How long does it take for a policy to affect the market? Analysing time lags in low-carbon technological change in Austria

Extended Abstract

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Short Abstract

We present an empirical approach to investigate temporal delay until a policy affects the market. We reconstruct timelines how selected low carbon technologies penetrated the market and how policy actors and agendas unfolded. This temporal relationship is studied via policy analysis and change point analysis. The methodological framework allows quantifying the time it takes to make certain policy steps and shows how swiftly these steps become effective for low carbon transformation.

Research Objective

Transforming the transport and energy sector of Western industrialised countries towards low carbon emissions calls for swift action. Relying on slow self-regulatory processes alone not only incurs substantial social and ecological costs but also limits the room for manoeuvre in the coming years (Stern 2006, Steininger et al. 2014, IPCC 2014). Facing these critical time constraints, decision-makers need to know which policies are effective and, more importantly, how fast these policies unfold on a society/regime level. The present paper estimates impact lags in policy implementation describing the timespan between policy actions, such as the passing of laws or regulations, and their actual impact on the market diffusion of low carbon technologies. Thus, we analyse the dynamic interactions between two parallel processes over time: the policy vector, describing how technology-specific policies are issued by EU, national and provincial authorities; and the technology diffusion vector, describing how a certain technology penetrates the market. Figure 1 illustrates schematically the interplay of these two vectors.

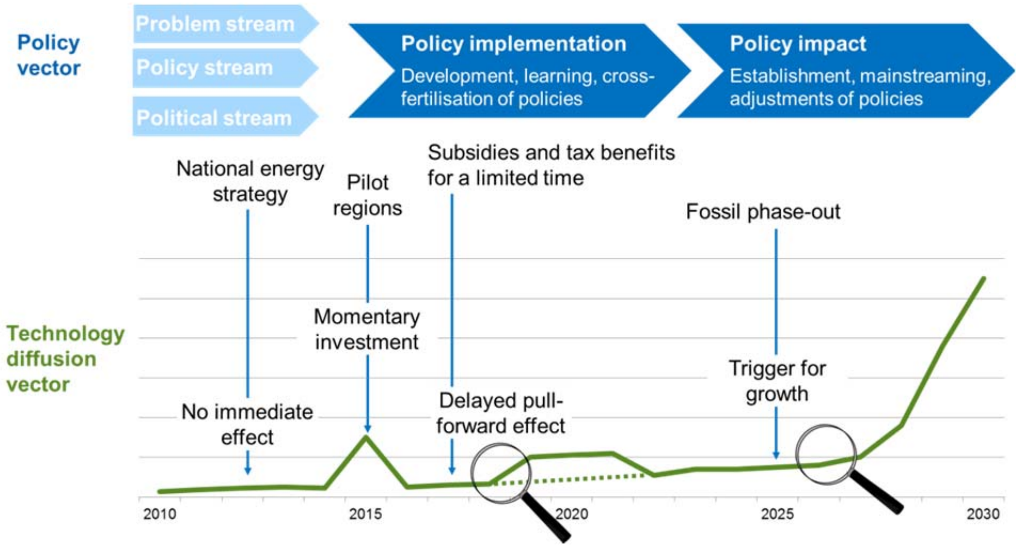

Figure 1: Schematic representation of the interplay between vectors

Time lags in the design, implementation and unfolding of policy measures have already been investigated in the economic literature on monetary policy (Kilponen and Leitemo 2011, Havranek and Rusnak 2013), or in political science (Crabbé and Leroy 2008, Nilsson et al. 2012, Spyridaki et al. 2014). However, to our best knowledge, an application to transformation research for a post-carbon society is still lacking.

Methodology

We investigate the market diffusion of electric and hybrid vehicles, heat pumps in residential buildings, and photovoltaics panels for private roofs for the case of Austria in yearly intervals during the last decades. The evolution of the policy vector is reconstructed along a historical time line drawing on document analysis and interviews with key informants. Multiple processes and actors are joined to narratives that identify critical junctures in Austrian policy deployment. The multiple streams model (Kingdon 1984, Howlett et al. 2016) serves to structure milestones how pertinent policies were developed, adapted and established. Additionally, where applicable, indicators of policy stringency such as fuel tax rates or feed-in tariffs are compiled as quantitative time series.

The technology diffusion vector is established from longitudinal market statistics (e.g., market shares, installed capacity). We fit six different model functions of increasing complexity (exponential growth, single change point detection, double change point detection, logistic growth, exponential growth with short term effect, integral of exponential growth with short term effect) to the diffusion curve of observed market data, and then estimate the probability of each observed data point under the assumption that the fitted model function is correct. Thus, outlier data points with a low probability (in other words, high significance) show points in time when the market unexpectedly deviated from the overall trend of the model function. Outliers may be the consequence of stand-alone policy events. Change points, on the other hand, are the statistically most likely points in time when the first-order derivative of the technology vector changed, i.e. when the speed of market penetration accelerated or decelerated. These turning points are then connected to preceding events in the policy vector. Fit indices such as AIC, BIC, R^2 and adjusted R^2 help to assess which model best represents the observed data. However, as only few market data points are available (e.g. from biannual resolution in the number of heat pumps), overfitting might be an issue and interpretation should be taken with care.

Figure 2 gives exemplary findings. Dots refer to observed market shares of newly registered commercial electric cars in the province of Vorarlberg; lines show the estimated models; the colour of the dots shows how likely a given market share in a given year is under the assumption that the estimated model correctly reflects the underlying market trend.

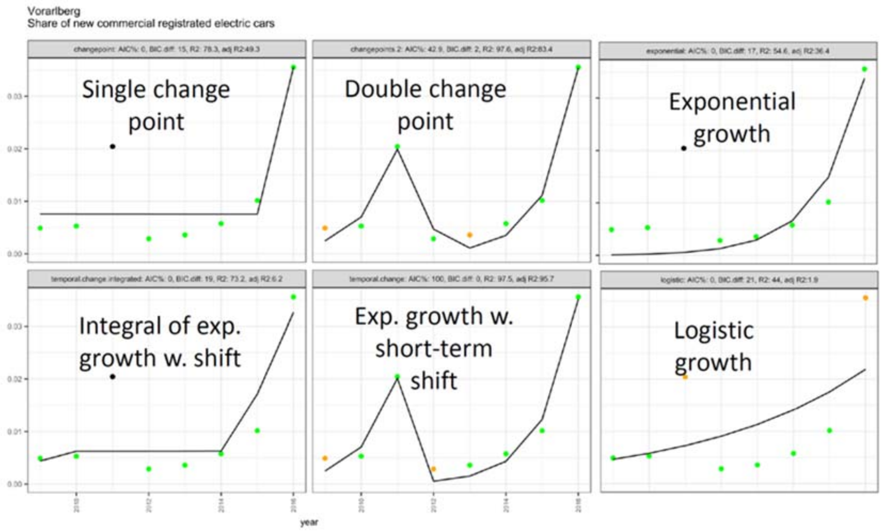

Figure 2: Change point analysis in the example of commercial electric cars in the province of Vorarlberg

Preliminary findings and discussion

Preliminary findings suggest a pull-forward effect of targeted polices for electric vehicles and heat pumps in the province of Vorarlberg. For instance, between 2008 and 2010 Vorarlberg had been Austria's first e-mobility model region (VLOTTE) and paid out significant subsidies to promote the purchase of electric vehicles. However, as soon as the subsidy was discontinued or small pilot regions had spent their investment volume, the diffusion curve fell back to the trend prevalent in other provinces. The model of temporal change (lower middle graph) shows the best fit and supports this interpretation.

Similar dynamics appear in the case of commercial e-cars in the province of Styria. From 2012 to 2015 the share of commercial e-car registrations rose overproportionately, but then the rate dropped suddenly. Then again in 2016, the diffusion curve rose strongly. Comparing the detected change points with the regional policy vector the first change point presumably is connected to the establishment of the e-mobility model region Graz and substantial funding of e-fleets in 2011. The Austria tax reform 2015 could have an impact on the rise of the e-car registration.

By compiling various cases of different technologies in different provinces, we aim to show typical policy impacts on market diffusion (see Figure 1):

- one-time effects with a momentary peak in technology uptake, e.g. from one-off large-scale investments
- pull-forward effects which push technology uptake for a short time, but then the diffusion curve falls back to the trend prevalent in other provinces, e.g. from subsidies which are offered over a limited period
- continuous growth effects when the slope of the diffusion curve becomes steeper, e.g. from introduction of mandatory product standards which favour low carbon technologies

The presented framework aims to quantify the time it takes for policy steps to become effective for low carbon transformation. However, temporal sequence alone does not suffice to derive full causality between policy and technology vectors: real-world policies may be developed in an adaptive and reflexive manner instead of dedicated milestones; technology vectors underlie socio-economic trends that may obscure the occurrence of change points; technologies evolve from niche to mature products following consumer acceptance. Thus, we propose to use insights from temporal delay as learnings for the timely design of transition pathways for Austria's transformation into a low carbon society.

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