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Transformative targets in sustainability policy making: the case of the 30% EU mitigation goal

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This paper explores to what extent moving towards the 30% GHG emission reductions by 2020 with respect to 1990 in the EU can be considered a *transformative target*. To do so, we first define the concept of transformative targets from a complex systems perspective and show a novel approach and original results using an extended application of the GEM-E3 model. Traditional macroeconomic models cannot easily handle key synergetic system effects derived from green growth and sustainability policies, and thus require additional features. We analyse the role of semi-endogenous growth driven by learning-by-doing and low-carbon investment expectations following a long-term transformative trajectory.

Keywords: EU climate policy; system attractors; macroeconomic modelling; sustainability

1. Introduction

Since the Rio Convention two decades ago, Europe has generally taken a proactive position with regard to international climate policies (Vogler and Stephan 2007, Oberthür and Roche Kelly 2008, Afionis 2010). Its leadership has been manifested by the willingness to implement higher greenhouse gas (GHG) emission reductions than any other large economy in the world. However, in recent times, and especially after the Conference of Parties in Copenhagen (CoP15), there are many signs that the European climate policy is losing much of the momentum it once had. In July 2011, the EU Parliament voted against moving the EU GHG abatement target from the current 20% to 30% by 2020 in relation to 1990 levels. This decision appears to be the product of a particular mode of framing the implications of tackling the global climate transition, mainly as a burden rather than a source for new forms of economic growth, development and social innovation. The European Commission

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(EC) has traditionally argued that the final EU stance in the international negotiations was to be dependent on the pledges of other countries in order to avoid 'higher costs', 'losing competitiveness' and to prevent European companies fleeing to other parts of the world with less stringent environmental regulations. We understand that such a way of framing is very much the result of the structure of modelling tools used to assess climate policy and its relations to GDP growth.

In this research, we look at to what extent certain environmental policy targets should be conceptualised, not simply as part of a sectoral and single-domain policy endeavour but rather as potential driving forces for the transformation of present social-ecological systems. In particular, we explore to what extent moving towards the 30% GHG emission reductions by 2020 with respect to 1990 (from now on called the '30% target') in the EU should be considered as a *transformative target*. To do so, we first define the concept of transformative targets from a complex systems perspective and discuss its usefulness in environmental and sustainability policies. Then we briefly review the recent EU climate regulatory framework to provide the background of the possible move toward this more stringent mitigation target. Next, we present a novel approach and original results using the GEM-E3 model, based on the assumption that traditional macroeconomic models tend to rule out key synergetic effects derived from green growth and sustainability by construction. A core premise is that a coherent policy context oriented towards a long-term transformation trajectory can boost green growth expectations and trigger a virtuous cycle of increased growth expectations, investment, learning-by-doing, GDP growth and employment. Hence, new modelling tools require taking into account these additional features and plausible system dynamics. Our results show the feasibility of a trajectory whereby moving towards the 30% target could boost GDP growth rate by up to 0.6% annually, both in the EU15 and the new EU12 member states, and would yield up to 6 million additional jobs in the EU27 by 2020.

2. Transformative targets in sustainability policy making: a complex systems perspective

Complex systems theory has traditionally been acknowledged by environmental science as a useful approach to understand the dynamics of natural systems and to develop tools and methods to support its management. Complexity is increasingly being regarded as a way to bridge natural and social sciences, to identify common patterns of social-ecological dynamics and structures and propose new ways of governance to cope with emerging intertwined risks of different types (Boulding 1975, Manson 2001, Folke *et al.* 2005, Janssen and Ostrom 2006, Liu *et al.* 2007, Teisman and Klijn 2008, Galaz *et al.* 2010). We limit ourselves to a discussion of how complexity informs the definition of the concept of *transformative targets* for sustainability and climate policy (Briassoulis 2004, Teisman *et al.* 2009, Gerrits 2010, Tàbara 2011) and in particular, its implications for macroeconomic modelling and assessment.

Complex systems exist whenever the behaviour of a number of interacting agents is characterised by a large number of degrees of freedom and follow large non-linearity dynamics. More precisely, complex systems are open systems that present the following properties: (1) large number of heterogeneous components/agents sharing a common landscape; (2) strong connectivity and interaction, i.e. different components are not independent and interact in non-trivial ways through clusters of networks, modules and hubs; (3) dynamics highly sensitive to initial conditions, leading to non-determinism and unpredictability of the system behaviour; (4) the existence of multiple cumulative feedback loops between different components, as well as at various levels in the system, which allow for systems' reconfiguration, learning and self-regulation; (5) the emergence: spontaneous self-organising structures irreducible to the system's components, related to how those components interact; (6) the presence of a large number of degrees of freedom; (7) strong non-linearity: small changes at a component level can have large effects at the global system level, although such effects are difficult to predict (Holland 1995, Byrne 1998, Holling 2001, Miller and Page 2007, Rotmans and Loorbach 2010). In addition, complex systems tend to be structured in polycentric and polymorphic modes. These types of structures entail that such systems cannot be understood or managed by using one single perspective or criterion. Agents operating in complex systems respond to multiple sets of rules and dynamics within units serving different purposes. The adaptive management of complex systems requires multiple ways of co-ordination, as well as some overarching mechanisms capable of harmonising the functioning and interactions between different subsystems.

We introduce the concept of *transformative targets*, as a potentially useful heuristics for policy making to support decisions related to overcome structural lock-in situations in complex systems, hence to prevent possible blockages and ensure their renewal and adaptation to changing conditions (Gunderson and Holling 2002). Our definition of a transformative target is based on the concept of attractors, as it is commonly used in complex system theory (Lansing 2003). On the one hand, attractors can be understood as the space in which systems configurations cycle back and again in a recursive way to the state in which they originally were (basin of attraction). However, more generally, an attractor can be seen as a point of order which induces particular dynamics and shapes the formation to a subset of agents or to the whole structure of the system. A particularly important feature of attractors specifically constructed for policy interventions resides in the fact that they allow the reduction of the space of possible states in which the system dynamics can evolve after a number of iterations. This makes it possible to perform analyses over smaller sets of plausible trajectories. In this regard, it is worth mentioning that attractors are often understood as equilibrium points. For example, Haynes (2008, p. 405) understood that "in qualitative terms, in a policy system, an attractor can be argued to be a set of values or logics that give a policy system a general characteristic of relative stability in a given time period". However, in our view, attractors need to be distinguished from equilibrium points. An attractor is better understood as the point to which the dynamics of a system – or parts of it – *tend to go*, while an equilibrium is where the system *remains unchanged* for some time. In some cases, attractors may be located in a space of equilibrium or stability, but in others, the system may be drawn to attractors, which are not stable, where such equilibrium or stability does not exist or cannot be known. This view is in accordance with Rotmans and Loorbach's interpretation of attractors in complex systems:

> Complex systems have multiple attractors. An attractor is a steady system preferred state, to which a complex system evolves after a long enough time. Attractors thus describe the long-term behaviour of a complex system ... Equilibrium behaviour corresponds to the fixed-point attractors, in which all trajectories starting from the appropriate basin of attraction eventually converge onto a single point. (Rotmans and Loorbach 2010, pp. 116–117)

In effect, complex systems tend to organise themselves around multiple attractors, operating at different system levels and responding to multiple interrelated functions and activities. The complexity of a system is precisely defined by the existence of such diversity of attractors, around which different components get organised for different purposes and often for complementary functions. Our approach considers 'the economy' as a dynamic complex system (the boundaries of which are socially constructed) operating within the larger social-ecological systems (SES). Thus, the 'economy' can simply be understood as a set of a particular type of interactions involving a set of agents in the broader context of a global system – thus following open and often unpredictable dynamics and prone to unexpected behaviours. This is opposed to the view of the economy as a closed system, which necessarily tends towards only single equilibrium. Our complex system view of the economy allows us to analyse dynamics which go beyond local perturbations around a 'business as usual' (BAU) scenario, or that assume an inevitable tendency towards stability (Holland and Miller 1991, Ramos-Martin 2003, Tesfatsion 2003). Under this perspective, we are able to consider multiple scenarios, equilibrium points as well as various outcomes and trajectories occurring at different levels and domains where economic agents interact. Indeed, there is clear historical evidence that economies can function under different regimes, and therefore multiple ways of structuring the economy are possible, depending on the different social-ecological conditions in which they operate; it is in this sense that complex systems resolve their dynamics around multiple attractors.

We consider a transformative target to be a policy-constructed attractor capable of triggering and/or accelerating large-scale modifications in the configuration of complex systems, and to reorient their overall and multiple dynamics towards a desired trajectory. A transformative target ought to enable the modification of dominant patterns of agents' interactions, trigger the formation of new networks of action, and mobilise resources of several subsystems towards a desired mode of organisation. Here we focus on one of the possible system attractors that could be used as a transformative target in environmental and sustainability policy making. In short, we assess to what extent the 30% target in Europe could be consistent with a path aimed at the restructuration of the European economy in ways that would yield a low carbon future, would boost new forms of GDP growth and investments and would be able to generate a new bulk of inclusive jobs within the EU in the coming decade and beyond.

3. Is the 30% target a transformative target?

3.1. Introduction

In April 2009, a series of EU Directives known as the 'Climate and Energy Package', as well as other legislative developments, were passed in an attempt to link a number of measures related to the reduction of GHG emissions, the promotion of renewable energy, and the improvement of energy efficiency.[1] The overall goal of the package was to achieve a 20% reduction of GHG emissions, improve energy efficiency by 20% and get to a 20% share in renewable energy by 2020. In addition, the Council of the EU also signalled its readiness to move to a 30% reduction target in 2020 under certain conditions, particularly with respect to the pledges of other countries.

Since then the European Commission (EC) has carried out a series of assessments to estimate the economic implications of moving beyond the 20% reduction target

Table 1. Effects of the 30% target according to Commission Staff (EC 2010a).

Variable	Lower bound	Upper bound
GDP (% change from 20% target)	−1.5	0.6
Employment (% change from 20% target)	−0.6	+0.7
Carbon price ETS (€/t CO_2)	30	55
Energy consumption (% change from 20% target)	−3.5	−6.5
Share of renewables in energy consumption (%)	20	22
Reduced oil and gas imports (billion €)	9	−14

by 2020 (EC 2010a, 2010b, 2012). The summary of such implications as per 2010 is given in table 1.

These estimates vary according to the assumptions made about the level at which the CoP15 pledges are implemented in the rest of the world, the access to international carbon credit markets, the modes of allocation of permits in the Emission Trading Scheme (ETS) sectors and the modes of recycling of revenues from the ETS. The overall picture suggests a relatively mild effect on employment and GDP, with a carbon price between €30 and €55. If the ETS revenues are recycled by reducing labour costs, this could create up to 1 million additional jobs (+0.7%). Other potential benefits are the decrease in energy consumption and in imports of fossil fuels. The EC has estimated that the economic crisis has made the achievement of the Climate and Energy package at least 30% cheaper (i.e. €22 billion) than in 2007 (EC 2010a). The crisis has also eroded the effect of the ETS as the core instrument to stimulate low carbon investments. Furthermore, and according to the Roadmap elaborated by the European Commission (EC 2011), in order to achieve GHG emission reductions of 80–95% by 2050 compared to those of 1990 would require intermediate reductions of 25% by 2020, of 40% by 2030, and of 60% by 2040.[2] In 2012, the Commission provided further analyses of the distributional consequences of moving to the 30% target at the member states level, and argued that:

> there seem to be potential mechanisms which, individually or in combination, could ensure an equitable distribution of costs and benefits between EU Member States if the political decision were taken to set a new GHG emission target for 2020 going beyond the current 20% reduction, taking into account the global context. (EC 2012, p. 9)

However, the modelling approaches used in these assessments do not consider the actual potential of green growth. They frame climate policy as the cost of the deviation from the single equilibrium growth path of the economy. As it will be shown in the next section, our approach to the implications of a strategy of moving beyond the 20% target and pushing it to the 30% takes a different line of reasoning. We advance an alternative modelling framing and consider the synergetic system effects of a policy fully committed to green growth and low-carbon development.

3.2. Modelling the systemic impacts of the 30% EU reduction target

Proposals to move towards strategies supporting ‘green growth’ and a ‘green economy’ are increasingly receiving international attention (OECD 2011, UNEP 2011). However, so far there is a lack of quantitative assessments of the actual effects of policies supporting low-carbon and sustainability pathways on GDP and employment. The bulk of economic climate assessments, including those used by the IPCC, model different scenarios as deviations from a single and optimal BAU trajectory. None of the SRES scenarios (IPPC 2000) take into account the potential synergetic effects on GDP growth, which could be derived from the actual implementation of low-carbon policies on a green growth path.

In order to deal with this difficulty and explore the potential transformative and systemic effects on certain policy targets, such as the 30% target, an alternative approach is required. For this purpose, we have developed a first attempt to develop a simulation procedure based on a standard computable general equilibrium model, the GEM-E3 model (Capros *et al*. 2010), which introduces several features allowing us to assess those scenarios that depart from the BAU scenario. In particular, we consider the semi-endogenous GDP growth effects of technological change derived from learning-by-doing, in a similar guise as proposed by Gerlagh and van der Zwaan (2003; see also Romer, 1990). In addition, we also look at the effects of positive expectations in the green growth trajectory, but we let them vary, as we consider that these are dependent on the actual effects of climate policy – and in our case, of the co-ordination of various policies aimed at achieving the 30% target (see Jaeger *et al*. 2011). In this research, by *positive expectations in the green growth trajectory* we understand those related not only to investments in low-carbon technologies, but also in other non-energy sectors as part of the alternative green growth path. Therefore, these expectations also include those that may be forming around new business in construction, industry, agriculture and services.

The GEM-E3 model is an applied computable general equilibrium (CGE) model that covers the interactions between the economy, the energy system and the environment (Capros *et al*. 2010). GEM-E3 is one of the prominent models used for climate policy assessment in Europe. The design of CGE models such as GEM-E3 is calibrated upon a unique, BAU, fossil-fuel intensive, equilibrium trajectory with full usage of resources and without endogenous technological change features. The GEM-E3 model covers the whole world aggregated to 37 regions (27 of which are the EU member states) and all production sectors aggregated to 26 economic activities. All regions are linked through endogenous bilateral trade flows. Firms operate under perfect competition regime and households follow a two-step budgeting decision process; first they decide between consumption and leisure/labour supply and second they allocate their budget among 13 consumption categories. The model includes all GHG emissions and their associated marginal abatement cost curves. GDP growth in the model is largely defined exogenously through the relevant assumptions on the exogenous technical progress, the evolution of active population and the expected rate of return on capital. The simulations performed with the model involved the imposition of a GHG emission constraint. This constraint generates a dual value (the carbon value) that is internalised in the economic agents' choices and drives the emission reductions. The simulation period extended up to 2020 where EU27 reduces its emissions by 30% as compared to 1990 levels. Thus, this methodological procedure was the one chosen to simulate the Business as Usual scenario.

In order to simulate the Green Growth scenario, we equipped the GEM-E3 model with semi-endogenous GDP growth features and with an alternative model of investment, which allows for variable expectations on green growth investments. Specifically, we proceeded to include into the GEM-E3 model the features related to the effects of learning-by-doing and the role of investment expectations as follows.

On the one hand, the consumption side of the GEM-E3 model is standard discounted utility maximisation, similar to the neoclassical growth model (Ramsey 1928, Cass 1965, Koopmans 1965). On the production side, the standard version of the model is characterised by exogenous technological change. Investment is driven by the myopic expectations of firms. Formally interest rate and expectations are linked through a relationship of the form:

$$I_t = \lambda K_t \left(\left(\frac{\mathcal{P}_k}{\mathcal{P}_i (r+d)} \right)^{\mu} (1+e) \exp(v) - (1-d) \right) \tag{1}$$

where λ, μ, v are parameters, K_t is the stock of fixed capital, d the depreciation rate of fixed capital, $\mathcal{P}_k$ is the price of capital, $\mathcal{P}_i$ the price of investment, r the interest rate and e measures growth expectations. We sum up equation (1) as

$$I = \mathrm{G}(\mathrm{r}, \mathrm{e}) \tag{2}$$

In the standard version of the model, technological change and expectations, which are the key drivers of growth through productivity and investment, respectively, are exogenously fixed and calibrated so as to reproduce the trajectories of a BAU scenario. The determination of equilibrium is very much in line with this in the neoclassical growth model: the growth rate is determined by the exogenous rate of technological change. Conversely, in the Green Growth scenario, expectations parameter e are used to represent the growth rate expected by the production sector. Expectations influence the level of investment and hence the growth rate. In our simulations, equilibria are understood as outputs of GEM-E3 simulations, such as that growth expectations and the actual growth rate coincide.

Moreover, in order to endogenise technological change we introduced learning-by-doing (see Arrow 1962) and let investment have an external effect on labour productivity through knowledge spillovers. Namely, we let labour productivity in the energy sector evolve as follows:

$$\omega_t = (I_t / K_{t-1} - d - g_{\omega} + 1)\omega_{t-1} \tag{3}$$

where g_{ω} is the exogenous growth rate of productivity, calibrated for the BAU scenario, and $(I_t / K_{t-1} - d)$ is the fixed capital growth rate (investment to capital ratio minus depreciation) in such a way that: (1) productivity increases faster than in the BAU scenario if fixed capital growth rate is higher than the BAU growth rate of productivity; (2) productivity increases as in the BAU scenario if the fixed capital growth rate equals the BAU growth rate of productivity; and (3) productivity increases slower than in the BAU scenario if the fixed capital growth rate is lower than the BAU growth rate of productivity. As the interest rate decreases, investment and then labour productivity increase. This makes a higher growth rate than in the BAU scenario feasible without additional labour resources. This is how learning-by-doing implements an inverse relationship between variations of the interest and the growth rate. This leads only to a marginal change in the equilibrium growth rate, but drastically modifies the shape of the technology curve. A shift in positive expectations in green growth can now drive the technology curve up, yielding real effects.

In order to account for the relative influence of learning-by-doing and the increase in the expected growth rate, two sets of simulations were run, one with learning-by-doing and expectations kept fixed, another without learning-by-doing but with increased growth expectations. Our simulations were carried out in a way that accounted for the synergetic positive effects of the development and implementation of low-carbon technologies on GDP growth and employment. However, a scenario which considers only increased expectations is not empirically relevant: it would require an increase of the labour force of more than 5 million people compared to any of the other scenarios, which simply cannot be empirically justified. In other words, the green growth scenario can only be supported by the conjunction of learning-by-doing and increased growth expectations.

Thus, the basic mechanism in the creation of such opportunity for a new growth path is the mobilisation of a *virtuous circle* of additional investment, learning-by-doing and renewed expectations in the actual feasibility of the green growth trajectory. Investing in low carbon technologies raises the investment rate above the BAU value and hence triggers GDP growth by raising aggregate demand. Learning-by-doing lets labour productivity increase together with investment. This makes a higher GDP growth rate than in the BAU scenario sustainable without overheating the labour market. A policy context fully committed to support a long-term transformative low-carbon trajectory can then spur a change in expectations in green business. Such a shift in expectations occurs as a result of the combination of the effects to the policy commitment to the mid- and long-term GHG emission reduction targets and the effect of learning-by-doing. In this case, a net positive real effect on GDP growth can be attained without crowding out alternative investments. It is precisely the consideration of these policy and systemic effects that is original in our modelling approach and which has largely been omitted by other perspectives so far.

Therefore, it is important to note that our analysis takes into account jobs created not only in the energy sector, but in all sectors of the economy. In fact, our approach has been rather conservative, insofar as it did not assume only a fast learning rate in technologies such as solar and wind (see Ek and Söderholm 2010, Jamasb and Köhler 2008). We assumed an average innovation rate across all sectors, based on historical empirical data. Notably, additional employment and GDP growth does not arise only from learning-by-doing and innovation in energy sectors. According to our findings (Tables 2 and 3), by 2020 raising the EU climate target from 20% to 30% has the potential to: (1) increase the GDP growth rate by up to 0.6% annually, both in the EU15 and the new EU12 member states; (2) generate up to 6 million additional jobs in the EU; (3) boost EU investments from 18% to 22% of GDP. Such results are independent of the attainment of an international post-2012 climate agreement and affect a broad array of economic sectors. Such a target is transformative in the sense that it puts in motion the necessary system changes in which GDP growth is materialised across various sectors, including agriculture, energy, industry, construction and services – all of which increase in production, with largest rates in the construction sector. Nevertheless, our results only demonstrate the feasibility of such a scenario if all the above conditions considered in our modelling apply. In the short-term period of one decade, the main reduction of emissions would come from increasing energy efficiency (including in buildings and integrated energy planning and management) and from shifting the use of coal to renewable energies and gas.

The features we added to the model let us explore some key dynamics in the GEM-E3 and help us to assess to what extent the 30% target can be considered a transformative target. Our research suggests that such a policy target is capable of leading to a new trajectory with significant positive effects on GDP growth,

Table 2. Macroeconomic features EU27.

Extended GEM-E3. Macroeconomic simulation results	New growth path for Europe	Business as usual	Δ
GDP in 2020 (billion $2004)	15,421	14,579	77%
GDP growth rate 2010–2020	2.8%	2.2%	0.6*pp*
Unemployment rate in 2020	5.3%	7.6%	−2.3*pp*
Millions of employed in 2020	239	236	−30.9%
Investment in 2020 (share of GDP)	22.4%	18.4%	4.0*pp*
Investment in 2020 (billion $2004)	3457	2685	28.8%
Emissions in 2020 (Mt of CO_2e)	3927	4414	−11.0%
Carbon price in 2020(€/tCO_2)	32.19	19.57	65.3%

Note: Δ: difference 20% vs. 30% either as percentage of 20% value or as difference in percentage points (*pp*).

Table 3. Sectoral production in 2020 (billion $ 2004).

Sector	Green growth	BAU	% change
Agriculture	520	508	2.49%
Energy	714	701	1.81%
Industry	10,935	10,052	8.79%
Construction	2028	1623	24.98%
Services	16,792	16,193	3.7%

employment and other co-benefits that would benefit sustainable development as defined in the seven goals of the EU Sustainable Development Strategy (EUSDS).[3] However, at the same time we acknowledge that such effects could only have a substantial transformative long-term impact as part of a longer time policy commitment to the goal of decarbonising the economy by the levels of 80–95% by 2050 – in ways that can secure the necessary time for learning-by-doing in green growth and the correspondent green growth expectations to consolidate.

5. Conclusion

This research provided a quantitative assessment of the impact of the EU 30% target, in order to explore to what extent it can be considered transformative from a systemic point of view. Our work started from the realisation that current macroeconomic tools are not able to deal with the synergetic system effects of the implementation of actual green growth policies, and therefore alternative modelling perspectives are required. As a preliminary solution, our approach extended the GEM-E3 model and equipped it with additional features for the development of scenarios which depart from a BAU trajectory. Our results showed a feasible scenario in which GDP growth rate could rise by up to 0.6% annually both in the EU15 and the new EU12 member states, yield up to 6 million additional jobs in the EU, and boost EU investments from 18% to 22% of GDP.

While the evidence provided in this research may not enough to qualify that such changes are 'fully transformative' by 2020 – mostly because of the relative short time span considered – our results suggest that showing that the effects of achieving such intermediate targets should not be considered as *costs*, but may trigger new forms of economic growth and employment, is a necessary starting condition for such transformation. Indeed, quantifying the potential synergetic effects of such policies is a necessary step in a reframing process in which the EU could engage in a new transformative pathway, in accordance with the more long-term and ambitious targets of 80–95% GHG emission reductions by 2050. Our analysis describes only that a new growth path driven by a 30% target is a plausible scenario, although it may not be the pathway leading to the highest GDP growth in absolute terms. There may well be other scenarios leading to higher GDP growth, but also with higher GHG emissions, thus not in accordance with the longer term EU target of the 80–95 % GHG reduction by 2050. For our scenario to fully materialise, it would require the full implementation of the measures within the EU Climate and Energy package, as well as other complementary ones that meet the 30% target and in the longer term the 85–90% target by 2050.

Therefore, the EU 30% target can only be regarded as transformative if conceived as part of the much more ambitious aim of overall system decarbonisation strategy and social-ecological restructuring, e.g. aligned with the long-term goal of EU 80–95% GHG reductions by 2050, with respect to 1990. Its force derives from the needed reconfiguration of a large number and diversity of economic sectors, most notably construction and industry – that is, not only limited to the energy sector. Of course other indicators to assess the transformative impact of such a policy target, besides the increase in green growth jobs and GDP, should also be considered in future research. Such high levels of GHG reductions cannot be achieved by technological fixes or by eco-efficiency alone. They entail not only changes in current economic practices and technologies, but also profound modifications in the core set of mindsets, values and tools used in thinking about the future of EU policy and economic systems' organisation. This demands a great deal of learning, experimentation and integration of knowledge at multiple subsystem levels. That is, a truly reframing process of the main set of general principles, as well as of innovation in models and methods, that are being used to assess the economic implications policies aimed to move human societies towards alternative and more sustainable trajectories.

To summarise, in the face of the current accelerated global change, a central role of environmental policy can be regarded as the art of identifying and selecting potential large-scale, complex system attractors and turning them into transformative targets better aligned with the predicament of sustainability. In this regard, climate policy goals should no longer be understood as a sectoral policy which is relatively detached from the dynamics of other policies or systems. On the contrary, they may better be thought through as potential structural transformative forces capable of pushing the configuration of our societies towards more sustainable futures. Our results show that this latter framing constitutes a much more robust way of understanding the current climate and development challenge, of the role of cross-cutting policy interventions, and of policy assessment tools and methods in this endeavour.

Notes

1. http://ec.europa.eu/clima/policies/package/documentation_en.htm
2. However, the European Parliament vote in July 2011 against pushing the EU mitigation goal towards 30% showed many of the difficulties that such science-policy process is

encountering and it is likely to encounter if an ambitious climate policy is to be pursued in the EU in the years to come.

3. These seven key challenges are the following: (1) climate change and clean energy; (2) sustainable transport; (3) sustainable consumption and production; (4) conservation and management of natural resources; (5) public health; (6) social inclusion, demography and migration; and (7) global poverty and sustainable development challenges (http://ec.europa.eu/environment/eussd/)

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