Carbon Taxes vs. Green Subsidies: Generational Conflicts and Distributional Consequences

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Abstract

We study the economic implications of a carbon tax vs. green subsidy in a heterogeneous agents New Keynesian model with brown and green energy production and endogenous green R&D. In the short run, we find that a carbon tax results in a relatively moderate reduction in consumption, as households benefit from the redistribution of tax revenues. Conversely, a subsidy on green energy leads to a significant decline in consumption, higher taxes and higher labor demand, caused by a major shift of resources towards green R&D. All but the top 20% of the wealth distribution strongly oppose the subsidy. However, a generational conflict arises: in the long run, the subsidy leads to higher output and consumption due to increased productivity in the green energy sector, making it more beneficial for future generations.

Keywords: Climate change, Heterogeneous agents, Fiscal Policy, Carbon tax, Green subsidies
JEL: C63, C32, E52, E47

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1 Introduction

It is now widely accepted that ambitious policies are necessary to reduce carbon emissions and mitigate the risks of climate change. But how will these policies impact society across different wealth or income groups? And how will they affect economies both in the short run and for future generations in the long run? In this paper, we show that these distributional and generational considerations are crucial for determining the optimal choice of policy instruments.

To achieve this, we develop a medium-scale DSGE model with heterogeneous agents and incomplete markets, based on the heterogeneous agent New Keynesian (HANK) framework. In our model, households face borrowing constraints and uninsurable labor income risk. This setup breaks Ricardian equivalence, making the fiscal tax and transfer system a key determinant of households' consumption and savings decisions. Additionally, the model incorporates both green ("clean," carbon-free) and brown ("dirty," carbon-intensive) energy as production factors, with each produced in distinct energy sectors. Finally, we include endogenous research and development (R&D) in green energy production technology, allowing the model to capture the innovation dynamics within the green energy sector.

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Based on this framework, we focus on two specific policies: a carbon tax and a green subsidy. Both policies distort the relative prices of brown and green energy. A carbon tax raises the ask price of brown energy, while a green subsidy lowers the price of green energy. In both cases, the policy induces a shift in energy production from the brown to the green sector, driving a gradual transition to a new steady state with a lower level of brown energy.[1]

However, the two policies generate significantly different transition dynamics. When a carbon tax is implemented, energy prices rise in the short run, which increases production costs for final goods. This leads to a decline in output, labor demand, and wages, resulting in lower labor income and household consumption. Despite this, the overall contraction from the carbon tax remains relatively moderate for two reasons. First, the shift in energy production toward the green sector boosts profits within this sector, which stimulates additional R&D investment. This helps to cushion the decline in production. Second, the carbon tax generates additional government revenue, which – assuming balanced budget – lowers the tax level, particularly benefiting poorer households.

In contrast, when a green subsidy is implemented, energy prices fall immediately, causing a major shift in demand toward green energy. Production increases due to cheaper energy inputs and a surge in demand from the green R&D sector. This leads to a significant rise in investment, labor demand and real wages, which, in turn, raises production costs and fuels inflation. Subsequently, consumption drops sharply in the short run for two main reasons. First, in response to higher inflation, the central bank raises nominal interest rates, which reduces consumption incentives for households that are not borrowing-constrained. Second, to finance the green subsidy the government must raise the level of taxes. For poorer households, this tax-hike outweighs the gains in labor income, resulting in an overall decline in total income.

These different dynamics have important implications for the desirability of a carbon tax versus a green subsidy. To assess this, we compute consumption equivalents, which represent the level of compensation households would require to prefer either policy over a scenario without carbon intervention. In the short run, all households, except for the very wealthy, favor the carbon tax over the green subsidy. This is because, under a carbon tax, consumption declines only moderately whereas reduced labor demand decreases disutility from work, and additional tax revenues lower the tax burden, thus increasing insurance against idiosyncratic income risk. In contrast, green subsidies are costly for households in the short term. The sharp drop in consumption, combined with increased labor hours and disutility, significantly reduces welfare. Moreover, higher taxes further erode household incomes, particularly for poorer groups. Only the wealthiest households benefit from the green subsidy, as they hold shares in firms, including green firms, which experience a boost in profits.

Yet, these results completely change when we consider the long-term implications of the two policies. The green subsidy triggers a larger surge in R&D investment early in the transition process compared to the carbon tax. In the long run, this innovation boosts productivity in the green energy sector, significantly reducing energy prices. These lower costs lead to a persistent boom in the production sector, further increasing labor demand and real wages. Ultimately, the higher income from labor outweighs the income loss due to lower transfers. In the new steady state, consumption, output, labor, and capital levels are notably higher under the green subsidy, driven by the greater efficiency gains in green energy production.

In sum, the desirability of different carbon policies ultimately comes down to balancing short- and long-term benefits and costs; in other words, it is a generational conflict. While the current generation strongly favors a carbon tax over a green subsidy, future generations benefit more from the long-term outcomes of the subsidy. This finding adds a new dimension to the political economy of climate change policies. When

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[1] The levels of the tax and subsidy are calibrated to achieve the same reduction in brown energy, or equivalently, carbon emissions.

presented with different policy options, governments may prioritize those that offer short-term advantages, even if they are less beneficial for society in the long run.

The remainder of this paper is structured as follows. In the rest of this section we review the related literature. Section 2 presents our economic model whereas Section 3 presents our central findings. Section 4 concludes.

Literature

Although there has been considerable progress in empirical and model-based research on the macroeconomic impact of climate change policies in recent years, a notable gap remains in understanding their distributional consequences and the relative desirability of different policy options.

Recent studies on the effects of transition policies have primarily focused on their impact on output and inflation. For instance, using a small open-economy DSGE model, Airaudo et al. (2022) find that carbon taxes can lead to permanently higher brown energy prices, resulting in a short-term inflation surge and persistent output losses. Similarly, Bartocci et al. (2024) argue that the gradual introduction of a carbon tax has recessionary and disinflationary effects in a large-scale DSGE model of the Euro Area. However, these recessionary effects are mitigated when green energy is subsidized, and labor taxes are simultaneously reduced. Lastly, Ferrari and Landi Nispi (2024) emphasize the role of expectations in shaping the economic effects of carbon taxes. Under rational expectations, a carbon tax is deflationary as agents internalize future income losses, while it initially leads to inflation under bounded rationality.

Empirical studies on the macroeconomic implications of climate policies include Moessner (2022), Metcalf and Stock (2023), Konradt and Weder di Mauro (2023), and Känzig (2023). Their findings are mixed. Some suggest that carbon taxes are mildly inflationary and lead to a decline in industrial production, while others argue that these taxes have negligible effects on prices and inflation –except when monetary policy is constrained.

Studies on optimal carbon policies include Fischer and Springborn (2011), Angelopoulos et al. (2010), Heutel (2012), Annicchiarico and Di Dio (2015), Hillebrand and Hillebrand (2019), Kotlikoff et al. (2021), and Hillebrand and Hillebrand (2023). These studies primarily focus on evaluating the optimality of climate policies in terms of their effectiveness in achieving emission reduction goals. For example, Hillebrand and Hillebrand (2023) uses a dynamic multi-country general equilibrium model to conclude that the optimal tax is one that fully internalizes externalities across regions. However, the main challenge in implementing such a tax lies in redistributing tax revenues to ensure that the climate burden is shared fairly among countries.

Our paper is particularly related to Känzig (2023) in its focus on the heterogeneous effects of climate policies across the distribution of households. Using household-level data, Känzig (2023) documents significant variation in how carbon pricing policies impact different income groups. While the consumption expenditure of high-income households declines only marginally, low-income households experience substantial and persistent reductions in expenditure. However, targeted fiscal policies can effectively mitigate the economic costs of climate policies and alleviate their negative distributional effects. Similarly, our analysis highlights the critical role of fiscal policy, as its interaction with climate policy significantly influences the transition process and the overall economic cost of climate policies.

The paper is also related to the long-standing literature on endogenous growth in DSGE models, including Comin and Gertler (2006), Bilbiie et al. (2008), Comin and Mulani (2009), Bambi et al. (2014), Bianchi et al. (2019), Anzoategui et al. (2019), and Okada (2022). These studies share a common approach of modeling endogenous technological change as an increase in the variety of goods, following Romer (1990), combined with a "time-to-build" structure, as in Kydland and Prescott (1982), to capture the delayed effects of technology investment and adoption. This body of work highlights the role of R&D spillover effects in establishing an endogenous link between business cycle fluctuations and long-run growth. For instance, Bianchi et al. (2019) show that the equity financing shocks prominent in the 2001 recession led to a more persistent and severe growth slowdown than the 2008 financial crisis, as these shocks are more critical to driving R&D investment. In contrast, debt financing shocks, which were more relevant during the 2008 crisis, had a smaller impact on long-term growth through R&D channels.

Finally, our paper also contributes to the HANK literature. Over the last decade, HANK models have become central to macroeconomic modeling, with household heterogeneity playing a crucial role in explaining recent economic phenomena. This includes studies on income and wealth dynamics (e.g., Auclert and Rognlie (2017), Auclert and Rognlie (2018), Bayer et al. (2020)), the effects of heterogeneity on macroeconomic outcomes and shock transmission (e.g., Krueger et al. (2015), Ahn et al. (2018), De Ferra et al. (2020)), and the distributional impact of fiscal and monetary policy (e.g., Kaplan et al. (2018), Gornemann et al. (2016), Auclert (2019), Bayer et al. (2023)). HANK models have also been used to address the forward guidance puzzle in monetary policy (e.g., McKay et al. (2016), Hagedorn et al. (2019)). The literature on the distributional aspects of climate change within HANK models is still emerging. Recent contributions, such as Benmir and Roman (2022) and Känzig (2023), explore how fiscal policy can alleviate the economic burden of carbon policies on the most affected households.

2 Model

Our model framework is a medium-scale heterogeneous agent New Keynesian ("HANK") DSGE model. Following Boehl (2023), households are heterogeneous in their productivity and asset holdings and face uninsurable income risk. On the real side, we add the following additional extensions: (i) We introduce energy as an additional production factor, alongside labor and capital. Energy is a mix of fossil (brown) and renewable (green) energy, produced in separate energy sectors. (ii) Brown and green energy are imperfect substitutes. This ensures that demand for either type does not completely disappear when relative prices change. (iii) There is endogenous technological progress in the green energy sector. Technological progress expands the production possibilities of producing green energy and makes its production more efficient at the aggregate.

We here only present the energy sector and the setup of households, and redirect further details (brown energy sector, consumption goods production, capital accumulation, aggregation) to Appendix A.

2.1 The energy sector

The energy product consits of brown and green energy,

$$E_t = BR_t + GR_t, \tag{1}$$

where E_t is the energy product, BR_t is brown energy and GR_t is green energy. A brown (green) energy producer combines different brown (green) energy inputs from intermediate firms to produce brown (green) energy; the final energy product is sold to goods-producing firms. Prices in the energy sectors are assumed to be perfectly flexible. Assume that q_t^E is the price that the goods producing sector pays for E_t. Furthermore, q_t^{BR} and q_t^{GR} are the prices for brown and green energy inputs that the respective energy producers receive. Due to perfect substitutability between BR_t and GR_t, it holds that

$$q_t^E = (1 + \tau^{BR})q_t^{BR} = (1 + \tau_t^{GR})q_t^{GR}, \tag{2}$$

where q_t^E is the sales price for energy and q_t^{BR} and q_t^{GR} are prices for brown and green energy (divided by the aggregate price index P_t), respectively. τ_t^{BR} and τ_t^{GR} are taxes (if positive) or subsidies (if negative) payed (or received) by the energy producers.

The green energy sector is presetend below while the brown energy sector, which shares most features with the green energy sector, is delegated to Appendix A.

2.2 The green energy sub-sector

The key difference between the two sectors is that green energy is produced with a number of inputs of measure A_t^m, which can vary over time. whereas the number of inputs in the brown energy sector is normalized to unity. The representative green producer thus combines green inputs of measure A_t^m

$$GR_t = \left(\int_0^{A_t^m} GR_{jt}^{\frac{\varepsilon-1}{\varepsilon}} \, dj \right)^{\frac{\varepsilon}{\varepsilon-1}} \tag{3}$$

with $\varepsilon > 1$. The variable A_t^m is endogenous and can be interpreted as the stock of different types of green inputs. The demand function for GR_{jt} is given by

$$GR_{jt} = \left(\frac{q_{jt}^{GR}}{q_t^{GR}} \right)^{-\varepsilon} GR_t, \tag{4}$$

where q_{jt}^{GR} is the price of green input j. The aggregate price of green energy is

$$q_t^{GR} = \left(\int_0^{A_t^m} \left(q_{jt}^{GR} \right)^{1-\varepsilon} dj \right)^{\frac{1}{1-\varepsilon}}. \tag{5}$$

Each green input is produced by one firm who rents capital at real rate r_t^k to produce its variety according to a Cobb-Douglas technology

$$GR_{jt} = A_t^{GR} \left(K_{jt}^{GR} \right)^{\alpha_{GR}} \tag{6}$$

with $\alpha_{GR} < 1$. The profit-maximizing price q_{jt}^{GR} is

$$q_{jt}^{GR} = \frac{\varepsilon}{\varepsilon - 1} \frac{r_t^k}{\alpha_{GR} A_t^{GR} \left(K_{jt}^{GR} \right)^{\alpha_{GR}-1}}. \tag{7}$$

Once again, symmetry across green input firms implies that $K_t^{GR} = \int_0^{A_t^m} K_{jt}^{GR} dj = A_t^m \overline{K}_t^{GR}$, where $\overline{K}_t^{GR}$ is the average green capital. Hence, using Eq. (3), the aggregate production function is

$$GR_t = A_t^{GR} \left(A_t^m \right)^{\frac{\varepsilon}{\varepsilon-1} - \alpha_{GR}} \left(K_t^{GR} \right)^{\alpha_{GR}}, \tag{8}$$

with $\frac{\varepsilon}{\varepsilon-1} - \alpha_{GR} > 0$. The variable A_t^m serves as a scaling factor for aggregate production. Each firm operates under a production technology characterized by decreasing marginal productivity. Consequently, a market with more firms, or equivalently, a higher value of A_t^m, has a higher level of productivity. This is because production resources are allocated more efficiently across firms under decreasing marginal productivity. In essence, a larger market for green inputs enhances aggregate productivity within the green energy sector. Finally, the price for green energy is given by

$$q_t^{GR} = \frac{\varepsilon}{\varepsilon - 1} \frac{r_t^{GR}}{\alpha_{GR} A_t^{GR} \left(A_t^m \right)^{\frac{\varepsilon}{\varepsilon-1} - \alpha_{GR}} \left(K_t^{GR} \right)^{\alpha_{GR}-1}}. \tag{9}$$

2.3 The green R&D sector

The green R&D sector is based on Comin and Gertler (2006) and Anzoategui et al. (2019). We assume that innovation expands the set of green inputs for producing the final green energy product GR_t. Since each firm produces one intermediate green product, innovation effectively increases the number of firms in the green sector. The process of innovation works as follows: innovators allocate resources to research and development (R&D) to develop technologies for new green intermediates. Assuming perfect competition, innovators then sell the rights to produce these products to firms within the green energy sector.

Following Comin and Gertler (2006), innovators conduct R&D by using an amount of S_t final good as input into developing new products, with the production function $\xi_t S_t$. New innovations are sold in the next period. Given that the innovation survives until the next period, the innovator receives price J_{t+1}. Hence, the representative innovator receives profits

$$\Pi_t^I = -S_t + \beta \phi_m E_t \left\{ \frac{\pi_{t+1}}{R_t} J_{t+1} \right\} \xi_t S_t, \tag{10}$$

where ϕ_m is the survival rate of the new innovation. Given perfect competition and free entry, the innovator's zero profit condition is

$$\frac{1}{\xi_t} = \beta \phi^m E_t \left\{ \frac{\pi_{t+1}}{R_t} J_{t+1} \right\}. \tag{11}$$

The price for the new product J_t is equal to the value of successfully bringing the new green intermediate into use, ie the present value of profits to the green firm j is

$$J_t = \Pi_{jt}^{GR} + \beta \phi^m E_t \left\{ \frac{\pi_{t+1}}{R_t} J_{t+1} \right\}, \tag{12}$$

where $\beta \phi^m E_t \left\{ \frac{\pi_{t+1}}{R_t} J_{t+1} \right\}$ represents the discounted future stream of profits, provided that the technology has not become obsolete with probability ϕ^m. In the aggregate, the total stock of innovations is given by

$$A_{t+1}^m = \xi_t S_t + \phi^m A_t^m, \tag{13}$$

and we assume that the conversion probability ξ_t is endogenous,

$$\xi_t = z_{R\&D} \left(\frac{A_t^m}{S_t} \right)^{\varepsilon^m}, \tag{14}$$

where $z_{R\&D}$ can be seen as a conversion productivity. As in Comin and Gertler (2006), there is a positive spillover effect from the aggregate stock of technologies A_t^m. But these spillovers might be dampened from congestion effects, S_t.

2.4 Households

Households, indexed by i, hold liquid bonds b_{it}, face idiosyncratic labor income risk e_{it} and a borrowing constraint on bond holdings. They wish to accumulate net worth for the purpose of consumption smoothing and to insure against the associated idiosyncratic income risk. They have Greenwood et al. (1988, GHH) preferences over the composite good x_{it}, and their Bellman equation is given by

$$V_t(e_{it}, b_{it-1}) = \max_{c_{it}, n_{it}, b_{it}} \left\{ \frac{x_{it}^{1-\sigma_c}}{1-\sigma_c} + \beta \mathbb{E}_t \left[V_{t+1}(e_{i,t+1}, b_{it}) | e \right] \right\}, \tag{15}$$

$$x_{it} = c_{it} - e_{it} \frac{n_{it}^{1+\sigma_l}}{1+\sigma_l}, \tag{16}$$

$$c_{it} + b_{it} = \frac{R_{t-1}}{\pi_t} b_{i,t-1} + w_t e_{it} n_{it} + \Pi_t \bar{\Pi}(e_{it}) - \tau_t \bar{\tau}(e_{it}), \tag{17}$$

$$b_{it} \geq \bar{b}, \tag{18}$$

where n_{it} denotes household i's supplied labor and c_{it} their consumption. i's household-specific productivity follows an AR(1) process in logs,

$$\log e_{it} = \rho_e \log e_{i,t-1} + \epsilon_{it}^e, \tag{19}$$

and $\bar{\tau}(e)$ and $\bar{\Pi}(e)$ are skill-specific incidence rules for taxes, dividends, and bank profits. For simplicity we assume that $\bar{b} = 0$ and households cannot accumulate any debt.

Due to GHH preferences, labor supply simplifies to

$$n_t^{\sigma_l} = w_t, \tag{20}$$

and markets clear with

$$\int_0^\infty c_{it} dj = C_t, \tag{21}$$

$$\int_0^\infty b_{it} dj = B. \tag{22}$$

2.5 Calibration and model solution

Table 1 presents our baseline calibration. Whereever possible, we use parameters that are standard in the literature. The value of α_y corresponds with the estimate of Boehl and Strobel (2024) whereas α_E reflects an average over the values reported in Kotlikoff et al. (2024). Our value of ρ_τ implies a smooth but relative quick transition to the new tax level. The number for ε^m is taken from Comin and Gertler (2006). The two values for σ_e and ρ_e are standard values to reflect empirical estimates of income risk (Auclert et al., 2021; Boehl, 2023) while the bond supply is chosen to match a realisic real rate. The presented nonlinear simulations of our medium-scale heterogeneous agent model are done using the EP toolbox, which implements the solution method of Boehl (2023).[2] To allow for nonlinear transition dynamics between two steady states which are relatively far apart, we extend the suggested solution method by a relaxation scheme for Newton's method.

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[2] The toolbox can be found at https://econpizza.readthedocs.io.

Parameter		Value/Target
	Real side	
ζ	Calvo probability	2/3
ε	elasticity of substitution	6
π	inflation target	2% p.a.
ϕ_π	policy rule inflation sensitivity	1.5
δ	capital depreciation rate	0.025
z	level of technology	normalize $y = 1$
α_y	capital share of final goods	0.2
α_E	energy share of final goods	0.1
	Energy subsectors	
ρ_τ	persistence of energy taxes	0.8
A_{BR}	productivity of brown energy production	1
A_{GR}	productivity of green energy production	match $\frac{BR}{E} = 2/3$
$zR\&D$	R&D conversion productivity	normalize $A_t^m = 1$
ε^m	R&D spillovers	0.8
	HANK	
σ_c	intertemporal elasticity of substitution	1.5
σ_l	intertemporal elasticity of substitution	3
β	discount factor	0.985
$\bar{a}$	borrowing constraint	0
σ_e	standard error of earnings	0.6
ρ_e	autocorrelation of earnings	0.966
b	bond supply	15
n_e	points for Markov chain of e	5
n_d	points for asset grid	500

Table 1: Model parameters.

3 Carbon Tax vs. Green Subsidy

This section presents our central results: the welfare and intergenerational aspects of a transition towards a lower carbon footprint. We analyse the dynamics associated with our two main policies – a carbon tax and a green subsidy – with regard to their effect on the current distribution of wealth, and on the question which policy a future generation would prefer. First, we examine the macroeconomic transition dynamics induced by each policy, followed by a discussion of the welfare implications across wealth distributions and generations.

3.1 Transition towards lower carbon emission

To compare the two policies, we target a 50% reduction in brown energy, representing a halving of carbon emissions. Achieving this with a carbon tax requires a tax rate of $\tau^{BR} = 74\%$, while the green subsidy needs to be set at $\tau^{GR} = -32.7\%$. Figure 1 illustrates the new steady states and the transition dynamics for each policy. The blue and orange dashed lines represent the steady states under the carbon tax and green subsidy, respectively, while the dotted line marks the pre-reform steady state.

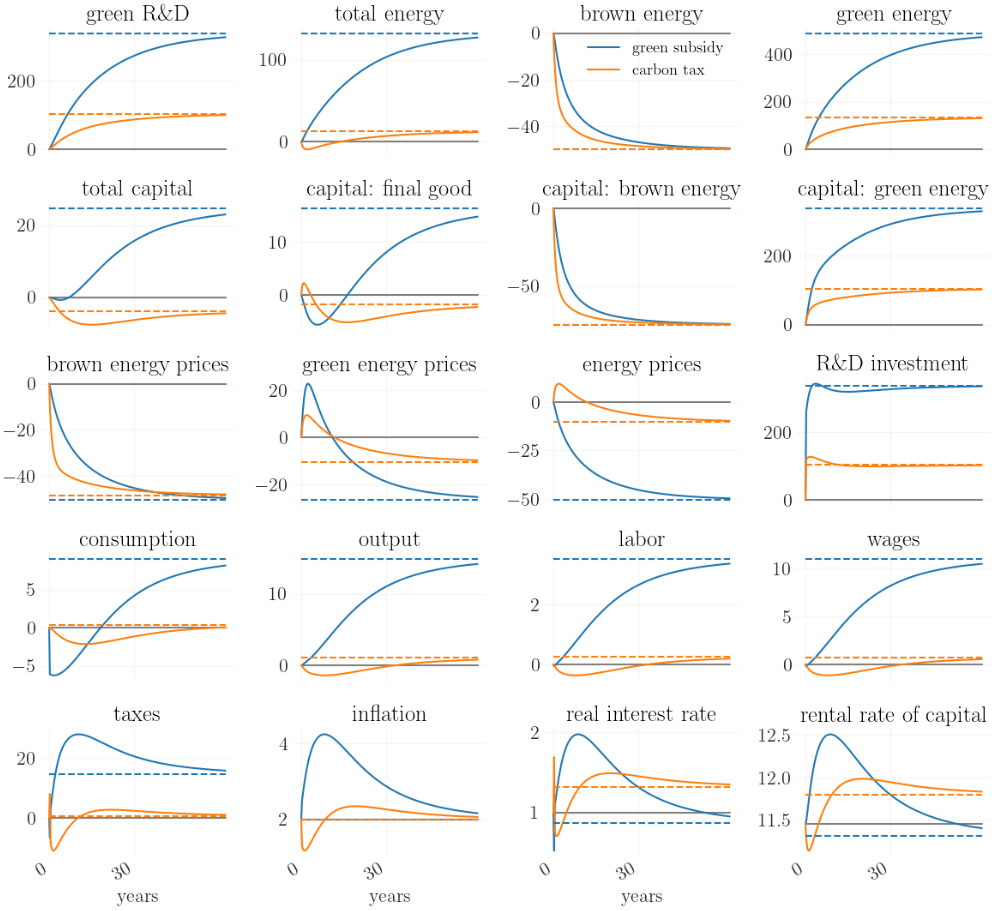

Figure 1: Transition dynamics towards a 50% reduction in brown energy via a carbon tax (blue) and a green subsidy (orange). All values are given in percentage deviation from the pre-reform state. Interest and inflation rates are given in absolute annualized percentages. The dashed lines mark the new steady states associated with each policy.

A central finding is that a subsidy fortifies R&D spending by increasing the profits of green energy producers: the subsidy reduces the relative price of green energy producers, thereby attracting higher demand. Since green energy producers still receive the full price, the prospect of future profits incentivises them to invest into R%D. This more than triples green R&D (double relative to a carbon tax) and thereby, in the long run, raises the productivity of the green energy production technology. This gives rise to an overall higher level of energy output and a shift from brown towards green capital. As a result, the aggregate capital stock rises together with a slight increase of labor demand which, taken together, lead to a higher level of output. While the larger share of this output increase goes into higher R&D investment, we can also observe a boost in the overall consumption.

In general equilibrium, the subsidy also stimulates aggregate demand. This is significant since HANK models emphasize the role of uninsurable income risk in household spending. Although the higher taxes to fund the subsidy reduce disposable income for poorer households – prompting additional precautionary savings – this effect is outweighed by higher labor demand and wages, which ultimately increase consumption.

Conversely, a carbon tax lowers demand for brown energy without directly stimulating green energy demand. The resulting increase in green energy is primarily a substitution effect. While this also raises future profits for green energy producers, it triggers a smaller increase in R&D compared to the subsidy. Consequently, green energy productivity grows less, and total energy production only marginally exceeds the pre-reform steady state. Therefore, the reduction in carbon emissions via the carbon tax is driven by an overall decrease in production, with slightly higher green energy profits offsetting some of the loss through increased R&D productivity.

In the long run, carbon tax revenues are insufficient to reduce the overall tax burden due to two factors: the decline in brown energy consumption (and hence lower energy prices) reduces revenue, while rising real interest rates – driven by higher capital costs – raise government debt servicing costs. Since labor income remains largely unchanged, aggregate consumption levels barely shift.

The transition period in Figure 1 spans 60 years, covering roughly two generations. In the short run, the subsidy causes a significant drop in consumption as resources are reallocated to R&D and investment in the capital stock, accompanied by an inflation spike and a temporary rise in real interest rates. Over the first 30 years, tax rates increase sharply to fund the subsidy, before productivity gains materialize. In contrast, the carbon tax induces only a modest decline in consumption, mainly due to higher R&D investment. Early carbon tax revenues rise as government debt costs fall, leading to a temporary tax rate reduction. This results in a slight initial dip in inflation, followed by a moderate increase. Green energy prices surge initially, reflecting increased demand.

3.2 Welfare: an intergenerational clash

We next discuss the welfare implications associated with the transition dynamics presented in the previous subsection. Note that this analysis does not account for aggregate uncertainty – that is, changes in the transmission of economic shocks – nor do we include the positive effects of a carbon reduction on well-being and the environment. Figure 2 shows consumption equivalent variations (CEVs) associated with both policy interventions. CEVs express how much current consumption a household would need to be indifferent between living through the tax reform and living in the pre-reform economy. Negative CEVs thus implies that households would be willing to forgo the given amount of consumption in order to avoid the reform. They solve the equation

$$E_0 \sum_{t=0}^{\infty} \beta^t u([1 + \mathfrak{v}(e_{it}, b_{it})]c^*_{it}, n^*_{it}) = E_0 \sum_{t=0}^{\infty} \beta^t u(c_{it}, n_{it}), \tag{23}$$

where $\mathfrak{v}(e_{it}, b_{it})$ is the CEV of a household with skill e_{it} and wealth b_{it} and $\{c^*_{it}, n^*_{it}\}$ is their consumption and labor supply in the pre-reform steady state.

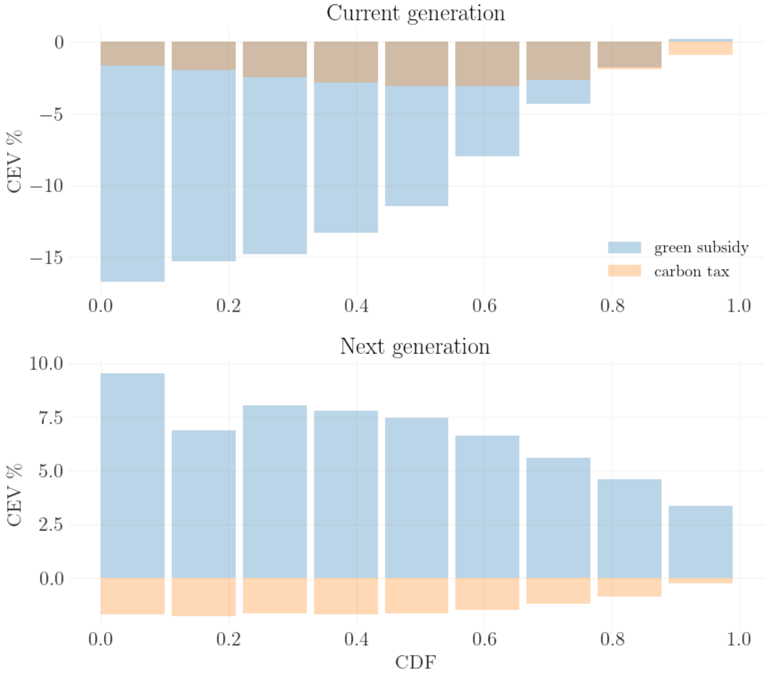

Figure 2: Consumption equivalent variations (CEVs) across the wealth distribution for the current generation (top panel) and the next generation in 30 years (bottom panel) The bottom panel assumes that agents compare CEVs with the counterfactual from the same wealth level without adjusting for transition dynamics.

The top panel of Figure 2 shows the CEVs for the current generation. Apart from the top 10% wealth holders, all agents would strongly oppose either of the two policies. If given the choice between the two, 80% of the agents would prefer the carbon tax over the subsidy. In particular the less wealthy households would be willing to give a large share of their current consumption to avoid a reform towards a green subsidy. The reason is that such reform comes with a large drop in current consumption in combination with larger taxes and, thus, less insurance against idiosyncratic income risk. In addition, households have to work more in order to build up the larger stock of capital while they simultaneously face an increase in prices. Only the very rich would be indifferent to the policy since it comes with the prospects of higher dividends. In contrast, the carbon tax comes with an initial fall in tax level, labor demand and inflation, which almost compensates for the outlook of a slightly lower level of consumption. Overall, the carbon tax also affects most households more equally.

The bottom panel of Figure 2 displays CEVs for the next generation, i.e. households active 30 years (or 120 quarters) after implementing the policy. This draws a very different perspective than before: since in the long run, the subsidy is associated with a higher level of consumption and labor income, households would much prefer the subsidy over the carbon tax, which features a slightly lower level of consumption together with a tax burden comparable to the pre-reform state. This holds in particular for the less wealthy whose main source of income comes from labor rather than wealth or dividends.

It is noteworthy that the bottom panel of Figure 2 contains the simplifying assumption that each households compares their utility to the utility of a household in the *same* wealth group 30 years after the reform, and thus does not account for any transition dynamics between these two states. However, we show that the implications from this figure still hold when fully adjusting for transition dynamics and different wealth levels. Figure 3 shows the development of social welfare for the two policies. We consider two measures of two welfare: the utilitarian welfare measure is the simple mean over the utility of all agents (left scale of the figure), whereas the max-min measure is the utility of least-well-off individual (right scale). Importantly, the utilitarian welfare measure can also interpreted as unconditional welfare under the *veil of ignorance*, i.e. the expected welfare for an individual which does not yet know in which skill/wealth group it will be born.

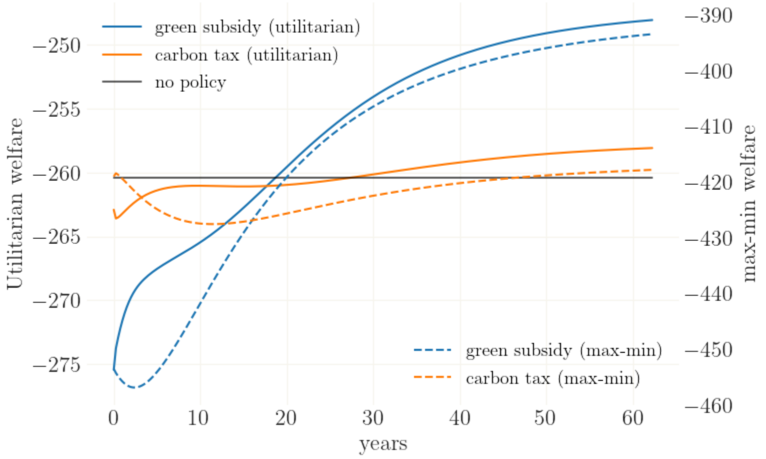

Figure 3: Welfare measures over time for the green subsidy (blue) and carbon tax (orange). We show utilitarian welfare (left scale) and max-min welfare (right scale). Both scales are anchored around the welfare level prevailing without any reform.

In Figure 3 it can be seen that the evaluation of both policies change drastically over time. As before, both reforms impair welfare in the initial period and, as pointed out, this negative effect is much stronger for the green subsidy. However, due to the positive effect of green R&D on productivity, welfare increases for later periods and becomes positive roughly after 20 years. Since the level of green R&D is considerably larger for the green subsidy, any cohort living 20 years from implementation of the policy would prefer the green subsidy over the carbon tax.[3]

4 Conclusion

We show that an intergenerational conflict emerges in the question of whether to achieve a reduction of carbon output via a carbon tax or via a green subsidy. In the short run, households would prefer a carbon tax since it reduces direct taxes and otherwise bears only mildly negative macroeconomic consequences. In contrast, a green subsidy triggers a large but temporal reallocation towards the development of greener production technologies and a larger stock of capital. In the long run however, agents benefit from a larger overall productivity, which reflects in higher wages and an increased labor income.

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[3] It might seem inconsistent that utilitarian welfare of carbon taxes for the next generation is slightly larger than steady state welfare, while *all* CEVs are negative. This effect is due to the pointed out inconsistency in the exercise, which does not account for the fact that the distribution between the two compared states changes.

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Appendix A Model details

Appendix A.1 The brown energy sub-sector

In the brown energy sub-sector, a representative producer aggregates a continuum of brown inputs to produce brown energy

$$BR_t = \left(\int_0^1 BR_{jt}^{\frac{\varepsilon-1}{\varepsilon}} \, dj \right)^{\frac{\varepsilon}{\varepsilon-1}}, \tag{A.1}$$

with elasticity $\varepsilon > 1$. For simplicity we assume that the elasticity in the final goods market and both energy subsector are the same. Profit maximization yields the demand function for input BR_{jt}

$$BR_{jt} = \left(\frac{q_{jt}^{BR}}{q_t^{BR}} \right)^{-\varepsilon} BR_t, \tag{A.2}$$

where q_{jt}^{BR} is the price of brown input j (divided by the aggregate price index). The price of brown energy is

$$q_t^{BR} = \left(\int_0^1 \left(q_{jt}^{BR} \right)^{1-\varepsilon} dj \right)^{\frac{1}{1-\varepsilon}}. \tag{A.3}$$

Inputs are produced by brown intermediate goods firms. Each firm j produces one input, using capital as a production factor.[4] Its production function is a Cobb-Douglas technology:

$$BR_{jt} = A_t^{BR} \left(K_{it}^{BR} \right)^{\alpha_{BR}} \tag{A.4}$$

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[4] For simplicity, we ignore labor as an input because the labor share is relatively low in the production of energy.

with $\alpha_{BR} < 1$. A_t^{BR} is technological level of firm j and K_{jt}^{BR} is its capital. Firm j rents capital at rate r_t^k. Hence, firm j maximizes their profits

$$\Pi_{jt}^{BR} = q_{jt}^{BR} BR_{jt} - r_t^k K_{jt}^{BR} \tag{A.5}$$

subject to demand in Eq. (A.2). This leads to the price-setting condition

$$q_{jt}^{BR} = \frac{\varepsilon}{\varepsilon - 1} \frac{r_t^k}{\alpha_{BR} A_t^{BR} \left(K_{jt}^{BR}\right)^{\alpha_{BR}-1}}. \tag{A.6}$$

Due to symmetry, it holds that $K_t^{BR} = \int_0^1 K_{jt}^{BR} dj$ and, thus, the aggregate production function is

$$BR_t = A_t^{BR} \left(K_t^{BR}\right)^{\alpha_{BR}}. \tag{A.7}$$

Finally, substituting Eq. (A.6) into (A.3) yields the final brown energy price

$$q_t^{BR} = \frac{\varepsilon}{\varepsilon - 1} \frac{r_t^k}{\alpha_{BR} A_t^{BR} \left(K_t^{BR}\right)^{\alpha_{BR}-1}}. \tag{A.8}$$

Appendix A.2 Production of consumption goods

The production of consumer goods takes place in two stages. First, a continuum of intermediate goods firms indexed by j produce heterogeneous output goods using capital, labor and energy. Then, a final good firm bundles the heterogeneous products of intermediate firms into a final output good using the following technology:

$$Y_t = \left(\int_0^1 Y_{jt}^{\frac{\varepsilon_y}{\varepsilon_y - 1}} dj\right)^{\frac{\varepsilon_y - 1}{\varepsilon_y}} \tag{A.9}$$

where ε_y pins down the elasticity of substitution between product varieties Y_{jt}. Demand for Y_{jt} is:

$$Y_{jt} = \left(\frac{P_{jt}}{P_t}\right)^{-\varepsilon_{y,t}} Y_t \tag{A.10}$$

Firms face a Cobb-Douglas production technology using labor, capital and the final energy product as inputs:

$$Y_{jt} = A_t \left(K_{jt}^Y\right)^{\alpha_y} N_{jt}^{1-\alpha_y-\alpha_E} E_{jt}^{\alpha_E} \tag{A.11}$$

where A_t is productivity in the goods sector. Firms own the capital stock, which evolves as follows:

$$K_{t+1} = I_t + (1 - \delta) K_t. \tag{A.12}$$

They rent capital to the production sector and the brown and green energy sectors:

$$K_t = K_t^Y + K_t^{BR} + K_t^{GR} \tag{A.13}$$

Intermediate firms are subject to Calvo (1983) price-setting frictions. In each period, each firm j faces a probability $1 - \theta$ of being able to choose its profit maximizing price. Firms solve the following profit maximization problem:

$$\max E_t \sum_{s=0}^{\infty} (\beta\theta)^s \Lambda_{t+s} \left(\frac{P^*_{j,t}}{P_{t+s}} - mc_{t+s} \right) Y_{j,t+s} \tag{A.14}$$

subject to the demand function in Eq. (A.10) and production function in Eq. (A.11). mc_t are the firm's marginal costs. Symmetry across firms allows to drop index j.

Appendix A.3 Monetary policy, aggregation and market clearing

Monetary policy follows a Taylor-type interest rate rule:

$$i_t = i + \phi_\pi (\pi_t - \pi) + \phi_y (\ln Y_t - \ln Y_{t-1}) \tag{A.15}$$

where Y_t is aggregate output and i and π are the steady state nominal interest rate and inflation rate, respectively.

We assume that government consumption is financed by raising debt and taxes and the government is running a balanced budget with

$$\tau_t + \tau_t^{BR} + \tau_t^{GR} + \Phi_t = \left(\frac{R^a_{t-1}}{\pi_t} - 1 \right) B + g_t. \tag{A.16}$$

where Φ_t are the profits of all (types of) firms. For bond market-clearing, we require that households hold the government bonds. Plugging this in to the integrated household budget constraint gives the aggregate accounting identity:

$$Y_t = C_t + S_t + I_t + G_t \tag{A.17}$$

Aggregate output is given by:

$$v_t Y_t = A_t \left(K_t^Y \right)^{\alpha_y} N_t^{1-\alpha_y-\alpha_E} E_t^{\alpha_E} \tag{A.18}$$

where $v_t \equiv \int_0^1 \left(\frac{P_{jt}}{P_t} \right)^{-\varepsilon} dj$ is a measure of price dispersion arising due to Calvo price rigidities.