***Optimal Mix of Policy Instruments and Green Technology Transitions***

Prudence Dato, University of Basel, prudence.dato@unibas.ch

Frank Krysiak, University of Basel, frank.krysiak@unibas.ch

## Overview

Technological change plays an important role in climate change policy and is one of the keys solution to ensuring green growth. Green and efficient technologies reduce the intensity of carbon emissions in the production process and the use of less natural resource. The transition to green technologies is expected in different sectors that mainly contribute to climate change. In the mobility sector, e-vehicles are replacing diesel and gasoline cars, while the electricity sector is switching from fossil-fuels to renewable energy. The same transition has been observed in the cooling sector with the phase-out of CFC-based products in the 1980s and 90s.

In the absence of public policies, markets alone are not sufficient to provide right incentives for the investment and diffusion of green technologies because of the presence of market failures. First, there are fundamental market failures associated to the innovation process due to the public good nature of knowledge and information. Appropriate policy instruments such as patents, licensing and R&D subsidies have been used for the innovation market failures. Second, there is an additional market failure associated with development of green technologies: the externality related to greenhouse gas emissions. Addressing these market failures altogether would necessitate the implementation of public environmental and technology policies with appropriate combination of policy instruments (Fischer and Newell, 2008).

On top of market failures, green technology transition often implies a change of the market structure as incumbents producing old technologies will face competition from new entrants that invest in the new technologies. As a response to this threat of competition, incumbents may decide to strategically invest in the new technology to avoid competition, to follow the new entrant or to become a leader in this new technology market (see Bondarev et al., 2020). This is the example of the mobility sector, more precisely the EV market. The environmental regulation has influenced incumbents behaviours in the EV market dynamic. For instance, Tesla has driven innovation in the EV market as a new entrant and has been followed by incumbents like General Motors, Toyota, Renault, Nissan, etc. However, the market structure is not static: local brands are becoming very competitive and contribute to drop EV prices.

In this context, what is the optimal combination of policy instruments that provides the right incentives to invest in green technologies? Does this optimal combination depends on the market structure and the level of environmental damages? What are the budget implications of this optimal combination for the regulator? Under which conditions on the level of damages is it socially acceptable to switch to the green technologies? Our paper intends to study some of these challenges by mainly focusing on the interrelations between market structure, r&d policy and environmental policy.

## Methods

To do that, we build our model on the framework developed by Bondarev et al. (2020) and include environmental and technology policies. We consider a small open economy in which the r&d investment is exogenous. We then limit our attention to the effects of environmental and technology policies on the local technology market. We assume that there are two types

of technology on an imperfectly competitive market: old technology that is polluting and new technology that is clean. We consider two instruments: emissions tax on the old technology for the environmental policy and subsidy to the clean technology for the innovation policy. Two different firms can offer the technologies: the old technology is developed only by the incumbent, while the new technology can be developed by both the incumbent and the new entrant. Depending on the market conditions, the market structure can be a Cournot competition with both new entrant and incumbent (with old and/or new technologies) or a monopoly with only one of the firms serving the technology market. The decisions of both firms and consumers are affected by the level of the instruments used for the two policies.

## Results

Using this model, we first analyse how market structure can affect optimal policy instruments during the green technologies transition. We show that the tax/subsidy scheme is different depending on whether incumbent supplies only the old technology or the new technology; or the new entrant only supplies the new technology. We then derive the combination of instruments that the social planner would prefer to implement depending on the level of environmental damages and the market structure. We find that in a simple case where the old technology is available and the incumbent supplies the new technology, low damages re- quire a subsidy while a tax is needed for high damages. While in the case only the entrant supplies the new technology, a tax is still needed for high damages but a subsidy is required for low damages only if the level of innovation of the entrant is sufficiently low. Furthermore, when the two firms share the market of the new technology and the old technology is phased out, there are some possibilities of negative r&d subsidies to the incumbent.

Second, we study the social budget associated with the optimal policies. We show that both the market structure and the level of environmental damages influences the social budget surplus or deficit. Finally, we conduct a welfare comparison and find that small accumulated level of innovation would motivate the regulator to choose only the old technology for small damages. However, when the market has accumulated enough innovation, the transition to only the new technology is welfare improving even for small damages.

## Conclusions

As policy implications, we suggest the implementation of both environmental tax on the old technology and r&d subsidy on the new technology-which should be different for the incumbent and the entrant-as policy instruments to support the green technology transition. However, to reflect the dynamics of the market structure, the regulator should not commit to a static combination of these two policy instruments. This mix of policy instruments should change depending how the incumbents and entrants behave.

## References

Bondarev, A., P. Dato, and F. C. Krysiak (2020). Green technology transitions with an endogenous market structure. Working Paper.

Fischer, C. and R. G. Newell (2008). Environmental and technology policies for climate mitigation. Journal of environmental economics and management 55 (2), 142–162.