Selfish Incentives for Climate Policy: Empower the Young!

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Abstract: Reduced carbon emissions can improve the climate, raising young people's future income and altering old people's wealth via changes in asset prices. We show that a small level of abatement changes the old and young generations' welfare in the same direction if and only if their elasticities of intertemporal substitution exceed one. Endogenous asset prices can change the sign and magnitude of the generations' selfish incentives to undertake climate policy. Our quantitative model shows that the young generation's concern for future consumption significantly reduces the equilibrium carbon trajectory, but the endogeneity of asset prices has a small effect.

JEL Codes: E24, H23, Q20, Q52, Q54

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THE CONSENSUS THAT FUTURE GENERATIONS are the major beneficiaries of current climate policy emphasizes the importance of intergenerational altruism (Nordhaus 2014b). This perspective largely ignores selfish incentives for this policy, the focus of

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our study. Recent studies indicate that peak global warming occurs within a decade of emissions.[1] Thus, current climate policy might benefit young generations later in their life. Climate policy also alters current income and the future productivity of assets, potentially affecting the asset prices and the wealth of asset owners, who are typically older generations.[2] This study is the first to examine the direction and magnitude of these two selfish incentives to undertake climate policy.

Qualitative analysis identifies when the young and the old generations' incentives are aligned and illustrates the effect of endogenous versus fixed asset prices on these incentives. Our quantitative model then assesses the policy relevance of the two selfish incentives to reduce carbon emissions. We find that the young agent's concern for her future consumption can significantly increase equilibrium abatement. The endogeneity of asset prices might encourage or discourage climate policy but has a small effect; this result is consistent with the mixed evidence on the extent to which markets price in climate risk.[3]

The young generation's influence in setting policy is especially important when the elasticity of intertemporal substitution (EIS) is less than one, as most estimates suggest (Havranek 2015). Surveys find that young people are significantly more concerned about climate change and more accepting of climate policy compared to their elders (Funk 2021). Recent international and national efforts seek to increase the young generation's representation in climate policy.[4] Our results, together with this econometric and survey evidence, show that this empowerment could meaningfully affect climate policy and climate outcomes.

Marshall Plan Foundation for financial support. We owe a particular debt to Thibault Fally for his explanation of the microfoundations of the CET aggregator. Appendix B.2.1 is based largely on course notes that Thibault made available to us.

1. See IPCC (2013, 2021), Ricke and Caldeira (2014), Mattauch et al. (2020), Dietz et al. (2021).

2. A homeowner with no direct interest in a local lake might contribute to cleaning it as a means of improving property values. In general, environmental protection can increase asset owners' wealth (Oates 1972), but the relevance of this idea to climate economics is poorly understood.

3. Empirical evidence shows that environmental outcomes can affect asset prices in real estate (Chay and Greenstone 2005; Bushnell et al. 2013) and portfolios (Bansal et al. 2016), but the extent to which markets price in climate risk is mixed. Severen et al. (2018) find that US land prices incorporate climate forecasts; Schlenker and Taylor (2021) show that weather markets reflect climate model predictions. Bernstein et al. (2019) find that US homes exposed to sea level rise sell for an estimated 7% discount, but Bakkensen and Barrage (2022) estimate that coastal home prices in Rhode Island understate climate risk by 13%. Other evidence suggests that markets underprice climate risk for food stocks (Hong et al. 2019) and stock portfolios (Kumar et al. 2019; Addoum et al. 2023).

4. Among other initiatives: (i) Action for Climate Empowerment ("ACE"), Article 12 Paris Agreement (Kiderlin 2022); (ii) Youth Advisory Group, United Nations, https://www.un.org/en/climatechange/youth-in-action/youth-advisory-group; (iii) US White House, Climate Education

To study the equilibrium effects of the two selfish incentives (endogenous asset prices and young people's concern for their future consumption), we employ a tractable model that departs from mainstream climate models in three essential ways.

First, we use a two-generation overlapping generations (OLG) model instead of the more common infinitely lived agent (ILA) model. This shift enables us to distinguish between current generations' self-interest and their possible altruism toward unborn generations. The two-generation structure also permits a clear distinction between the two types of self-interest: the young generation's concern for its future consumption and the old generation's desire to protect its wealth. The OLG structure overcomes another limitation of the ILA model, where the representative agent cannot simultaneously be both a buyer and seller in the asset market. In our framework, the old generation sells and the young generation buys undepreciated assets, so they have different views on the desirability of higher asset prices.

Second, we replace the commitment equilibrium in which the generations alive today can choose both current and future policies, with a Markov perfect equilibrium to a dynamic game among planners. The commitment equilibrium is time inconsistent, and it is questionable on both ethical and practical grounds. Should current policymakers be allowed to lock in their successors' policies?[5] The practical issues may be even more important. Very long-term commitments may be infeasible, and recent results suggest that short-term commitments have little value in the climate context (Iverson and Karp 2021). In our game, today's planners can choose current but not future policies.

Third, we replace a fixed end-of-period asset price (hereafter "asset price") with endogenous asset prices. To achieve this, we generate a strictly concave production possibility frontier (PPF) by means of a constant elasticity of transformation (CET) between investment and consumption goods. The CET PPF model is widely used in the CGE literature and has microfoundations in the trade literature (Constinot et al. 2020). The model collapses to the pure endowment economy or the standard composite commodity model as special cases.[6]

Endogenous asset prices introduce a mechanism, absent in most integrated assessment models (IAMs), through which abatement measures can affect the two selfish

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and Literacy Initiative. Simulations in Yang and Suh (2021) illustrate how policy consistent with the Paris Agreement benefits most younger generations and leaves older generations worse off.

5. Thomas Paine (1791) answered this ethical question thus: "The vanity and presumption of governing beyond the grave is the most ridiculous and insolent of all tyrannies. Man has no property in man; neither has any generation a property in the generations which are to follow."

6. We follow mainstream IAMs in representing capital as a single aggregate. As in these models, the return to capital within a period is endogenous, so the beginning-of-period price of capital is endogenous. However, in these models the end-of-period price of capital is fixed (by choice of units) at the price of the numeraire. By replacing the linear with a strictly concave PPF we make the price of investment, and thus, the end-of-period price of the asset endogenous.

incentives for climate policy. In our model, as in most IAMs, abatement measures compel industries to adopt cleaner but more expensive production methods, reducing world income and the current return of capital. This cost effect causes an inward shift of the production possibility frontier that necessarily leads to lower income and consumption for the old agent. Consequently, the selfish old agent always opposes climate policy in this setting. However, in our model, abatement has an additional general equilibrium effect on asset prices, resulting in a movement along the PPF. This effect is absent in most IAMs, where the asset price is fixed at the price of the numeraire consumption good (Golosov et al. 2014; Nordhaus 2014a). If abatement increases the endogenous asset price (as can occur in our model), the increase in the old agent's wealth offsets the reduction in her income. In this case, endogenous asset prices weaken or even overturn the old agent's selfish incentives to oppose climate policy. Similarly, the young agent may benefit from the abatement-induced increase in future productivity, even if it lowers the current wage and raises the price of the investment good. Thus, both agents might benefit from climate policy when the asset price is endogenous.

To study the general equilibrium effect of endogenous asset prices on incentives to abate (a movement along the PPF) we adopt the standard assumption that the marginal cost of the first unit of abatement is zero, thus shutting down the first-order cost effect of abatement (the inward shift of the PPF). Abatement triggers income and substitution effects, whose net impact on the young agent's savings decisions determines the direction of the general equilibrium effect on the asset price. The increase in the young agent's lifetime welfare due to a more productive next-period environment increases her demand for consumption while young, and therefore reduces her demand for savings (income effect). The higher opportunity cost of current consumption, due to more productive next-period capital, increases her demand for savings (substitution effect). These effects cancel each other when $\text{EIS} = 1$.

We find that the two generations' selfish incentives for (small) climate policy are aligned if and only if the substitution effect dominates, $\text{EIS} > 1$. Here, abatement boosts the young generation's demand for savings, driving up the asset price and benefiting the old generation by raising their wealth. The higher next-period consumption more than compensates the young agent for their lower current consumption, so the two generations' interests are aligned. However, for the widely accepted estimate $\text{EIS} < 1$, the two generations' incentives are not aligned; the young generation's strong representation in setting climate policy then becomes critical to achieving meaningful (selfishly motivated) abatement. Limiting cases show how the endogeneity of asset prices affects the current generations' incentive to undertake policy.

1. LITERATURE REVIEW

We contribute to models with an endogenous asset price, climate applications of OLG models, dynamic policy games without commitment, and other related literature.

We follow the mainstream literature and adopt a model with a single privately owned asset, instead of computable general equilibrium (CGE) models (McKibbin and Wilcoxen 2013) with thousands of equations and sector-specific endogenous prices for capital. Our CET PPF framework is more tractable than GE models á la Heckscher-Ohlin-Samuelson and Ricardo-Viner (which also give rise to a strictly concave PPF) and avoids their confounding complication of making the relative factor prices depend on policy and climate. In addition, it provides a way of generating endogenous asset prices that does not rely on convex adjustment costs (Lucas and Prescott 1971). The plausibility of this type of adjustment cost is questionable in our setting, in which each period spans half a lifetime; it may be reasonable in models with a shorter time step, as in Pindyck and Wang (2013) and van den Bremer and van der Ploeg (2021). These two papers focus on risk and uncertainty, which is not central to our research question,[7] and do not include the other important features of our model: overlapping generations and lack of commitment.

Our theoretical framework relates to the literature that uses OLG models with endogenous asset levels and prices, for example, Chamley and Wright (1987) and Abel (2003).[8] These papers address different questions, use alternative approaches to generate endogenous asset prices, and feature exogenous policy, so the question of commitment does not arise.

A growing literature uses OLG models to study environmental problems.[9] Bovenberg and Heijdra (1998) show that a policymaker who can commit to future environmental

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7. Most climate applications of risk and uncertainty, e.g., Jensen and Traeger (2014) and Cai and Lontzek (2019), involve optimization or simulation, not game-theoretic settings. Introducing uncertainty, although numerically feasible (but by no means trivial), is unlikely to qualitatively change generations' selfish incentives concerning climate policy. To complicate matters, there are many different parameters that we are uncertain about (e.g., climate sensitivity, technological growth) and different ways of thinking about risk (e.g., recursive preferences, ambiguity aversion). It is not obvious which would be the most valuable to include in a model designed to explore selfish incentives for climate policy.

8. Chamley and Wright (1987) study fiscal incidence in a model with two productive assets, a fixed stock of land and a nondepreciating capital stock that grows as a result of endogenous investment. The changing capital stock renders the price of land endogenous. We have a depreciating capital asset and a second stock variable, cumulative emissions, which affects the price of capital. Abel (2003) studies the effect of demographic and technology changes on the price of capital in a model with adjustment costs. Other papers, beginning with Huffman (1985), use OLG models to study asset pricing. The transmission of efficiency gains through asset price changes is important in, for example, public financing of education (Poutvaara 2003) and public pension reform (Koethenbuerger and Poutvaara 2006). Glover et al. (2020) study the welfare implications across generations of aggregate total factor productivity (TFP) shocks, dissecting their effects on incomes and asset prices.

9. Prominent contributions include Howarth and Norgaard (1992), John and Pecchenino (1994), Gerlagh and Keyzer (2001), Schneider et al. (2012), Karp and Rezai (2014), Williams et al. (2015), and Karp (2017). Appendix B.8 provides further discussion.

and fiscal policy can use debt and taxes to make intergenerational transfers, ensuring that all generations benefit from environmental improvements. Anderson et al. (2020) and Kotlikoff et al. (2021) quantify these welfare gains in the climate setting. Anderson et al. (2020) show that debt and a distortionary labor tax can finance a sequence of abatement rates. Kotlikoff et al. (2021) find that an increasing carbon tax achieves a 0.73% uniform welfare increase over business as usual (BAU). These two papers assume policy commitment and have a fixed asset price; they seek to quantify the possibility of Pareto improvements.[10] We study a dynamic game with an endogenous asset price in order to study the role of selfish incentives to undertake climate policy.

Our numerical model has many of the features found in IAMs, including exogenous growth in population and technology. The depreciation factor for capital allows for both physical depreciation and the fact that technological change renders old capital less productive than new capital. We also incorporate the evidence of the rapid response in temperature to emissions. The single-asset model cannot distinguish among stranded and other asset classes (van der Ploeg and Rezai 2020). Stranded assets are important to their owners, but society as a whole is more concerned about the effect of climate policy on assets writ large, not just a narrow class of assets. In addition, the value of a narrow asset class might fluctuate because of changes in technology or geopolitics, or other reasons unrelated to the climate.[11]

Many papers use dynamic games to study public policy. We follow the bulk of the literature in assuming that the equilibrium is Markov perfect.[12] Hassler et al. (2003) and Conde-Ruiz and Galasso (2005) provide early applications of this type of game for the provision of public goods: the Earth's capacity to absorb carbon emissions in our setting.

2. THE MODEL

We describe the young agent's savings decision, discuss the assumed technology, and then introduce preferences and define the decentralized equilibrium. Appendix B.1 (apps. A–C are available online) contains a flow diagram summarizing the model, and appendix A collects all derivations and proofs.

2.1. Agents' Utility and Savings

A cohort of constant size, $L \equiv 1$, is born in each period. Section 4 introduces changes in both technology and population. Agents live two periods. The young agent's welfare

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10. See app. B.7 for further discussion of these papers.

11. For example, fossil fuel companies ("energy"), the common example of stranded assets, were worth \$5 trillion and composed 16% of the S&P 500's index in 2014; in 2020, energy was the smallest sector in this index, at less than 2% (Bullard 2020).

12. In line with a well-known folk theorem, Rangel (2003) shows that trigger strategies can support intergenerational transfers as a subgame perfect equilibrium. Markov perfect equilibria exclude trigger strategies.

in period t equals their discounted sum of utility, $U(\cdot)$, derived from consumption while young, c^y, and old, $c^o : U(c_t^y) + \rho \ U(c_{t+1}^o)$, with ρ the utility discount factor. The old agent's (remaining) welfare at t is $U(c_t^o)$. Utility, $U(\cdot)$, satisfies the Inada conditions. The young agent receives labor income, w_t, but no inheritance and spends c_t^y on consumption, the numeraire good. The depreciation rate δ, accounts for both physical depreciation and technological change that renders old capital less productive than new capital. With this understanding, the capital remaining at the end of period t, $(1-\delta)K_t$, and newly produced capital, I_t, are equally productive; therefore, in equilibrium they have the same price, p_t. Goods and undepreciated capital are sold at the end of the period; there is no discounting within a period.

The young agent saves $p_t[s_t(1-\delta)K_t + I_t]$, buying s_t shares of the old capital stock and I_t units of new capital. In equilibrium the demand and the (predetermined) supply of undepreciated capital are equal ($s_t = 1$), so the savings decision identifies the demand for new capital. The rental rate on capital is r_t. When old in period $t+1$, the agent earns the factor payment $r_{t+1}(s_t(1-\delta)K_t + I_t)$ and obtains revenue from selling the end-of-period stock, $p_{t+1}(1-\delta)(s_t(1-\delta)K_t + I_t)$. Agents are selfish, so the old agent consumes all her income. Agents take prices, w_t, r_t, and p_t, as given and have rational point expectations of r_{t+1} and p_{t+1}.

We denote the last period as time T and the first period as $t = 0$. At $t = T$, savings, production of the investment good, and the price of undepreciated capital are all zero because there is no future. The young agent's maximization problem at $t < T$ is[13]

$$\begin{aligned} \max_{\{I_t,\, s_t,\, c_t^y,\, c_{t+1}^o\}} \quad & U(c_t^y) + \rho \ U(c_{t+1}^o) \\ \text{s.t.} \quad & c_t^y \le w_t - p_t(s_t(1-\delta)K_t + I_t) \\ & c_{t+1}^o \le (r_{t+1} + p_{t+1}(1-\delta))(s_t(1-\delta)K_t + I_t). \end{aligned} \tag{1}$$

Using the definition of the marginal rate of intertemporal substitution, $\psi_t \equiv U'(c_t^y)/\rho U'(c_{t+1}^o)$, we can write the young agent's savings condition (the Euler equation) as:

$$\psi_t = \frac{r_{t+1} + p_{t+1}(1-\delta)}{p_t} \Rightarrow \tag{2a}$$

13. The objective function is concave and the constraint set convex, so the optimization problem has a unique solution. The young agent chooses both its purchase of undepreciated capital, $s_t(1-\delta)K_t$, and new capital, I_t, so both of these are choice variables. An interior solution requires that in equilibrium the agent is indifferent between these two means of savings. This indifference makes the first-order conditions for s_t and I_t identical. The equilibrium requirement that supply equal demand ($s_t = 1$) removes the (apparent) indeterminacy. An alternate (equivalent) way of solving this problem has the agent choosing only aggregate savings and then uses the equilibrium condition $s_t = 1$ to determine purchases of new capital.

$$c_{t+1}^o = \psi_t(w_t - c_t^y). \quad (2b)$$

The first-order condition for savings, equation (2a), states that the marginal rates of intertemporal substitution and transformation are equal. The right side of this equality equals the number of consumption units a young agent obtains in the next period by reducing consumption by 1 unit today and investing instead. This ratio equals the marginal rate of intertemporal substitution, ψ_t, which equals 1 plus the endogenous interest rate between period t and $t + 1$. Equation (2b) uses equation (2a) and the constraints in the young agent's maximization problem; the agent takes the endogenous value of the right side of equation (2a) as given. The young agent receives this rate on each unit of savings, $w_t - c_t^y$ (income minus consumption). Rearranging equation (2a) yields the asset price equation for $t < T$:

$$p_t = \frac{r_{t+1} + p_{t+1}(1 - \delta)}{\psi_t}. \quad (3)$$

2.2. Technology

In most IAMs, the PPF in the consumption-investment plane (C, I) is a line. By choice of units, the asset price is fixed at 1, the price of the numeraire consumption good. Here, climate policy can affect the location of the PPF and level of investment but not the asset price.

We generalize the standard IAM to produce a model with a strictly concave production possibility frontier, where the price of the investment good is endogenous. The production possibility set for the consumption good $C_t = c_t^o + c_t^y$ and the investment good I_t depends on inputs and policy, $\mathbf{z}_t = (K_t, L, E_t, \mu_t)$: K_t is the stock of capital, L is the labor supply (normalized to 1), E_t is the stock of atmospheric carbon in excess of preindustrial levels ("Excess carbon"), and $\mu_t \in [0, 1]$ is the abatement rate. The state variables, K_t and E_t, change endogenously, and the abatement rate is the policy variable. We often suppress time subscripts.

In the standard model, output is a composite commodity that can be converted between the consumption and the investment good at a 1∶1 rate by choice of units. We denote this composite commodity as $G(\mathbf{z})$, a model primitive. We adopt:

> **Assumption 1:** (i) $G(\mathbf{z})$ is increasing and concave in K, L; it is decreasing in (E, μ), concave in μ and concave in E for small E, and it is twice continuously differentiable in $\mathbf{z}$. (ii) The marginal cost of the first unit of abatement is zero: $\partial G/\partial \mu|_{\mu=0} = 0$. (iii) ("DICE") $G = D(E)\Lambda(\mu)L^{\beta}K^{1-\beta}$.

Parts i and ii are standard. Part iii, taken from DICE07 (Nordhaus 2008), assumes that G is multiplicatively separable. The Cobb-Douglas function $L^{\beta}K^{1-\beta}$ equals the level of G absent climate-related damages or abatement costs; $D(E)$, a decreasing and (for small E) concave function, is the fraction of this output remaining after accounting for climate-related damage; $\Lambda(\mu)$, a decreasing concave function, is the fraction of output remaining after accounting for abatement costs. We use part ii for the comparative static analysis and part iii to consider special cases and for numerical analysis.

To obtain a concave PPF we embed G in a constant elasticity of transformation (CET) function with elasticity of transformation $\infty \geq \sigma \geq 0$ and shape parameter a. (Section 2.2.1 discusses three interpretations of this model.) Production of C and I satisfies

$$C^{\frac{1+\sigma}{\sigma}} + aI^{\frac{1+\sigma}{\sigma}} = (1 + a^{-\sigma})^{-\frac{1}{\sigma}} G(\mathbf{z})^{\frac{1+\sigma}{\sigma}}. \quad (4)$$

Equation (4) gives C as an implicit function of I, and thus is an implicit formula for the PPF. Under assumption 1.i, an increase in capital, K, or labor, L, or a decrease in abatement, μ, or the stock of pollution, E, all increase G, thereby causing a radial expansion of the PPF.

The parameter σ determines the curvature of the PPF, with larger values producing a flatter curve. In the limit as $\sigma \to \infty$, our PPF corresponds to the standard linear PPF with slope −1, where the asset price is fixed at 1 by the choice of units. We therefore refer to the case $\sigma = \infty$ as corresponding to exogenous asset prices. We choose the coefficient of G on the right side of equation (4), a function of (σ, a), so that as we increase σ (holding everything else constant) the family of increasingly flat PPFs are tangent at a point where their slope equals (negative) 1, the price of the investment good in the standard setting. The parameter a determines the consumption/investment ratio at this tangency point (fig. 1 and app. A.2).

Given $(p, \mathbf{z})$, world income in a competitive equilibrium, $N(p; \mathbf{z})$, is

$$N(p; \mathbf{z}) = \max_{C,I} C + pI \text{ s.t. equation } (4). \quad (5)$$

Our choice of the coefficient of $G(\mathbf{z})$ on the right side of equation (4) (described in the previous paragraph) implies that $N(1; \mathbf{z}) = G(\mathbf{z})$, for all σ.

Although (σ, a) have a precise technical definition, it is not straightforward to calibrate them. Therefore, both in discussing and calibrating the model, we use the parameters (κ, S), monotonic transformations of (σ, a): S is the aggregate equilibrium investment as a share of output, and κ is the elasticity of investment supply with respect to the price of investment; both of these are evaluated at $p = 1$.[14] A larger elasticity of supply, κ, corresponds to a larger elasticity of substitution and a flatter PPF.

Figure 1 illustrates the PPF for three values of the elasticity of investment supply, κ, holding fixed the investment share of output at $S = 0.243$. (Again, both the elasticity and the share are evaluated at $p = 1$.) The figure shows that for all κ (equivalently, for all σ), the PPFs intersect at the same point, where their slope is −1; there, the ratio of the consumption to the investment good is $S = 0.243$. For $\kappa = 0.01$ the PPF is

14. Given (σ, a), we have $(1 - S)/S = a^{\sigma}$ and $\kappa = \sigma(1 - S)$.

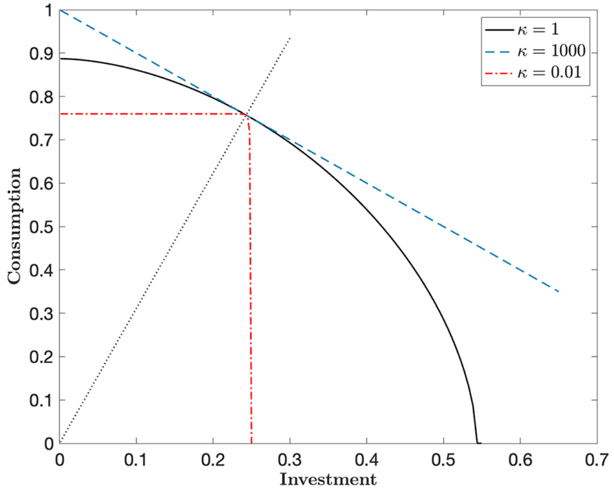

Figure 1. Production possibility frontiers (PPFs) for three elasticities of investment supply, κ, at $p = 1$: smooth ($\kappa = 1$), approximately linear ($\kappa = 1{,}000$), and approximately Leontieff ($\kappa = 0.01$). Investment as a share of output is calibrated to equal 0.243 at $p = 1$.

indistinguishable from the Leontieff (or pure endowment) economy; for $\kappa = 1$ it has a familiar curved shape; and for $\kappa = 1{,}000$ the PPF is almost indistinguishable from the standard straight-line composite commodity model. As noted above, an increase in capital or labor or a decrease in excess carbon or the abatement rate cause a radial expansion of the PPF, preserving the tangency at $p = -1$ on the upward sloping dotted line in the figure.

2.2.1. Interpretations of the CET PPF

We present three interpretations of the CET. Our results do not depend on which one the reader adopts. A neutral interpretation regards the CET function merely as a tractable means of distributing the economy's productive potential over two outputs. Powell and Gruen (1968) introduced this idea to model a joint-product representative firm owning a stock of land that can be used to grow two or more crops. This modeling device is now routinely used in computable general equilibrium models (van der Mensbrugghe and Peters 2020), often to represent output in the agricultural sector when the stock of land is given. Instead of a joint-product firm (sector) producing different crops, we have a joint-product economy producing different goods, the consumption and the investment good. Instead of a fixed supply of a factor such as land, we have an endogenously changing "productive asset" $G(\mathbf{z}_t)$ (fixed during a period) used in both sectors. In using the CET function to represent a strictly concave PPF we follow a large body of literature that applies this idea at the sectoral level.

The second interpretation rests on a growing body of trade theory that builds on the Roy (1951) model to provide microfoundations for the CET PPF (Constinot et al. 2020; Bergquist et al. 2022). In this setting, a continuum of price-taking agents allocate an asset, for example, land, to produce either the consumption or the investment good. In our setting, the productive asset is $G(\mathbf{z_t})$. An agent's production is linear in this asset, but her output per unit of the asset is a random variable with a Frechet distribution. These random variables are independent across agents and sectors. Aggregate output in a competitive equilibrium in this economy is isomorphic to output in the representative agent model with a CET PPF.

The third interpretation views the CET PPF as a model of adjustment costs arising from the change in the ratio of production of the two goods, not a change in their levels (as is more standard). For example, suppose that some firms operate in the consumption good sector and others in the investment good sector. If all firms' productive asset increases proportionally but there is no reassignment of firms, production moves outward on a ray through the origin to a higher PPF. In this case, there are no adjustment costs. However, if there is a change in p, then adjustment costs arise as some firms switch sectors. These costs are associated with a change in the mix of outputs, not with a change in their levels.

The trade motivation may be unfamiliar to our readers, and the adjustment cost motivation is nonstandard. Since our results do not hinge on any particular interpretation of this model, we discuss both of these microfoundations for the CET PPF in appendix B.2.

2.2.2. Some Building Blocks

This section shows how the real returns to labor and capital, w, r, depend on the asset price, p_t, and on $\mathbf{z_t}$ (the levels of abatement, excess carbon, and factor supplies). Here we take p_t and μ_t as given; section 4 explains how these endogenous objects are determined. We also explain that with endogenous asset prices, a change in abatement creates both the familiar "cost effect" and a novel "general equilibrium" effect. Finally, we explain why relative factor prices are invariant to the level of abatement and the stock of carbon.

Using the first-order condition to equation (5) and firms' optimality conditions for the choice of inputs, we obtain expressions for the real factor returns and investment supply as functions of p_t and $\mathbf{z_t}$. Although essential to our analytic and numerical results, these formulae contain little insight. Here we report the following three comparative static results, relegating other details to appendices A.1 and A.2:

$$\frac{\partial N}{\partial p} = I > 0,\ \frac{\partial w}{\partial p} = \frac{wp^{\sigma}}{a^{\sigma} + p^{1+\sigma}} > 0 \text{ and } \frac{\partial r}{\partial p} = \frac{rp^{\sigma}}{a^{\sigma} + p^{1+\sigma}} > 0. \tag{6}$$

An increase in p draws factors of production from the consumption good sector, increasing output in the investment good sector and increasing factors' value of marginal product (price times marginal product) there. With the consumption good as the numeraire, the higher w and r represent higher real returns to both factors.

Abatement, μ, has two types of equilibrium effects. The standard "cost effect" arises because abatement forces the economy to use less polluting, more expensive production methods, reducing $G(z)$ and causing an inward shift of the PPF. A novel "general equilibrium (GE) effect" arises if abatement changes the asset price, thereby altering national income and factor payments. The GE effect manifests as a movement along the PPF.

By assumption 1.ii, the cost effect of the first unit of abatement is zero. Hence, the first-order effect of a small level of abatement equals the GE effect, which is proportional to $\partial p/\partial\mu|_{\mu=0}$. Composite commodity models eliminate the GE effect by fixing $p = 1$, resulting in a zero first-order effect. Appendix A.1 confirms that the CET PPF produces the composite commodity model as $\sigma \rightarrow \infty$, and it produces a pure endowment economy as $\sigma \rightarrow 0$.

Our model captures the two primary mechanisms by which abatement affects asset prices: (i) abatement reduces income, tending to reduce the demand for investment, and (ii) abatement reduces future pollution stocks, increasing the future productivity of capital, tending to increase the demand for investment.

Multiplicative separability (assumption 1.iii) makes the relative factor price, w/r, independent of both current abatement and the stock of pollution, exactly as in most climate models. This invariance eliminates some causal channels between policy and outcomes, but it has several advantages: it isolates the two selfish incentives for climate policy, it brings the model closer to the familiar climate models, and it simplifies interpretation of the results.[15]

2.2.3. The Equations of Motion

The equations of motion for the state variables (E_t, K_t) complete the description of the technology. With zero abatement, business as usual (BAU) emissions are an increasing continuously differentiable function of capital and labor, $\zeta F(K_t, L)$, with $\zeta > 0$ a scaling parameter. With the abatement μ_t, actual emissions equal $(1 - \mu_t)\zeta F(K_t, L)$. Given E_0 and K_0, the transition equations for the stock of atmospheric carbon and capital with constant decay rates δ for capital and ϵ for atmospheric carbon are

$$E_{t+1} = (1 - \epsilon)E_t + (1 - \mu_t)\zeta F(K_t, L), \quad \text{and} \quad K_{t+1} = (1 - \delta)K_t + I_t. \quad (7)$$

2.3. Welfare in a Conditional Equilibrium

Section 4 presents the game that determines climate policy, the sequence of emissions standards, $\{\mu_{t+h}\}_{h=0}^{T-t}$, for $t \in \{0, \dots, T\}$. Here, we take this policy sequence as given

15. Appendix B.3 provides an alternative technology that does not satisfy the invariance property with regard to w/r. This example makes it easier to appreciate the value of assumption 1.iii.

and define the conditional equilibrium under the assumption of positive investment in every period except the last:

> **Definition 1:** Given the sequence $\{\mu_{t+h}\}_{h=0}^{T-t}$ and states E_0 and K_0, a conditional competitive equilibrium at t is a sequence of the carbon and capital stocks and asset prices, $\{E_{t+h}, K_{t+h}, p_{t+h}\}_{h=0}^{T-t}$, satisfying: the asset market equilibrium, equation (3), the transition equations (7), and the factor price conditions reported in appendix A.1.

Given a choice of the single-period utility function and the equilibrium savings implied by equation (2a), we obtain expressions for welfare in a conditional equilibrium. We assume that agents have constant elasticity single-period utility, $U(c) = (c^{1-\eta} - 1)/(1-\eta)$, with $\eta \geq 0$; for $\eta = 1$, $U(c) = \ln c$; η is the elasticity of marginal utility. With this utility function, and given our previous assumption that welfare is the discounted sum of utility, $\eta = 1/\text{EIS}$. Hereafter, we express results using EIS. The old generation's welfare, denoted Ω_t^o, equals its utility while old; the young generation's welfare, denoted Ω_t^y, equals the discounted stream of utility in the current and the next period. Using equilibrium savings, we have the welfare expressions:

> **Remark 1:** For a given climate policy, equilibrium lifetime welfare in period t is Ω_t^y for the young agent and Ω_t^o for the old agent, with

$$\Omega_t^y \equiv U(c_t^y) + \rho \quad U(c_{t+1}^o) = \begin{cases} \dfrac{\text{EIS}}{\text{EIS} - 1}\left((c_t^y)^{-\frac{1}{\text{EIS}}} w_t - (1+\rho)\right) & \text{for EIS} \neq 1 \\ (1+\rho)(\ln w_t - \ln(1+\rho)) & \text{for EIS} = 1, \end{cases} \tag{8}$$

and

$$\Omega_t^o \equiv U(c_t^o) = \begin{cases} \dfrac{\text{EIS}}{\text{EIS} - 1}\left\{[(r_t + (1-\delta)p_t)K_t]^{\frac{\text{EIS}-1}{\text{EIS}}} - 1\right\} & \text{for EIS} \neq 1 \\ \ln[(r_t + (1-\delta)p_t)K_t] & \text{for EIS} = 1. \end{cases} \tag{9}$$

3. WELFARE EFFECTS OF CLIMATE POLICY

Abatement has qualitatively different welfare effects under fixed versus endogenous asset prices. To avoid uninteresting special cases, we assume that the climate problem is serious enough that a small level of abatement today increases next-period output, taking into account both the change in the carbon stock and the induced change in investment.[16]

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16. This assumption states that there is not a second-best rationale for worsening the climate problem in order to ameliorate another market failure, e.g., possible underinvestment.

Assumption 2: Holding μ_{t+1} fixed, the first unit of abatement in period t increases output in period $t + 1$: $dG_{t+1}/d\mu_t > 0$, evaluated at $\mu_t = 0$.

With a fixed asset price, climate policy harms the current old agent by reducing the current return to capital, eradicating her selfish incentive to reduce emissions. The agent born in the next period benefits from a small level of abatement under assumption 2. Today's young agent, who suffers from the policy-induced reduction in the wage but benefits from a more productive future economy, has ambiguous net change in welfare.

Matters are more complicated when the asset price is endogenous. By changing both the supply and demand for investment, policy influences the asset price. We first identify under what circumstances the current generations' selfish incentives to abate are aligned or in opposition (i.e., whether the first-order welfare effects for the two generations have the same or the opposite signs). We then examine the price and welfare effects of policy when preferences are linear (EIS $\to \infty$), logarithmic (EIS $= 1$), or Leontieff (EIS $\to 0$).

3.1. The Alignment of Agents' Incentives to Abate

We consider the equilibrium welfare effect of a small level of current abatement ($\mu > 0$, $\mu \approx 0$), holding future abatement fixed.[17] Abatement raises the old agent's welfare if and only if it increases the asset price. We say that the two generations' selfish incentives are aligned if and only if their first-order welfare effects have the same sign; otherwise their incentives are opposed. We show that their incentives are aligned if EIS > 1, and opposed if EIS < 1.[18]

Proposition 1: Under assumptions 1.i and 1.ii and with fixed levels of future abatement:

(i) A small level of current abatement increases the old generation's welfare if and only if this policy raises the asset price:

This assumption could be derived from primitives by imposing further structure on the problem. However, even in the two-period setting, this approach would introduce a great deal of nonilluminating algebra that would merely obscure the uncontroversial assumption articulated in assumption 2.

17. We approximate the welfare effect in the usual manner, using the first-order term of the Taylor expansion of welfare around $\mu = 0$. Section 4 endogenizes the abatement decision, recognizing that future policy responds to current policy via changes in the state variable.

18. Proposition 3 shows that the first unit of abatement has zero first-order effect on asset prices, the consumption point, or agents' welfare, if EIS $= 1$. Therefore, proposition 1.ii excludes the case EIS $= 1$.

$$\frac{d\Omega_t^o}{d\mu}|\mu = 0 > 0 \Leftrightarrow \frac{dp_t}{d\mu}|\mu = 0 > 0.$$

(ii) For EIS $\neq 1$, welfare of the old and the young generations change in the same direction, due to a small level of abatement, if and only if EIS > 1:

$$\frac{d\Omega_t^y}{d\mu}|\mu = 0 > 0 \Leftrightarrow \frac{\text{EIS}}{\text{EIS} - 1}\frac{dp_t}{d\mu}|\mu = 0 > 0.$$

The old agent benefits from a small level of abatement that increases the asset price, even if she has no capital to sell at the end of the period (i.e., if $\delta = 1$). If the first unit of abatement raises the asset price, it also raises the return to capital (eq. [6]), benefiting the old agent (eq. [9]); if $\delta < 1$, the higher price increases the value of the old agent's end-of-period undepreciated assets, further raising the agent's welfare. These two effects are both absent in the composite commodity framework.

Figure 2 provides intuition for proposition 1.ii. A smaller EIS implies a more convex indifference curve over current and next-period consumption. The line through point A with slope $-\psi_t$ graphs the budget constraint, $c_{t+1}^o = \psi_t(w_t - c_t^y)$, equation (2b). At the initial equilibrium, with $\mu = 0$, the young agent at t consumes at point A and has lifetime welfare shown by the indifference curve Ω_t^y. Suppose that a small level of abatement increases p_t. In this case, w_t increases (by eq. [6]), as represented by the rightward shift of the budget constraint's horizontal intercept, w_t. The increase in p raises the old agent's utility and therefore must increase her consumption. The higher price also causes the production point to move down the PPF, leading to lower aggregate production of the consumption good. Market clearing therefore requires that c_t^y falls, for example, from point A toward B (with higher welfare) or toward C (with lower welfare) for the young agent.

We now explain the relation between the magnitude of EIS and the direction of the movement (either toward B or toward C), conditional on the assumption that p increases. Suppose that the consumption point moves toward B; in this case, the small level of abatement (which by assumption increases p) also raises the young agent's welfare. The increase in p (and the consequent increase in w_t and the reduction in c_t^y), together with the assumed increase in the young agent's welfare mean that the budget constraint must have become steeper, as shown by the line through B: ψ has increased. That is, the young agent's opportunity cost of each unit of current consumption, in terms of future consumption, has risen.

This conclusion follows from a proof by contradiction: if the increase in p had raised welfare and also lowered the opportunity cost of current consumption, then both the income and the substitution effect would work in the same direction and would lead to an increase in the young agent's current consumption. But that increase is not consistent with equilibrium, because the higher p raises the old agent's consumption and

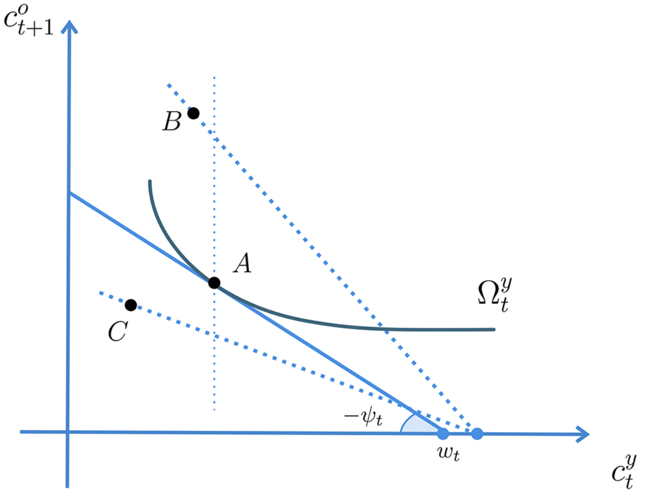

Figure 2. The initial equilibrium, with $\mu_t = 0$, is at point A on the young agent's indifference curve, denoted Ω^y_t. This curve gives the locus of current and future consumption points that yields the same level of welfare. The slope of the budget constraint is the equilibrium value of $-\psi_t$ (the right side of eq. [2a]) and the horizontal intercept is w_t. A small level of abatement, $\mu > 0$, that increases p_t raises w_t and decreases c^y_t. These changes are consistent with a movement of the consumption point toward B, and an increase in Ω^y_t, if and only if EIS > 1. They are consistent with a movement of the consumption point toward C, and a decrease in Ω^y_t, if and only if EIS < 1.

reduces the supply of the consumption good. Therefore (given our assumptions that p and the young agent's welfare have both increased), it must be that the opportunity cost of current consumption has increased, as we asserted, and as illustrated by the line through B. This conclusion implies that the substitution effect dominates the income effect. With iso-elasticity utility, the substitution effect dominates the income effect if and only if EIS > 1, in line with proposition 1.

To complete the explanation, we consider the case where the higher p lowers the young agent's welfare, that is, where the consumption point moves toward point C. That decrease implies that ψ_t has fallen. (If the abatement increased ψ_t, then welfare would have risen, because the higher p_t raises w_t.) The lower ψ_t encourages higher c^y_t via the substitution effect; the lower welfare encourages lower c^y_t via the income effect. If consumption moves toward point C, then the income effect dominates the substitution effect: EIS < 1.

3.2. Special Cases

Here we compare the effects of a small level of abatement under endogenous versus fixed asset prices. We use a two-period setting for linear and Leontieff preferences and a many-periods setting for logarithmic preferences. Table 1 summarizes the welfare

Table 1. Comparative Statics of Welfare and Price with Respect to Abatement

			Δ Welfare		
Preferences	Asset Price	Δp	Young$_t$	Old$_t$	Young$_{t+1}$
Linear	Endogenous	+	+	+	+
	Constant	0	(−)	(−)	+
Leontieff	Endogenous	−	+	−	+
	Constant	0	+	(−)	+
Log	Endogenous	(−)	(−)	(−)	+
	Constant	0	(−)	(−)	+

Note. An endogenous asset price corresponds to $\sigma < \infty$, and an exogenous asset price corresponds to $\sigma = \infty$. The linear and Leontieff cases use a two-period model; the logarithmic case uses an arbitrary number of periods. (.) denotes second-order effects, when first-order effects are zero.

and price effects, taken from propositions 2–4; appendix A.3 contains proofs. When the first-order effect of the Taylor expansion is zero, we display the sign of the second-order term in parentheses.

A small level of abatement increases the endogenous asset price when utility is linear and lowers the asset price when preferences are Leontieff. With linear preferences, where the two currently living agents' incentives are aligned, both generations benefit from a small level of abatement. With Leontieff preferences, where the two generations' incentives are opposed, abatement benefits the young agent and harms the old agent.

The most striking difference between endogenous versus fixed asset prices occurs with linear preferences; there, the sign of the welfare effects flip. In other cases, the endogeneity of asset prices affects the magnitude but not the sign of the welfare effect. With Leontieff preferences, abatement harms the old agent under both endogenous and fixed asset prices. However, this is a first-order welfare reduction under endogenous asset prices but only a second-order effect with fixed asset prices. Thus, for Leontieff preferences, the endogeneity of asset prices reinforces the old generation's opposition to climate policy: that policy not only lowers the old generation's current return to capital but also lowers its end-of-period wealth.

By assumption 2, abatement always benefits the generation born in the next period.[19] However, there are important differences between endogenous versus fixed asset prices. With fixed asset prices, abatement crowds out investment, leaving the next-period generation with a cleaner environment but a smaller stock of capital.

19. Assumption 2 simplifies the exposition, but it is not needed under logarithmic preferences or in the two-period model with linear preferences. With logarithmic preferences, the first unit of abatement has zero first-order effect on next-period capital, and with linear preferences it has a positive first-order effect on next-period capital. See the proofs of propositions 2 and 3. This abatement always has a negative first-order effect on the next-period stock of carbon.

The endogeneity of asset prices compounds this effect under Leontieff preferences; there, abatement reduces investment not only due to the inward shift in the PPF (a second-order effect) but also due to a movement along the PPF toward the consumption good (a first-order effect). In contrast, with linear preferences, the abatement-induced increase in asset prices raises current investment: abatement leaves the next-period generation with a cleaner environment and a larger stock of capital.

The savings rule under logarithmic preferences is independent of current or future policy. This invariance simplifies the analysis, but it eliminates the importance of endogenous asset prices. Apart from this useful but knife-edge case, the endogeneity of asset prices matters.

3.2.1. Linear Preferences (EIS $\rightarrow \infty$)

The two-period model ($T = 1$) shows how the welfare effects of abatement depend on whether asset prices are endogenous ($\sigma < \infty$) versus fixed ($\sigma = \infty$), as summarized above.

> **Proposition 2:** Suppose that assumptions 1.i, 1.ii, and 2 hold, with EIS $\rightarrow \infty$ and $T = 1$. (i) For $\sigma < \infty$ (endogenous asset price), a small level of abatement in period 0 increases the asset price and improves the welfare of all agents. (ii) For $\sigma = \infty$ (fixed asset price), period-0 abatement lowers the welfare of agents in period 0 and benefits the agent born in period 1.

Part i of the proposition states that a small level of abatement increases the period-0 asset price. By proposition 1, the higher asset price raises the welfare of both the young and the old in period 0. The increase in the asset price increases investment, due to a move along the PPF. Therefore, abatement lowers the carbon stock and increases the capital stock in period 1, increasing the wage and thus increasing the welfare of the agent born in $t = 1$.

In contrast, with a fixed asset price ($\sigma = \infty$), we have the standard result that period-0 abatement crowds out investment. The asset-pricing equation here implies $p_0 = 1 = \rho r_1 = \rho G_K(K_1, E_1)$. Investment falls to offset any abatement-induced reduction in the next-period stock of carbon, leaving the period-1 return to capital unchanged. By assumption 2, the combined change in the stocks of capital and carbon nevertheless increases the period-1 wage.

Appendix A.3 uses the infinite horizon model with linear preferences to show that the endogeneity of the asset prices induces selfish agents to internalize some of the benefit of climate policy. The selfish agents act to protect the value of their asset, and in the process they benefit agents born in the future.

3.2.2. Logarithmic Preferences (EIS $= 1$)

For an arbitrary time horizon with EIS $= 1$, the first unit of abatement causes a second-order fall in the asset price and a welfare loss to currently living agents; future agents gain. Selfish agents choose zero abatement, even though positive abatement would increase aggregate welfare. These welfare results reproduce the conclusions in standard IAMs with a fixed asset price.

Proposition 3: Suppose that EIS $= 1$ and assumption 1 holds. (i) There exists a unique stable equilibrium price $p(\mathbf{z})$, independent of future abatement. (ii) The marginal unit of abatement at $\mu = 0$ has zero first-order effect on the asset price and welfare of both the young and the old agents alive at $t = 0$. This abatement creates a first-order reduction in the next-period stock of carbon, without reducing the inherited stock of capital, thereby benefiting the agent born in the next period. (iii) For $\mu > 0$, an increase in abatement lowers welfare of the agents alive at $t = 0$, lowers the next-period stock of capital, and for $\delta < 1$ lowers the asset price.

The basis for this result is that for EIS $= 1$, young agents save a constant fraction of their income. The young agent's demand for physical capital depends on the asset price and labor income but not on future abatement decisions.

3.2.3. Leontieff Preferences (EIS $\rightarrow 0$)

In the limit as EIS $\rightarrow 0$, $\Omega^y \rightarrow \min(c_t^y, (c_{t+1}^o)/\rho)$. The young agent saves to the point where $c_t^y = c_{t+1}^o/\rho$, implying the asset price equation

$$p_t = \frac{w_t}{K_{t+1}} - \frac{(r_{t+1} + (1-\delta)p_{t+1})}{\rho}. \tag{10}$$

Proposition 4: Under assumption 1 for $T = 1$ (the two-period case): (i) For $\sigma < \infty$ (endogenous asset prices), the first unit of abatement in period 0 lowers the asset price, lowering welfare for the old agent in that period, lowering investment, and increasing welfare of the young agent. Under assumption 2, the first unit of $t = 0$ abatement increases welfare of the agent born at $t = 1$. (ii) For $\sigma = \infty$ (fixed asset prices), the first unit of abatement strictly increases welfare for the current young and for the agent born in the next period, creating a second-order welfare loss for the current old generation.

Current abatement increases productivity and both agents' consumption in the next period. The lack of intertemporal substitutability causes the current young generation to increase its current consumption. The ensuing reduction in savings lowers the asset price, creating a first-order welfare loss for the old agent.

The two parts of proposition 4 show how the endogeneity of the asset price alters the welfare effect of abatement. With both fixed and endogenous asset price, both the current young agent and the agent born in the next period benefit from the reduction in the $t = 1$ carbon stock. Because the marginal cost of the first unit of abatement is zero (assumption 1.ii), abatement causes only a second-order loss to both agents' $t = 0$ income when the asset price is fixed. Here, the aggregate welfare gain arises from reducing the climate externality; there is no (first-order) intergenerational welfare transfer.

In contrast, with an endogenous asset price, abatement causes a first-order reduction in this price, leading to a first-order reduction in the old agent's wealth. The old agent also suffers from the second-order reduction in its income, via the fall in the rental rate. Here, there is a welfare transfer from the old agent to the other two agents, in addition to the gain arising from reducing the climate externality. In summary with a fixed asset price, abatement creates only a second-order income loss to the old agent, but with an endogenous asset price, abatement also causes a first-order reduction in the old agent's wealth.

The two-period model with low EIS shows how beliefs about future policies can affect current equilibrium policies. Suppose that in a political economy equilibrium, generations alive at $t = 0$ choose climate policy to maximize a convex combination of their welfare (as in sec. 4) and that the young generation has enough political power to produce a positive level of abatement. Now add a previous period, $t = -1$, to this two-period model. The generation that is young at $t = -1$ understands that the positive abatement at $t = 0$ will reduce its consumption at that time. This generation's welfare is $\min(c_{-1}^{y}, c_0^{o}/\rho)$. The reduction in c_0^{o} caused by the anticipated $t = 0$ abatement makes the young agent at $t = -1$ willing to transfer consumption from $t = -1$ to $t = 0$. The agent can make this transfer by saving a bit more, but abatement produces a more efficient transfer for this agent. First, it reduces the climate externality. Second, it shifts some of the costs on to the old agent at $t = -1$. Thus, in a world where the young agents have significant political power, the anticipation that abatement will be positive in the future, together with a low EIS, promotes abatement in the current period.

4. NUMERICAL ANALYSIS

We use a numerical model to study equilibrium policy, the solution to a dynamic game. In each period, abatement is chosen to maximize a convex combination of young and old agents' consumption-related welfare, $\xi\Omega_t^{y} + (1 - \xi)\Omega_t^{o}$, with $0 \leq \xi \leq 1$.[20] We refer to the fictitious agent who maximizes this function as the *selfish planner*. The parameter ξ measures the young generation's influence in the decision-making process.

Each planner in the sequence of planners is an agent in a dynamic game. Apart from logarithmic preferences (proposition 3), planner t's optimal policy depends on future policies, via their effect on the asset price. The equilibrium abatement policies

20. There are several ways to motivate this criterion, e.g., using a probabilistic voting model in which voters care about their consumption-related welfare and about ideology (Lindbeck and Weibull 1987; Persson and Tabellini 2000). However, neither the microfoundations nor the manner of implementing the policy (e.g., a tax or a quota) matter for our purposes.

are not first-best; therefore, equilibrium levels of investment are also not efficient. To avoid a model in which climate policy is used to influence investment, we assume that planners take the level of investment as given:[21]

> **Assumption 3** (Nash): The planner takes the current level of investment as given. Agents take prices and abatement policy as given.

Planners understand that current abatement shifts the PPF inward. At a given asset price, abatement reduces the factor prices, w_t and r_t, because it increases production costs. The planner also understands that by changing the next-period carbon stock, abatement can alter the asset price, changing the value of undepreciated assets (wealth) and further altering factor prices. However, by assumption 3, the planner takes as given the equilibrium point on the investment supply function, $I = x(p)G(\mathbf{z}_t)$, rather than behaving as a monopsonist with respect to this supply function.

The directly payoff-relevant state variable is the triple (K, E, t); t picks up exogenous trends in technology and population. We study a Markov perfect equilibrium (MPE) where current policies and expectations concerning future policies are functions of the current state variable. Equilibrium policies from periods $t + 1$ onward induce an equilibrium price function, denoted $p_{t+1} = \Psi(K_{t+1}, E_{t+1}, t + 1)$. The T-period model, $T < \infty$, uses the boundary condition $p_T = 0$; in the final period, abatement and investment are both 0.[22]

The planner chooses μ_t to maximize the convex combination of currently living agents' welfare, resulting in the equilibrium policy function, $M(K, E, t)$:

$$M(K, E, t) = \underset{\mu_t}{\operatorname{argmax}}\, \xi\, L_t\, \Omega_t^y + (1 - \xi)\, L_{t-1}\, \Omega_t^o. \qquad (11)$$

To evaluate the maximand we use the asset price equation (3), the equations of motion (7), the definitions of welfare in equations (8) and (9), and the expressions for factor prices (eq. [14] in app. A.1). To take into account exogenous population growth,

21. Policymakers who are focused on the climate problem seem unlikely to attempt to manipulate investment. In addition, allowing climate policy to be chosen partly to influence investment would considerably complicate a difficult numerical problem. The results would be hard to interpret and the inclusion of an additional scenario would further complicate the exposition. Finally, our quantitative results show that investment decisions are insensitive to moderate changes in abatement, making climate policy a weak instrument for influencing investment.

22. The finite horizon setting avoids the problem of the "incomplete transversality condition," a familiar source of multiplicity. We find no evidence of multiplicity in our finite horizon model. We choose $T = 14$ (490 years), which is long enough that a change in T has no discernible effect on policies in the first 200 years. We report equilibrium trajectories for the first eight periods (280 years), long enough to capture the important dynamics and short enough to avoid strong influence due to the approaching terminal time.

L_t equals the size of a generation born at t. The investment supply function, given by equation (15) in appendix A.1, closes the model. Substituting the price and abatement functions into that supply function gives equilibrium investment

$$I_t = x(\Psi(K_t, E_t, t))G(K_t, L_t, E_t, M(K_t, E_t, t), t). \tag{12}$$

Appendix C describes the numerical algorithm.

4.1. Two Benchmarks

We compare the political economy equilibrium under the selfish planner with two benchmarks. Under business as usual (BAU), abatement is zero in every period. At the other extreme, the altruistic planner chooses abatement to maximize the convex combination (with weight ξ) of the discounted population-weighted sum of the agents' utility. Both the altruistic and the selfish planners take investment as given. With c_t^o and c_t^y equal to the per capita consumption of the old and young agents at t, the altruistic planner's dynamic programming equation is[23]

$$J(K_t, E_t, t) = \max_{\mu_t} \xi L_t u(c_t^y) + (1-\xi)L_{t-1}u\left(c_t^0\right) + \rho J(K_{t+1}, E_{t+1}, t+1) \tag{13}$$

subject to transition equations (7) and the general equilibrium relations that determine consumption and investment.

4.2. Calibration

We use DICE-2016R (Nordhaus 2017) to calibrate trends in technology and population in our baseline model and follow Dietz et al. (2021) in replacing DICE's carbon and temperature dynamics by a model of cumulative emissions. We conduct sensitivity studies with respect to parameters governing preferences, technology, and damages, solving the model for thousands of parameter combinations and using regressions to assess their equilibrium effect.

Our baseline implies that BAU climate damages are small in the near future, eventually becoming potentially large without posing an existential threat. The calibration is optimistic about technology, assuming that eventually it will be inexpensive to undo damages caused by previous emissions.

These assumptions encourage purely selfish agents to defer, or perhaps never to undertake, policies that reduce climate change. Therefore, the fact that in most equilibria selfish agents do undertake meaningful (but still inadequate) policy, cannot be ascribed

23. We also experimented with an alternative in which the return function equals the total per capita utility, $P_t U(C_t/P_t)$, with $P_t = L_t + L_{t-1}$, population at t, and C_t equal to aggregate consumption. This alternative is closer to the standard IAM, but the choice we adopted makes the selfish and the altruistic planners directly comparable.

to our having exaggerated the severity of the climate problem or the low cost (today) of ameliorating it.

Assumption 4 summarizes the model's functional forms:

Assumption 4 (Functional forms): $G(K, E, t) = D(E)\Lambda(\mu)F(K, L, t)$ with $F(K_t, L_t, t) = K_t^{1-\beta}(A_t L_t)^\beta$ and $0 < \beta < 1$; $\Lambda(\mu_t) = 1 - \nu_{1,t}\,\mu_t^{\nu_2}$ with $\nu_2 > 1 > \nu_{1,0} > 0$; and $D(E_t) = (1 + \iota \; E_t^2)^{-1}$ with $\iota > 0$.

Labor obtains the constant output share β. Reducing emissions to 0 ($\mu = 1$) reduces output by the fraction $\nu_{1,t}$, a decreasing function of time to reflect improved abatement technologies; ν_2 is the elasticity of abatement costs. We replace physical capital K_t with capital in efficiency units $k_t = K_t/A_tL_t$. Appendices B.4 and B.5 discuss other calibration assumptions, including the exogenous population (L_t) and labor productivity (A_t) dynamics.

Table 2 collects parameter names and baseline values, including $\nu_{0,0}$ (the initial cost of eliminating emissions) and the initial values of labor productivity, A_0. We scale nominal units by 10^{12} 2010 USD (trillion). Capital stock, K_0, in 2015 is 223 $\$T$. With annual world output of 105.5 $\$T$, output during the first 35-year period is $35 \times 105.5\,\$T \cong 3,692.5\,\$T$ (Nordhaus 2017). We calibrate the initial old and young populations so that the total initial population equals 7.4 billion, and we fix the population dynamics so that the growth rate of the young population equals DICE's growth rate of total population. The stock of labor in our model is the population of the young, and in DICE it is the total population. Given the initial output and endowments of capital and labor $L_0 = 5.1$ and setting $\beta = 0.6$, initial labor productivity is

Table 2. Parameter Definitions and Baseline Values

Parameter	Value	Description
ρ	.7	Discount factor
EIS	(.5, 1, 2)	Elasticity of intertemporal substitution
β	.6	Labor share
δ	.88	Capital depreciation
ζ_0	.0957	Carbon intensity
ι	$9.44(10^{-9})$	Damage parameter
A_0	4,748	Initial labor productivity
σ	1.3210	PPF elasticity
a	2.3636	PPF shape parameter
$\nu_{1,0}$	.074	Full abatement cost share in 2015
ν_2	2.6	Abatement cost elasticity
ϵ	0	Stock decay rate

calibrated to $A_0 = 4{,}748$.[24] Our baseline assumes that capital depreciates at 6%/year (implying $\delta = 0.88$), above the mean of 4%/year for 2010 of the Penn World Table and below the 10%/year used in DICE-2016R. Agents live for 70 years, and one period lasts 35 years. Agents discount future utility at 1%/year, implying $\rho = 0.7$.

Our climate state variable is cumulative emissions, not temperature, so $\epsilon = 1$. Units of the carbon stock, E, are gigatons of carbon (GtC). By 2015, cumulative emissions since the preindustrial period were 571 GtC (Allen et al. 2009), with 2015 emissions of 10.1 GtC (Nordhaus 2017). Initial carbon intensity measured in GtC per $\$T$, ζ_0, is $10.1/105.5 = 0.0957$. Following DICE, we impose a ceiling of 6,000 GtC on cumulative emissions. Emissions in period t equal $e_t \equiv \zeta_t(1 - \mu_t)\, K_t^{1-\beta}(A_t L_t)^{\beta}$.

We calibrate the damage parameter ι using the Nordhaus (2014a) damage function and the Nordhaus (2017) estimate that a 2°C temperature anomaly reduces output by 0.94%. We use the transient response to cumulative emissions (TRCE) model to convert cumulative emissions of 1,000 GtC into a 2°C temperature increase.[25] Our calibration implies a 0.94% output loss at $E = 1{,}000$ (as in DICE), an 8% loss at $E = 3{,}000$, and a 25% loss at $E = 6{,}000$ (compared to 19% in DICE).

Current emissions affect damages with a one-period (35-year) lag. Recent evidence suggests that most of the warming effect occurs within a decade of emissions (Ricke and Caldeira 2014). DICE implies that the peak warming effect occurs approximately 60 years after emissions. Our implied 35-year lag between emissions and damages is a compromise.

The DICE-2016R abatement cost elasticity is $\nu_2 = 2.6$; $\nu_{1,t}$ measures the share of GDP needed to abate all emissions ($\Lambda(1) = 1 - \nu_{1,t}$), based on a backstop technology. The initial backstop cost, $\$550/tCO_2$, declines over time, implying that eliminating emissions would cost 7.4% of output today, 1.0% in 100 years, and 0.03% in 300 years. Rapid reductions in mitigation costs delay optimal abatement, leading to a climate "policy ramp" (Nordhaus 2017).

As in DICE, we allow $\mu > 1$ to reflect the possibility that it becomes possible to remove carbon from the atmosphere, thereby reducing damages. Our baseline uses the upper limit of $\mu = 1.2$. For $\mu > 1$, $E(t)$ falls; in this case $E(t)$ equals cumulative emissions minus the carbon stocks removed from the atmosphere.

The EIS is an important parameter in dynamic models. Havranek (2015) concludes, based on 2,735 estimates from 169 studies, that the mean of microbased estimates of the EIS, when corrected for reporting bias, ranges from 0.3 to 0.4 and that values above 0.8 are "inconsistent with the bulk of the empirical evidence." He finds

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24. With $\beta = 0.6$ and $\rho = 0.7$, the savings rate under log utility is 0.25. We do not calibrate on the savings rate, so different parameters produce different rates.

25. The TRCE model is a linear approximation to a nonlinear system, so we do not use it to predict temperature changes corresponding to very high levels of cumulative emissions (IPCC 2013; Dietz et al. 2021). Appendix B.4 explains our use of this model.

that researchers who use Epstein-Zin utility obtain smaller EIS estimates, but only by about 0.02–0.03.

We report results for EIS $\in \{0.5, 1, 2\}$. The conventional choice in IAMs sets EIS $= 0.5$. Proposition 3 states that equilibrium abatement is zero for EIS $= 1$, so this case is valuable as a means of checking the numerical routine's accuracy. The case EIS $= 2$, despite being outside Havranek's 2015 plausible range, is important for assessing the quantitative importance of our propositions. These show that the two generations' selfish interests tend to be more opposed, and the current old generation is likely to be harmed by climate policy, when EIS is small. There, we expect that a strong influence of the young generation (ξ large) is necessary for meaningful abatement to occur in equilibrium. For large EIS we expect that equilibrium policy is less sensitive to ξ (because the two generations' selfish interest tend to be more closely aligned). Our results confirm this conjecture.

Finally, we need the shape and elasticity parameters, a and σ (eq. [4]), to complete the description of technology. We estimate aggregate investment as a share of output when $p = 1$ as $S = 0.243$.[26] Using the formula $\kappa = \sigma(1 - S)$ and $(1 - S)/S = a^{\sigma}$ (n. 14) and the estimate $\kappa = 1$ (Goolsbee 1998), we obtain the baseline values $\sigma = 1.321$ and $a = 2.3636$.[27]

4.3. Results

We first show how changes in EIS and the political influence parameter (ξ) affect first-period abatement and the carbon trajectories under our baseline assumptions. We then summarize sensitivity studies using over 3,000 parameter combinations. The final subsection examines the relative importance of the two potential selfish reasons for undertaking climate policy: the young agent's concern about their future consumption, and the endogeneity of asset prices.

4.3.1. Baseline Policies and Trajectories

Table 3 shows first-period abatement, the tax that supports it, and peak cumulative emissions under the selfish and the altruistic planners.[28] Early selfish abatement is

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26. See gross capital formation (% of GDP) in the World Bank's world database, https://data.worldbank.org/indicator/NE.GDI.TOTL.ZS.

27. Goolsbee (1998) is the most authoritative estimate we found, but it corresponds more closely to a short-run elasticity. Therefore, our robustness checks include elasticities up to $\sigma \approx 4$. Similar comments apply to our other baseline values. For example, many people think that the DICE damage estimates are implausibly small. We use parameter estimates taken from prominent publications, not our personal views.

28. The tax under altruism with EIS $= 0.5$ is much smaller than estimates of the social cost of carbon, e.g., \$40/tCO_2, or \$147/tC. Because our goal is to examine the selfish incentives to undertake climate policy, not to recommend optimal policy, we care about the relation between the selfish and the altruistic policies, not the level of either. Therefore, we retain a familiar

Table 3. Baseline Policies and Outcomes

	ξ = .2			ξ = .5			ξ = .8		
	$/*t*C	μ%	$\bar{E}$	$/*t*C	μ%	$\bar{E}$	$/*t*C	μ%	$\bar{E}$
	Aligned Incentives (EIS = 2)								
Selfish	21	6	2,682	38	8	2,157	52	10	1,882
Altruistic	693	49	940	635	46	965	543	42	1011
	Nonaligned Incentives (EIS = .5)								
Selfish	6	3	5,991	14	5	2,742	18	6	2,228
Altruistic	93	15	1,870	74	13	1,759	64	12	1,711

Note. First-period carbon tax ($/tC), percentage abatement rate (μ%) and peak 280-year carbon stock ($\bar{E}$) under the selfish and altruistic Markov perfect equilibrium (MPE) planners. Taxes must be divided by 3.666 to convert to $/t$CO_2$.

nonnegligible, although much smaller than the altruistic level. However, for many parameter configurations the selfish policies achieve substantial reductions in the carbon stock and damages over time. Figure 3 shows trajectories of cumulative emissions under the different scenarios. When the young generation has significant representation in the policy decision, selfish agents undertake substantial abatement, except where EIS is close to 1. Our carbon stock/temperature dynamics are similar to those of DICE-2016R for BAU and the altruistic planner under EIS = 0.5. The altruistic planner under EIS = 2 chooses more ambitious policy with cumulative emissions peaking at around 1,000 GtC (equivalent to 2°C), while optimal policy in DICE-2016R would choose 3°C.

Cumulative emissions under the altruistic planner remain under 1,011 GtC for EIS = 2 and under 1,870 GtC for EIS = 0.5, and they decrease with the young generation's influence parameter, ξ. Most carbon trajectories are nonmonotonic because of the assumption that abatement can exceed 100%. Cumulative emissions under BAU reach 6,000 GtC, their upper limit. Investment and therefore emissions are higher for EIS = 2 compared to EIS = 0.5, so the BAU economy reaches the carbon ceiling earlier for EIS = 2.

For all of the simulations, the young generation has a greater incentive than the old to undertake climate policy. Therefore, the trajectory for equilibrium cumulative emissions

calibration, rather than adjusting it to make the altruistic policy match estimates of the social cost of carbon. We report cumulative emissions, not the temperature anomaly, because the TCRE model that converts cumulative emissions to temperature may be unreliable at high levels of cumulative emissions. Nevertheless, the damage function returns reasonable damage levels even at these high levels of cumulative emissions.

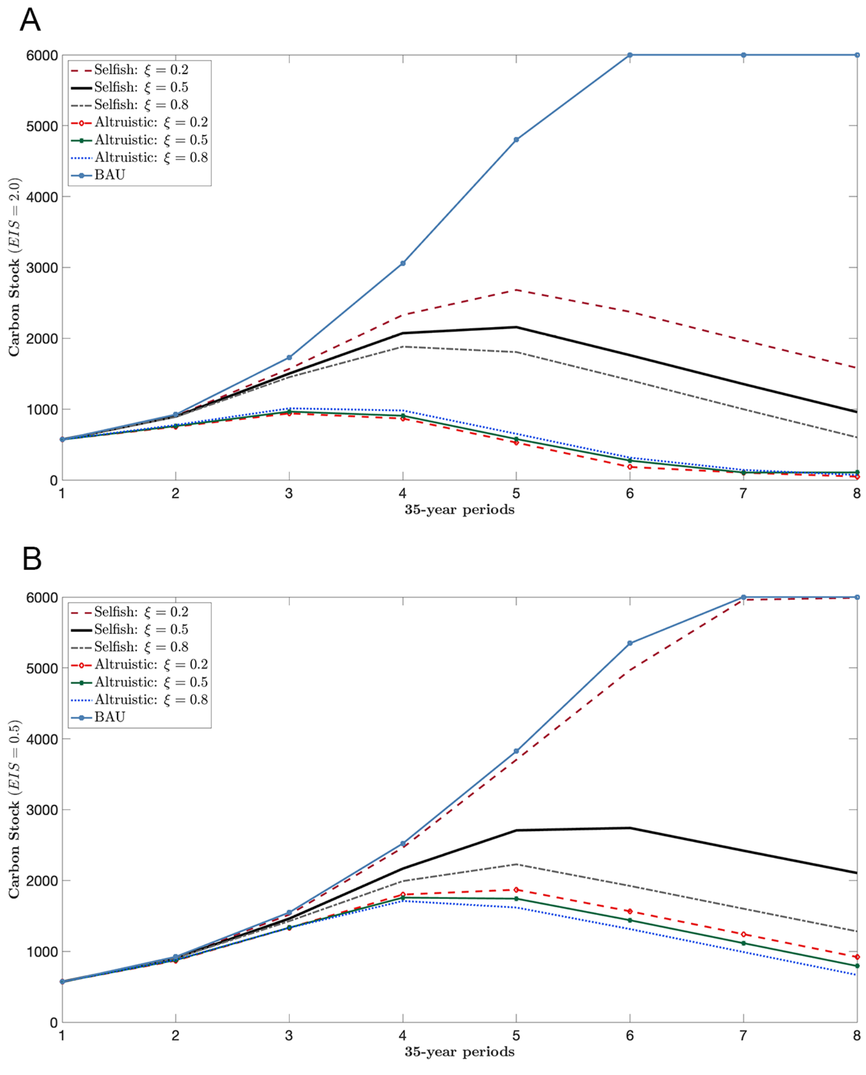

Figure 3. Equilibrium cumulative emissions (carbon stock) for EIS = 2 (panel *A*) and EIS = 0.5 (panel *B*) under BAU, and for three values of the political influence parameter ξ, under the selfish and altruistic planners.

moves toward the corresponding trajectory of the altruistic planner as the young agent's influence in the political process increases (ξ increases). The outcome under the altruistic planner is insensitive to ξ.[29]

29. The altruistic planner's trajectory is moderately sensitive to the EIS, with a higher EIS leading to stricter policy, a result familiar from standard IAMs.

A comparison of the two panels of figure 3 also shows the quantitative importance of proposition 1, which establishes that for small policy the two agents' incentives are aligned if and only if EIS > 1. For EIS = 2 (top panel), the equilibrium carbon trajectories are only "moderately" sensitive to ξ. Although the two generations prefer different levels of climate policy, the fact that they at least agree about small policy means that a change in their political power leads to only moderate differences in the equilibrium trajectory of the carbon stock when EIS = 2. In contrast, for EIS = 0.5 (bottom panel) the generations' interests are strongly opposed—even for small policy. Here, when the young generation has little political influence ($\xi = 0.2$) the equilibrium trajectory is close to the BAU trajectory, but when the young agent is dominant ($\xi = 0.8$) the equilibrium trajectory is close to the altruistic trajectory. For both EIS = 0.5 and EIS = 2, the equilibrium trajectory is approximately halfway between the BAU and altruistic trajectories.

In summary, we find that the equilibrium trajectory is (very) sensitive to the agents' relative political power only when their self-interest strongly diverges, that is, for EIS < 1. Because the empirical evidence suggests that the EIS lies in this range, our results imply that empowering the young can be an especially powerful means of strengthening climate policy.

Appendix B.6 provides additional numerical results. The tax trajectories in figure B3 (figs. B1–B4, C1 are available online) illustrate the familiar DICE-style policy ramp, initially rising and eventually falling after most of the carbon has been removed (using $\mu > 1$). Apart from the altruistic scenario with EIS = 2, the initial tax is low. Figure B4 shows that the MPE carbon trajectories are insensitive to κ, the price elasticity of investment supply. (Recall that larger κ corresponds to a more concave PPF.) Section 4.3.3 considers the role of κ in greater detail. The BAU and altruistic (compared to the MPE) carbon trajectories are slightly more sensitive to κ.

4.3.2. *Robustness*

Table 4 reports the coefficients and standard errors of response surface linear regressions of three standardized outcome variables,[30] first-period asset price, abatement, and carbon tax, on the standardized coefficients, for the selfish planner using EIS = 2 and EIS = 0.5.[31]

30. To concisely present our findings, we use response surface regression with simultaneous deterministic design. Appendix C.5 provides more information about this approach.

31. This standardization means that all standard errors within a regression are the same, so a comparison of coefficients across parameters indicates the parameters' relative importance. We exclude results for EIS ≈ 1, where abatement and the tax are always zero. Table B1 in app. B.6 presents results from three regressions, similar to those reported in table 4, except that each regression corresponds to a single value of EIS: EIS = 2, EIS = 0.5, and EIS ≈ 1. The regressions corresponding to EIS ≈ 1 show that abatement is approximately zero when preferences are approximately logarithmic, consistent with proposition 3.

Table 4. Policy Determinants

	Price	Abatement	Carbon Tax
Depreciation	.039*	−.001	.001
	(.021)	(.010)	(.013)
Labor share	.138***	−.050***	−.073***
	(.021)	(.010)	(.013)
Discount factor	.155***	.090***	.133***
	(.021)	(.010)	(.013)
Abatement cost shifter	−.000	−.079***	.001
	(.021)	(.010)	(.013)
Elasticity PPF	.067***	.016*	.006
	(.021)	(.010)	(.013)
Damage parameter	−.001	.831***	.730***
	(.021)	(.010)	(.013)
Social planner weight	−.000	.265***	.328***
	(.021)	(.010)	(.013)
Observations	3,240	3,240	3,240

Note. Coefficients from regressing standarized outcome variables (first-period price, abatement, and tax) on standardized parameters under the selfish planner. The coefficient equals the number of changes in the standard deviation of an outcome per standard deviation change in the parameter. The sample is restricted to EIS = 2 and EIS = 0.5. Standard errors in parentheses.

* Significant at 10%.

** Significant at 5%.

*** Significant at 1%.

The labor share, discount factor, and PPF elasticity are statistically significant at 1% for the first-period asset price. All parameters except for the depreciation rate and the PPF elasticity are statistically significant at 1% in determining the abatement levels. Except for the abatement cost shifter (see below), these parameters are also significant in determining the equilibrium tax.[32] Policy increases if the young have more influence (larger ξ).

Table 4 is based on 4,860 parameter combinations: depreciation, $\delta = \{0.75, \mathbf{0.88}, 0.96\}$; labor share $\beta = \{0.5, \mathbf{0.6}\}$ (lowering the share from 60% to 50% to reflect recent trends); discount factor $\rho = \{0.5, 0.6, \mathbf{0.7}\}$ (varying the annual discount rate from 1% to 1.5% and 2%); full mitigation cost, scaling $\nu_1(t)$ by $\{0.8, \mathbf{1}\} \times \nu_1(t)$, to reflect cost reductions in renewable energy; the elasticity of the PPF $\sigma = \{.33, .99, 1.32, 2.64, 3.96\}$, corresponding to supply elasticities of investment ranging from 0.25 to

32. A lower cost of abatement leads to greater abatement and makes it possible to achieve the same level of abatement using a lower tax. Therefore, the effect of the abatement cost on the tax is ambiguous in sign and generally small.

3; damage parameter $\iota = \{0, \mathbf{9.44}, 18.88\} \times 10(-9)$, doubling the damages at low temperature levels; EIS $= \{0.5, 1, 2\}$; and social planner weights on young $\xi = \{0.2, \mathbf{0.5}, 0.8\}$. (Bold entries denote baseline values.)

4.3.3. *The Two Selfish Reasons for Policy*

Currently living agents might have two selfish reasons to undertake climate policy: the young benefit from a cleaner environment later in their life, and the asset price might respond to abatement. We determine the sign and the magnitude of the asset price effect by eliminating it, holding other parameters at their baseline values. This experiment leaves only the young generation's concern for its future consumption as a selfish motivation for climate policy. We then compare equilibrium policy and outcomes with and without asset price endogeneity.

We eliminate price endogeneity by setting the elasticity of supply of the investment good to $\kappa = 1{,}000$, compared to $\kappa = 1$ in our baseline (see fig. 1). In this experiment, the equilibrium asset price is (approximately) fixed at 1, its exact value in the composite commodity model. We also reduced the importance of asset prices by using 100% depreciation ($\delta = 1$); here, the old generation has no assets to sell at the end of a period. As noted in section 2.2, a change in the asset price alters factor prices, thereby affecting the old generation even if capital completely depreciates during a period. It is therefore not surprising that the results differ depending on which method we use to reduce the importance of asset prices. In three experiments, we used one or both of these methods of reducing the asset price effect.

We also consider the opposite extreme, where investment in physical units, as a share of output, is constant. We achieve this by setting the elasticity to $\kappa = 0.01$, resulting in (approximately) the Leontieff PPF, with the kink at the investment share in physical units of 0.243 (see fig. 1). For each scenario, we solve the policy game with other parameters at their baseline levels, again varying the EIS and the political influence weight. The entries in table 5 show the percentage change in the first-period abatement rate, $[(\mu - \mu_b)/\mu_b]$ %, and in the peak stock of carbon, $[(\bar{E} - \bar{E}_b)/\bar{E}_b]$ %, under the variation, relative to the baseline.

The numbers corresponding to $\kappa = 1{,}000$ and $\delta = 0.88$ are particularly noteworthy. They show that for EIS $= 2$, turning off asset price endogeneity reduces first-period equilibrium abatement; for EIS $= 0.5$ (the conventional choice), turning off asset price endogeneity increases first-period abatement. These results are consistent with propositions 2 and 4. Proposition 2 shows that for EIS $= \infty$, eliminating the endogeneity of asset prices reduces incentives to abate. Proposition 4 shows that for EIS $= 0$, eliminating this endogeneity reduces the conflict between generations. That reduction tends to promote abatement.

Eliminating asset price endogeneity ($\kappa = 1{,}000$) has the opposite equilibrium effect compared to magnifying asset price endogeneity ($\kappa = 0.01$). In addition, as noted above, the effects of reducing asset price endogeneity by moving to the composite

Table 5. Sensitivity Analysis

	$\xi = .2$		$\xi = .5$		$\xi = .8$	
	$[(\mu - \mu_b)/\mu_b]$ %	$[(\bar{E} - \bar{E}_b)/\bar{E}_b]$ %	$[(\mu - \mu_b)/\mu_b]$ %	$[(\bar{E} - \bar{E}_b)/\bar{E}_b]$ %	$[(\mu - \mu_b)/\mu_b]$ %	$[(\bar{E} - \bar{E}_b)/\bar{E}_b]$ %
			EIS = 2			
$\kappa = .01, \delta = .88$	2.5	−2	1.2	.3	.2	−1.4
$\kappa = 1{,}000, \delta = .88$	−2.8	2	−1.5	−.2	−.5	1
$\kappa = 1, \delta = 1$	.3	−.1	.1	−.1	−.1	−.3
$\kappa = 1{,}000, \delta = 1$	−1.9	1.4	−.7	−1.2	.1	0
			EIS = .5			
$\kappa = .01, \delta = .88$	−13.4	.2	−11.7	3.4	−11.2	.1
$\kappa = 1{,}000, \delta = .88$	9.1	.2	7.6	−.5	7.5	−2.3
$\kappa = 1, \delta = 1$	.5	.1	.1	−.2	.1	−.3
$\kappa = 1{,}000, \delta = 1$	8.9	−.2	7.2	−1	7.2	−2.7

Note. Baseline parameters are $\kappa = 1$ and $\delta = 0.88$. The elasticities $\kappa = 0.01$ and $\kappa = 1{,}000$ correspond to the approximately Leontieff and composite commodity PPFs, respectively. The factor $\delta = 1$ implies full depreciation. The ratio $[(\mu - \mu_b)/\mu_b]$ % equals the percentage change under the alternative in the row heading, relative to our baseline (for the same welfare weight). The ratio $[(\bar{E} - \bar{E}_b)/\bar{E}_b]$ % equals the percentage change under the alternative relative to our baseline.

commodity approximation differ—both qualitatively and quantitatively—from the effects of full depreciation.

The asset price effect is small, always less than 14%. Selfish reasons may motivate currently living agents to undertake climate policy that, over the span of several generations, leads to significantly lower cumulative emissions compared to BAU. However, this effect is due almost entirely to the young agent's concern about their future consumption. Asset price endogeneity influences equilibrium climate policy in the direction suggested by our qualitative analysis, but the magnitude of the effect is small. These results suggest that empowering the young would likely promote climate policy or reduce opposition to it.

5. CONCLUSION AND POLICY IMPLICATIONS

Most climate economics seeks to determine optimal abatement or the optimal instrument mix, for example, cap and trade, a carbon tax, or subsidies to green technology. In emphasizing that most of the benefits of climate policy accrue to unborn generations, this literature downplays the possibility that current generations have selfish reasons to undertake policy. Our departure from this framework recognizes that selfish interests might also motivate climate policy and also that current policymakers may be unable to choose their successors' policies.[33] Our results suggest ways of reframing the debate to achieve stronger climate policy.

A long-standing and empirically well-supported hypothesis states that environmental outcomes—and therefore environmental policy—affect asset prices. Previous IAMs could not engage this issue, because they use a composite commodity model that implies a fixed end-of-period asset price. Using a more general model with endogenous asset price, we show that although the desire to protect wealth might work either to support or oppose climate policy, the magnitude of the effect is likely small. This conclusion, which is consistent with recent empirical research (see n. 3), implies that wealthy people are unlikely to support climate policy for selfish reasons. However, the desire to protect wealth does not necessarily give them a reason to oppose policy. Society should care about the value of assets writ large, without giving special attention to the narrow class of "stranded assets."

Young people might support climate policy because it increases their lifetime income, even if it reduces their current income. We find that this incentive can lead to substantial reductions in the carbon trajectory, provided that the young have a significant voice in policy discussions. This effect is strongest when the elasticity of intertemporal substitution is less than 1, as the empirical literature suggests. The introductory section discusses current national and international efforts to increase young

33. This research focus does not question the importance of intergenerational altruism in solving long-term problems. However, by abstracting from this altruism we can determine the importance of selfish incentives.

people's representation in the climate decision-making process. Our results suggest that these efforts could meaningfully shape climate policy.

Our research requires replacing the ILA with an OLG model and replacing the Ramsey social planner with a dynamic game among a succession of currently living generations. In addition, we introduced a nonlinear aggregation of consumption and investment good sectors to endogenize the price and the level of investment. This model maintains the policy invariance of relative factor returns, thereby isolating the effect of policy and climate on asset price. It parsimoniously describes a concave PPF, which can be calibrated to the elasticity of investment supply, thereby maintaining analytic and numerical tractability.

We show analytically that for small levels of abatement the two generations' incentives are aligned if and only if the elasticity of intertemporal substitution (EIS) is greater than 1. Using two-period specializations, we find that for linear preferences (EIS $= \infty$), a small level of abatement increases investment and the asset price, increasing welfare for the current young and old generations, and leaving the generation born in the next period with both a cleaner environment and a larger stock of capital. In contrast, for Leontieff preferences (EIS $= 0$), a small level of abatement crowds out investment, lowering the asset price and harming the current old generation, while still benefiting the current young generation and the generation born in the next period. The conventional choice in IAMs sets EIS < 1. With this choice, our results show that different generations are likely to have different (selfishly motivated) views on even moderate climate policy. This conclusion amplifies the importance of empowering the young in the climate debate.

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