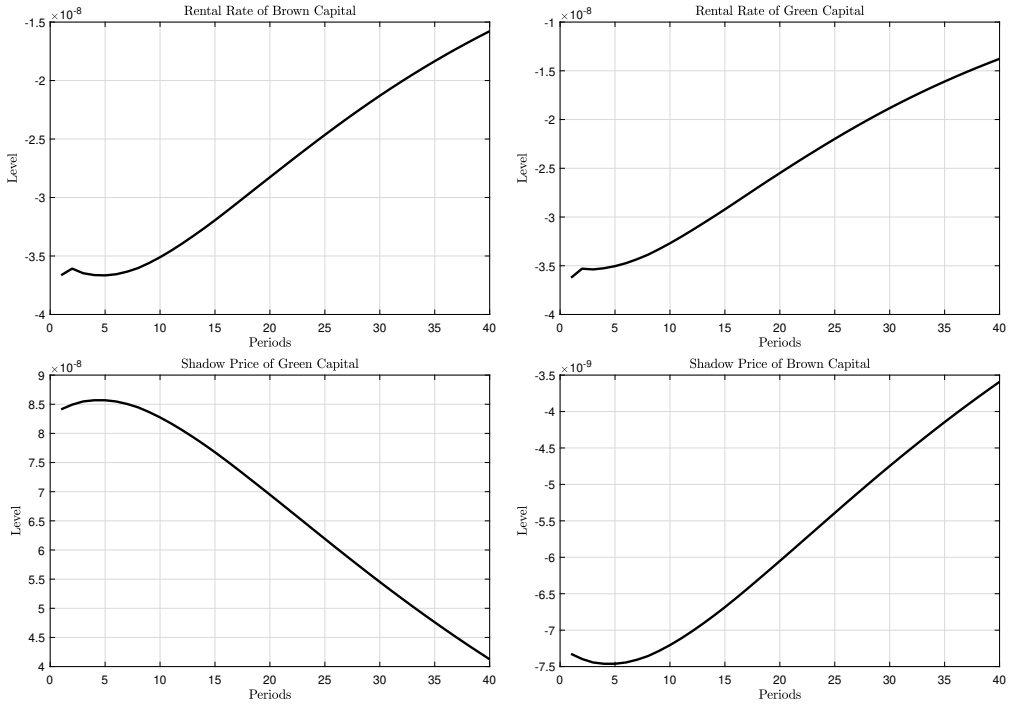

Figure 6: Impulse Response Functions - Price Variables - $\theta = 0.37$

The third and more realistic scenario showcases similar results as the "all-green" scenario but in different magnitudes. Our analysis showcases that, in the presence of frictions, which are associated with the production of green capital in the economy, the role of the government and especially its preferences over the

distribution of investment is crucial. When the government does not prefer green capital at all, then the economy, following a fiscal expansion, is faced with a negative impact on both the real side of the economy and the environment. The crowd-out of private investments in capital causes a recession in the economy and a drop in consumption. Furthermore, the increase in emissions due to the decline of green capital has negative effects for both the short-term and the long-term since the stock of pollution is increasing. When the government applies a more conservative approach, giving weight to both green and brown investments, then we observe that it can achieve two things with a single instrument. Firstly, the crowd-out effect reduces brown capital but increases green capital since government investments are higher than the loss of investments in the green sector. This result drives economic growth and an increase in consumption. Secondly, the mix is beneficial for the environment since emissions are decreasing.

Furthermore, we have analyzed the above scenarios when the government also raises the level of carbon tax. We do not report the results of this evaluation since there are similar results with no major changes but of different magnitude. We believe that this result is driven by the higher costs that firms have to pay due to their emissions. Again, the role of government preferences over green investments appears to benefit the economy, while investments in polluting activities lead to a recession. It would be interesting to evaluate the above scenarios when both carbon taxes and government preferences are time-varying. Then, a policy evaluation on the optimal level of carbon taxes and government preferences can be performed, along with a welfare evaluation of the different scenarios. However, this is the work of another research report.

4 Conclusion

We develop an E-DSGE to assess the role of government preferences over investments in stimulating capital in the economy. Using a small-scale DSGE model, two distinct types of capital, and limitations in creating new green capital, we evaluate the role of government investments in stimulating green investments in the economy, driven both by the new EU legislation for green government investments, over total government investments, and the limitations in the creation of green capital. Our findings suggest that government preferences play a crucial role in the economy. Firstly, we observe a crowd out effect of private investments following a fiscal expansion. This result is in line with the economic theory, which suggests that government investments can shift private investments in capital. Secondly, preferences over green and brown investments matter. Investment solely in brown capital leads to economic recession due to the presence of carbon taxes in the economy. However, in the two other scenarios, the full green and in line with the EU legislation benchmark, public investments stimulate the economy, leading to economic growth and accumulation of green capital in the economy, with positive effects on other key variables. This result highlights, in the

context of our specification, the importance of government investments in the green sector and the positive spillover effect they have on the economy. In the environmental side of our model, government preferences also play a crucial role in decreasing emissions in the economy due to the beneficial role of green capital. In the scenario where the government only invests in brown capital, it aggravates the environmental conditions of the economy, leading to further productivity damages. In the other two scenarios, it helps firms reduce their emissions, thus leading to smaller carbon axes paid to the government. The stock of pollution does not appear to have big variations, but this comes as no surprise since the stock of pollution has long-lasting effects that are out of the scope of this analysis. In conclusion, our research provides some key policy insights regarding the role of the government has in stimulating the economy and in leading her to a greener future.

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