Build Today, Regret Tomorrow? Infrastructure and Climate Policy

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Abstract

The timing of optimal policy to combat climate change is controversial: while some advocate a "gradual slope" in policy, others emphasise the importance of redirecting investments rapidly if we hope to meet a "2 degree" goal. We consider this question in the light of irreversible "dirty" and "clean" investments, such as in coal-fired and solar electricity generation. This leads to a "Reverse Green Paradox": to avoid stranded assets that demand fossil fuel (e.g. power stations) in the knowledge of an increasing carbon tax, we reduce emissions in the short term. This contrasts with the well-known effects of such policy on the suppliers of fossil fuels, such as coal mines. Moreover, when the cost of clean technologies decreases in line with their cumulative deployment (as has been clearly observed for solar power) it is optimal to begin deployment early. We derive these results theoretically, and quantify optimal policies in a dynamic general equilibrium climate-economy model.

Key words: infrastructure, clean and dirty energy inputs, stranded assets, carbon budget, climate change policies, green paradox

JEL codes: O44, Q54, Q58

Extended Abstract

How soon should we make sure all new investments are green? For example, what is the optimal time to stop investment into fossil fuel based power plants? The world continues to make big investments into their construction, particularly coal plants: estimates suggest almost 1 trillion US dollars of such investments are planned (Shearer et al. 2016). Moreover, over the last decade, emissions implied by investment in power generation have been rising at 4 percent per year. Given the long lifetimes of fossil fuel based power plants, the emissions embodied in this infrastructure potentially undermine more stringentlong-term

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climate objectives, such as the 2 C target (see Pfeier et al. 2016). And avoiding these potentially stranded investments provides an incentive to accelerate directed technical change (cf. Acemoglu et al. 2012).

We investigate these questions both theoretically and numerically. Unlike other leading models, we differentiate between capital stocks in use, with irreversibility in investments. We obtain results about both clean and dirty sectors of the economy.

First, we establish a novel theoretical result, which we call the Reversed Green Paradox: if dirty capital cannot be converted to other capital, then it is optimal to stop investing into dirty capital earlier than otherwise. This follows because we treat investments as irreversible (cf. Arrow 1968, Arrow and Kurz 1970). It implies an earlier shift to investment into the clean sector, to avoid later stranding of dirty energy sector assets. It therefore reduces emissions in the short term. Second, we show quantitatively that, to limit global temperature changes to 2 C, we stop investments in coal power plants very soon indeed but when policy is less stringent then these investments do not cease this century.

Others have also emphasized the wisdom of delay in deploying costly alternatives such as renewable electricity generators. But as we find, early investment is crucial. Our model of learning-by-doing is well supported empirically: we assume costs of new technologies decline as a function of cumulative installed capacity in the sector (Arrow 1962). Of course, this effect is accentuated by the early withdrawal from the dirty energy sector.

The set-up is a dynamic general equilibrium model, in which production of the final good requires energy, as well as labor and a general capital stock. Energy is a composite of electricity and other dirty energy sources; the electricity, in turn, is generated by clean and dirty power plants. Investment into building these plants is irreversible. The energy sector is calibrated using recent estimates from the literature (Hassler et al., 2012; EIA, 2016; Papageorgiou et al., forthcoming). The environmental set-up uses the representation of the carbon cycle and climate-economy feedbacks based on the most recent DICE framework (Nordhaus, 2014). However, in the light of recent criticism of damage functions in such models (see, e.g. Weitzman, 2010, 2014; Pindyck, 2015; Stern, 2016) we consider a wider range of economic damages from climate change. We especially focus on scenarios in which the global temperature change is limited to 2 C, in line with current real-world policy aspirations.

Our work further relates to the literature in the following ways. Our theoretical result linking investment irreversibility and ending investment into fossil fuel based power plants is novel, to the best of our knowledge. Our results are closest in spirit to findings of Arrow (1968), who was first to examine investment irreversibility in a deterministic setting. He showed that optimal irreversible investment is characterized by alternating periods of positive gross investment and zero gross investment; during the latter periods, the shadow value of capital is less than its user cost.

Secondly, the results relate to the so-called Green Paradox literature (see, e.g., Sinn 2015). Here, the prospect of future regulation increases emissions in the short term, as suppliers of fossil fuels wish to maximize their profits before their assets are stranded. In contrast to this literature we focus on the demandside for fossil fuels. In our model, the anticipation of future stringent climate policies decreasesshort-term investment in assets that might be stranded (such as coal-power plants). It follows that demand for fossil fuels decline, relative tothe counterfactual, and consequently emissions are reduced.

Our work is also related to a quantitative literature. Integrated assessment models quantify the effects of a variety of climate-economy interactions on climate policy. Papers assessing future emissions from the energy sector include Pfeier et al. (2016) and Davis et al. (2010). However, these are not dynamically optimizing frameworks, as in the economics literature. Other climate-economy models generally ignore the interplay between irreversible investment decisions, inertia in energy systems, and climate policies, on which this paper focuses. To the best of our knowledge, the only exception is Rozenberg et al. (2014).

Indeed, few integrated assessment models incorporate endogenous technical change. A notable exception is the work of Rezai and van der Ploeg (2014, 2016). However, their model permits very rapid learning, and so a very rapid transition between technologies, while our inclusion of sector-specific capital stocks implies a much earlier and slower transition.

Our paper is also related to the rich and growing literature on path dependence and climate change (e.g., Fouquet 2016; Aghion et al. 2014; and Aghion et al. 2016). We contribute to this literature by analyzing implications of path dependence embodied in carbon-intensive infrastructure in form of irreversible investment for the design of optimal climate change policies.

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