***Optimal climate policy in the face of tipping points and asset stranding***

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## Overview

The accumulation of greenhouse gases in the atmosphere is putting at risk the stability of the climate system. There is already solid empirical evidence that climate fluctuations reduce productivity, damage capital and thereby slow economic growth. There is also significant concern about non-linearities and tipping points in the climate system that may be encountered in the not-too-distant future. For these reasons and others, the international community has agreed to limit the increase in global temperatures by reducing greenhouse gas emissions to net zero over a period of just a few decades. Reducing emissions in this way will require a drastic reduction in the production and consumption of fossil fuels: a transition to a low-carbon economy.

Two main obstacles lie in the way of decarbonisation. First, modern production systems are heavily dependent on fossil fuels as intermediate inputs. Fossil fuels are still the main source of energy for electricity generation globally, they are required in the manufacturing of steel, cement, chemicals and other goods, and they power international transport. While in certain sectors low-carbon technologies are available and relatively attractive (e.g.renewable electricity), in others low-carbon alternatives are still far from being competitive with the incumbent technologies e.g.in heavy-duty road transport, shipping and aviation, and in cement, chemicals and steel manufacturing. Hence, further innovation is needed to offer viable low-carbon technologies to firms, which takes time.

Second, much of the existing stock of capital and infrastructure has been designed to work in tandem with the use of fossil fuels (e.g. coal and gas power plants and accompanying electricity distribution networks, steel mills and road networks). These are typically long-lived physical assets, financed with large initial investments under the expectation of a long and profitable asset life. Once installed, it would be costly, or sometimes impossible, to convert high-carbon stocks to other low-carbon uses. This creates a strong incumbency bias against a rapid low-carbon transition, as: i) firms do not want to suffer a negative revaluation of their assets, or a reduction in capacity utilisation; ii) investors holding financial assets issued by high-carbon firms want to avoid a drop in their market valuation; and iii) governments aim to avoid large-scale investments to decarbonise public infrastructure faster than its natural replacement cycle.

## Methods

This paper investigates how to strike a balance between avoiding dangerous climate change on the one hand and stranding high-carbon assets on the other hand. To do so, we develop an integrated assessment model (IAM) that simulates socially optimal carbon emissions and corresponding investments in two distinct capital stocks: green and dirty (in other words low- and high-carbon). The model has three distinctive characteristics. First, we introduce rigidities – adjustment costs – associated with the accumulation of either type of capital, with the conversion of high-carbon capital into low-carbon capital, and with the speed of emission abatement. Capital conversion plays a particularly important role. Whenever optimal investment in high-carbon capital is negative, high-carbon assets are stranded and firms spend money converting these assets into low-carbon capital. This incurs resource costs to the firms concerned and, if undertaken at high speed, it incurs wider economic costs. Second, optimal capital investment must be made under multiple climate and economic uncertainties, each of which is captured by a stochastic process. The social planner anticipates these uncertainties and responds to them by making corrections to the optimal emissions/investment path. That is, we solve the optimal path using dynamic programming, and our model belongs to the emerging class of `recursive IAMs'. In doing so, we employ Epstein-Zin-Weil preferences, which disentangle risk aversion from intertemporal consumption substitution, consistent with empirical data on asset returns. Third, we carefully calibrate the costs of emissions abatement in our model on data from a large number energy systems models contained in the IPCC database. We consider a number of different scenarios and perform sensitivity analysis on parameter values.

## Results

We find that introducing inertia in abatement has a large effect on the optimal emission scenario. The social cost of carbon is 15% higher compared to a model where stranding costs are neglected. For the optimal path from today onwards, we find that it is optimal to repurpose or strand 400 $Billion of dirty assets per year (1.5% of total investment).

Delaying the introduction of the globally optimal carbon tax by a decade, which we can think of as an approximation of continued difficulties in negotiating a sufficiently strong set of national climate commitments and implementing them, more than doubles the amount of stranded assets. Delaying climate action by 2 decades leads to a decrease in welfare of 0.7%, a cost of $108.5 trillion dollar at current prices.

We could seek to avoid stranding assets. Instead of imposing a Pigouvian tax on CO2 emissions, governments could institute a combination of taxes on dirty capital investment and subsidies on clean capital investment. We quantify the welfare cost of this second-best policy and we find that welfare is reduced by $10 Trillion at current prices.

## Conclusions

We show that taking the inertia of fossil fuel capital into account is important in designing optimal policy. Along with avoiding stranded assets, we should also put ‘smart’ stranding and repurposing of assets on the policy agenda. The uncertainties related to future climate damages, future policies and future abatement costs makes the case for early abatement stronger.