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ASSESSING THE COST-EFFICIENCY OF INVESTMENTS IN LOW- AND ZERO-CARBON TECHNOLOGIES

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Overview

We study the optimal timing and costs of investments in low-carbon and zero-carbon technologies (resp. LCTs and ZCTs) for producers of energy services (e.g, private mobility or power production). We assume that producers must decarbonize their production while facing an inelastic demand. We find that Marginal Abatement Costs (MAC, the cost of the last abated unit of greenhouse gas) are not equal to the carbon price, and are in general not equal for two different green technologies. Because of the inelastic demand, investments in one technology remove an option to abate with the other technology. Therefore, ZCTs should be deployed at a higher MAC than LCTs. The policy take-away message is that the cost-efficiency of technology-specific policies cannot be assessed from a crude comparison between the MACs (sometimes called the shadow carbon price) and the social cost of carbon.

Method

We develop an analytical optimal control model where a social planner controls the supply of a non storable energy service (e.g, private mobility) or a commodity (electricity). Starting from a sector which depends entirely on a high carbon technology (e.g, coal power), it builds and uses green capacity, which can produce this output at a higher cost and emit less GHG (e.g. wind or efficeint gas). It has to meet a *limited-demand constraint*, where at each point, the total production of the commodity cannot exceed an exogeneous unelastic demand. It also has to cope with a given carbon budget. In a second modeling step, we perform a numerical application to the European power market. This model adapts the model by Vogt-Schilb et al. (2013) to the case of competing technologies within a sector. The innovations are the limited-demand constraint, and an endogeneous utilization rate. This utilization rate allows to compute exact intertemporal MACs endogeneously.

Results

We find that optimal marginal abatement costs are not equal to the carbon price, and are in general not equal for two different green technologies. Moreover, ZCT should be deployed at a higher MAC than the LCT, because they embed the option to abate more in the long run. We also find that the optimal investment path to decarbonize the power sector displays several phases. Fig. 1 to 3 show our main results in a praghical way (the paper details the Propositions analytically).

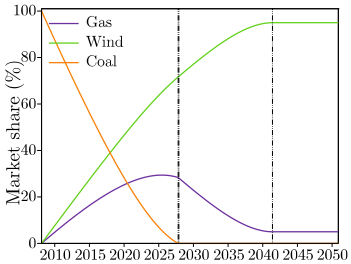

Figure 1: Market shares

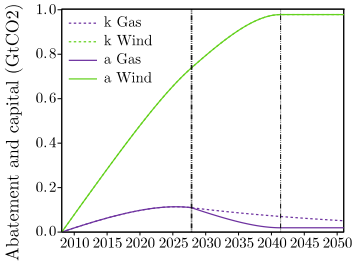

Figure 2: Abat. & capacities.

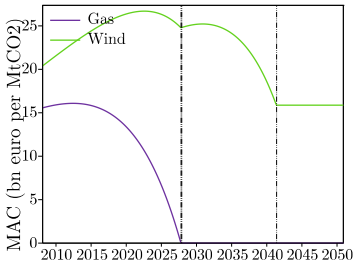

Figure 3: MACs.

Fig. 1 shows that market share of the baseline (coal, in orange) declines rapidly in the first phase, replaced by wind (in green) and gas (in purple). In the second phase, gas is replaced by wind. Fig. 2 shows that abatements with gas decrease faster than installed capacities in the 2^{nd} phase. Fig. 3 shows that the MAC of wind is higher than the MAC of gas.

Conclusions

We find that optimal marginal abatement costs are not equal to the carbon price, and are in general not equal for two different green technologies. Therefore, equalizing marginal abatement costs across technologies is not an optimality criterion to assess investments made to deploy competing low or zero carbon technologies. Zero carbon technologies (e.g, renewable power, electric vehicles) should be deployed at a higher marginal abatement costs than low carbon technologies (e.g. CCGT power production, fossil-fueled vehicles). This suggests that existing technological policies designed to spur investments in low-carbon capital may lead to an optimal outcome even if they first appear to set different carbon prices for different technologies.

Also, we found that the assessment of optimal efforts at a given point in time with a given technology requires to know in advance the future carbon price, profile of investments, utilization rate, and resulting costs of deploying and using each green technology. A program for further research is to determine, in a framework that would ideally incorporate uncertainty, limited possibility and incentives to commit, and imperfect foresight, what set of instruments may be designed by governments with limited access to this information, while actually helping firms to dimension their investments.

References

Vogt-Schilb, A., Meunier, G., and Hallegatte, S. (2013). Should marginal abatement costs be different across sectors? The effect of green capital accumulation.