

*Climate change mitigation:
Relevant
insights from evolutionary
economics*

Pablo del Rio

Instituto de Políticas y Bienes Públicos

Consejo Superior Investigaciones

Científicas (CSIC)

INDEX

- What is Evolutionary Economics?
- What is special about Evolutionary Economics?
- What makes it a useful approach for climate policy analysis (value added)?
- What are the climate policy implications of an Evolutionary Economics perspective?
- What are the main problems of the approach when applied to CPA (modelling)?

What is Evolutionary Economics (EEv)?

- The scientific requirement to decarbonise the global energy system suggests the need for another technological revolution, implying major structural shifts in the energy industries and requiring the diffusion of low-carbon technologies (Barker 2007, p.189).
- Mitigation technologies ARE technologies: technological change theories/models apply.
- EEv deals EXPLICITLY with technological change from an economics perspective.
- EEv is particularly suitable to deal with a technological/institutional transition to a low carbon economy.

What is Evolutionary Economics?

- Several streams.
- Common features (Faber 2005, Frenken et al 2006, van den Berg 2007, del Río 2009):
 - Bounded rationality versus “perfect rationality”.
 - Heterogeneity/diversity of firms, strategies and technologies (in contrast to the “representative firm”).
 - Multiple equilibria (rather than an instantaneously reached, single equilibrium as in neoclassical economic models).
 - Uncertainty and routines to cope with uncertainty.



inertia and technological irreversibilities (**path dependencies, lock-in**). A major focus: competition between technologies.

- Technological change...


What is Evolutionary Economics?

- Technological change:
 - An endogenous process which depends on economic incentives and interests, knowledge accumulated in firms and institutions, capacities of firms and the institutional structure.
 - Treated as a dynamic and systemic process. Innovation and the socioinstitutional context interact (coevolution).
 - A cumulative process, with multiple feedbacks between stages (relevance of learning processes).

What is Evolutionary Economics?

- EEv tries to identify the factors that make society locked in to specific technological trajectories/technoinstitutional complexes.
- The neoclassical approach: is not very fit to grasp system changes, radical innovations or socio-economic transitions, because it is not capable to deal with diversity of behaviour and imperfect rationality (Frenken et al 2006, Van den Bergh et al 2005).
- Evolutionary models may be helpful in assessing and developing policy strategies to trigger technological transitions from one technological system to a future technological system (Frenken 2006).

What is Evolutionary Economics?

- The rigidity of the system to experience major technological changes is the result of several forces at play.
- Two major “lock-in” factors stem from the evolutionary economics literature (interrelated):
 - 1) The systemic view of technological change and the “structural” inertia of technoeconomic systems.
 - 2) The impact of learning effects and dynamic economies of scale  reductions in unit costs as the scale of production increases and the markets develop + improvements in quality .
- Two approaches to TC
 - Neoclassical models: focus only in factor prices inducing the adoption of a technology. “Get the prices right”.
 - EEv: technological transitions are triggered by higher prices of the old paradigm AND by the exhaustion of technological opportunities in the old paradigm and new technological opportunities in alternative paradigms.

What is Evolutionary Economics?

The systemic view of technological change and the “structural” inertia of technoeconomic systems:

- Inertia takes place at the level of individual and systemic (interrelated) technologies.
- Systemic interdependencies and coevolution take place between different elements of the technological system and between the technological system and the institutional framework in which it is embedded.
- Technological systems: multiple interrelated technologies and their supporting infrastructures and the technical, informational, economic and institutional relationships that enable them to work together (Maréchal 2007, Unruh 2002, del Río and Unruh 2007).
- Technological systems: very difficult to change because existing technologies benefit from a socioinstitutional context adapted to them.
- Radical technological changes require all sorts of changes (technological, institutional, social, economic and cultural).

What is Evolutionary Economics?

The impact of dynamic economies of scale and learning effects.

- R&D investments and diffusion provide a source of improvement and cost reductions for existing technologies.
- Diffusion allows technologies to benefit from learning effects and dynamic economies of scale.
- A dynamic source of lock-in: emerging, more expensive technologies may fall into the aforementioned vicious circle: they are not adopted because they are too expensive and they are too expensive because they are not adopted. Only public policy may break this source of lock-in.
- Conflict between short-term and long-term efficiency?

INDEX

- What is Evolutionary Economics?
- What is special about Evolutionary Economics?
- What makes it a useful approach for climate policy analysis (value added)?
- What are the climate policy implications of an Evolutionary Economics perspective?
- What are the main problems of the approach when applied to CPA (modelling)?

What is special about Evolutionary Economics

- “Of the large realm of innovation possibilities, a few are selected and used as the basis for further development. The selection has to do with economics (costs and prices) but also with expectations and institutions in the widest possible sense. History matters here in favouring innovations that fit existing regimes. Because of this society is locked into particular paths” (René Kemp 2008) <http://kemp.unu-merit.nl/#view>
- “EEv offers insights into the mechanisms that underlie innovations, structural changes and transitions, making it therefore of great value in framing policies aimed at environmental innovations and transitions to sustainable development” (Faber et al 2005).

What is special about Evolutionary Economics?

- Opening of economics to insights from other disciplines.
- Acknowledgement of structural and institutional barriers.
- Technological interdependence and interrelatedness.
- Focus on dynamics (long-term) and systems.
- Coevolution between the social, institutional and the technological realms, leading to path-dependence:
 - For example, formal and informal institutions can emerge alongside technological systems and impact their evolution in important ways.
 - For example, expectations and preferences co-evolve with and become adapted to the dominant technological system in an endogenous path-dependent manner (Unruh 2000).
- Path dependence: technological as well as institutional. Once established, technologies and institutions tend to become locked-in and undergo only incremental change for long periods.
- At the macroeconomic scale, technological systems and institutions can become intimately interlinked, feeding off one another in a self referential system: technoinstitutional complex, regime, paradigm...

INDEX

- Aim
- What is Evolutionary Economics?
- What is special about Evolutionary Economics?
- What makes it a useful approach for climate policy analysis (value added)?
- What are the climate policy implications of an Evolutionary Economics perspective?
- What are the main problems of the approach when applied to CPA (modelling)?

What makes EEv a useful approach for climate policy analysis (value added)?

- Technological change is very important in understanding the long-term relationship between the economy and the environment. Technological change is at the core of the Evolutionary approach.
- Precedents:
 - CGE modelling: technological change is exogenous, a “manna from heaven” (AEEI factor). It abstracts away from technological and institutional evolution. The understanding from engineering (bottom-up models) and history about path dependence and ITC is disregarded. Continuity and path independence is assumed. No LBD is assumed.
 - ETC modelling incorporate a form of learning processes. CGE models face considerable difficulties in incorporating ETC. Thus, the absence of ETC biases climate policy assessments (Koehler et al 2006), exaggerating abatement costs.
- When ETC is introduced (i.e., TC driven by economic factors), then the benefits from waiting are replaced by benefits from acting so as to induce the change and reduce the future costs (Köhler et al. 2006, Stern 2006, Barker 2008).

What makes EEv a useful approach for climate policy analysis (value added)?

- However, ETC is allowed for energy output but not for other sectors nor for other variables (X, L, C)(Barker 2008).
- ETC they still fail to integrate the main features of an evolutionary-inspired approach of TC, namely, systemic interdependencies, heterogeneity of agents and historical contingencies (Marechal 2007).
- An emerging stream of the economic literature on climate change mitigation has applied an evolutionary approach with the aim to emphasize the inertia in current technological systems (Kemp 1996, Unruh 2000 and 2002, Maréchal 2007, del Río and Unruh 2007, Rip and Kemp 1998, Foxon 2003...).

What makes EEv a useful approach for climate policy analysis (value added)?

- Evolutionary Economics could provide an insightful alternative because it allows for the integration of concepts such as “bounded rationality” while also focusing on economic dynamics resulting from innovation, selection accumulation, giving rise to new insights into the framing of environmental policies (van den Bergh et al., 2006).
- What is exogenous in traditional economics “comprises the endogenous core of evolutionary economics” (Dopfer, 2005).
- The added value of an evolutionary approach: TC is “contextualised” (i.e. the circumstances of its emergence are explained), A systemic vision of technologies as “interrelated” (Marechal 2007).
- EEv provides insights into the non-economic barriers to mitigation technologies and how they may be overcome (Barker 2008).
- The traditional treatment of production also normally rules out of court any modelling outcome that increases the growth rate of the economy as an outcome of climate policy (op.cit.). Is this realistic? Porter hypothesis, bottom-up modelling, ancillary benefits...

What makes EEv a useful approach for climate policy analysis (value added)?

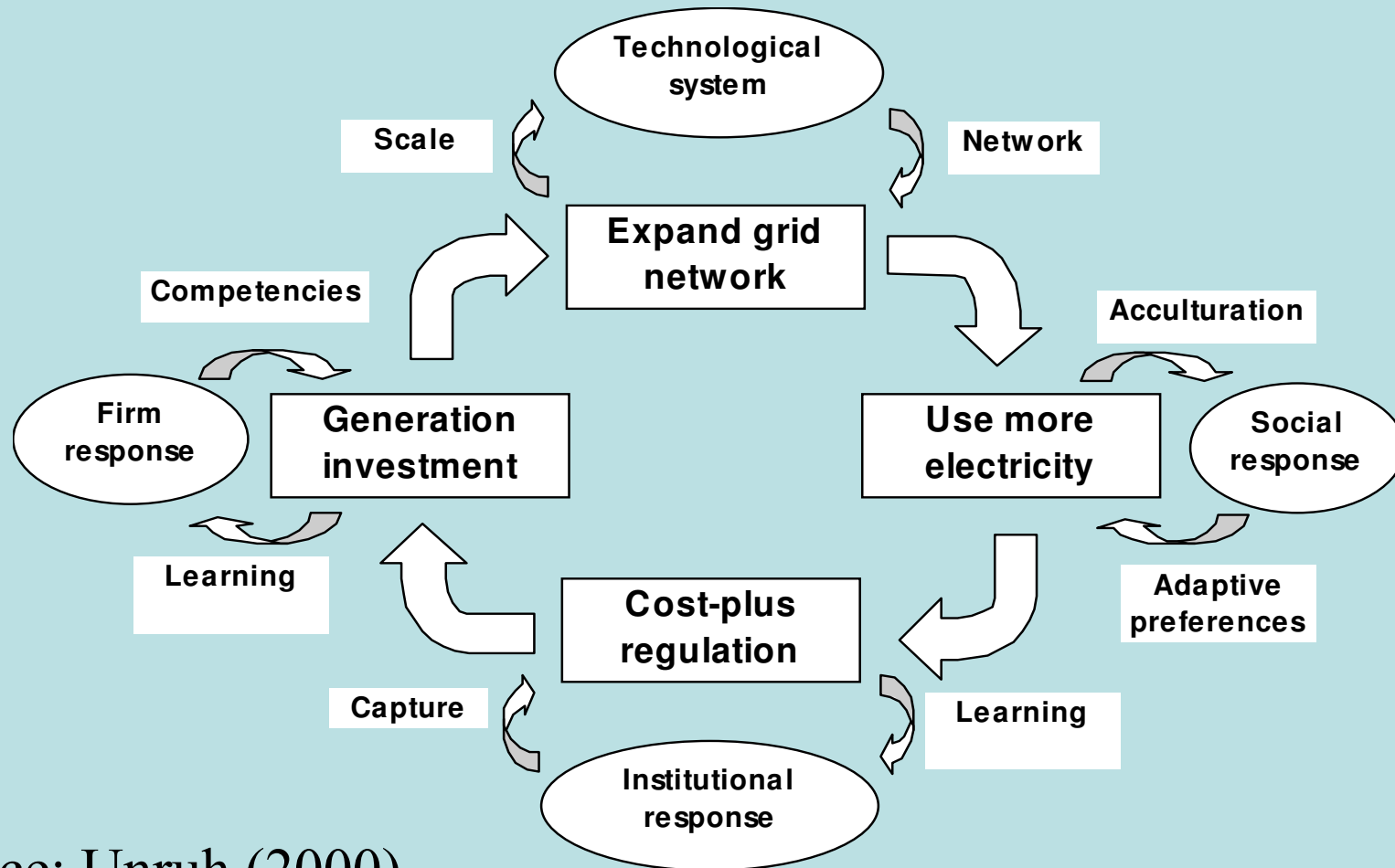
- Technologies belong to “technological systems” (interrelated components of connected in a network or infrastructure that includes physical, social and informational elements, Unruh 2000). For example, the automobile transport system is composed of cars, roads, traffic signs, garages, etc.
- Technologies are not only linked to other technologies, but are also interrelated with the cultural and institutional aspects of their environment (Marechal 2007).
- Inertia of technological and institutional systems, i.e., technological lock-in, path-dependence. Technological systems follow specific trajectories that are difficult and costly to change. As shown in Arthur (1989), these trajectories depend on historical circumstances, timing and strategy as much as optimality (i.e. the main focus of traditional economics).

What makes EEv a useful approach for climate policy analysis (value added)?

- Evolutionary Economics stresses that the dominance and persistence of lock-in leads to an ineffective and inefficient climate policy.
- “Carbon lock-in” has been used to denominate this persistent dominance of high-carbon technologies (in spite of the existence of low-carbon ones).
- Carbon lock-in: industrial economies have been locked into fossil fuel-based energy systems through a process of technological and institutional co-evolution driven by path-dependency (Unruh 2000).
- In industrial countries, the bulk of CO₂ emissions arise from complex technological systems (i.e., electricity generation and transportation) which are composed of interdependent, jointly consumed goods and services (Unruh 2002).

What makes EEv a useful approach for climate policy analysis (value added)?

Electricity generation techno-institutional system



Source: Unruh (2000)

What makes EEv a useful approach for climate policy analysis (value added)?

- Evolutionary economics provide a better understanding of the key factors that explain how and in what context technological change arises in order to adequately design climate policies aimed at promoting climate-friendly technologies and escaping carbon lock-in.
- The implications of climate change are long-term. Evolutionary Economics provides a framework to deal with long-term problems. Any framework inherently favouring the short-term is of little use for CPA (Marechal 2007).
- Systems thinking, which has frequently been lacking in climate policy decision-making.
- Insights from EEv. may inform policy aimed at large-scale transitions, such as from fossil fuels to renewable energy.
- Policy lessons might further involve insights about which instrument to use in which part of the innovation cycle (research, development, demonstration and deployment): Instrument combination.

What makes it a useful approach for climate policy analysis?

- Political economy, collective action and public choice considerations are essential, complementary and should be added.
 - Environmental economists: economic instruments are dynamically efficient because they provide a “price signal”. This “price signal” is assumed to be exogenously set by the regulator.
 - In reality, however, the setting of the target (and the signal) results from the interaction of the regulator and the regulated. In order to provide a sufficient incentive for technological change, such price signal should be set at a high enough level.
 - But when the influences of different stakeholders on target setting by decision makers are considered, it is unlikely that either tax rates or permit prices are high because there is an incentive by regulators to minimise the potential conflict with polluters.

INDEX

- Aim
- What is Evolutionary Economics?
- What is special about Evolutionary Economics?
- What makes it a useful approach for climate policy analysis (value added)?
- What are the climate policy implications of an Evolutionary Economics perspective?
- What are the main problems of the approach when applied to CPA (modelling)?

What are the climate policy implications of an Evolutionary Economics perspective?

- The conclusions regarding climate policy have shifted from “do little, later” to “take strong action urgently before it is too late” (Barker 2008).
- Evolutionary theory does not offer an “optimal policy” (Faber et al 2005).
- Techno-institutional lock-in is relevant to the climate change debate.
- Lock-in leads to the non-continuity of mitigation technologies and costs (Stern 2006).
- An alternative low-carbon world economy is more less costly depending on the reductions in costs that emerge when new technologies come into widespread use.
- Interlocking technological, institutional and social forces can create policy inertia towards the mitigation of global climate change, i.e., they they make it difficult to change the development path of existing technoinstitutional systems.
- Techno-Institutional Complexes (TICs) arise because large technological systems cannot be fully understood as a set of discrete technological artifacts but have to be seen as complex systems of technologies embedded in a powerful conditioning social context of public and private institutions.

What are the climate policy implications of an Evolutionary Economics perspective?

- Escaping lock-in is difficult: macro level forces create systematic barriers to the adoption of carbon-saving technologies at the level of technological systems and institutions.
- Most fossil-fuel energy technologies can be better understood as part of larger technological systems that provide energy services to consumers.
- Keep the options open (diversity versus standardisation). Difficult to pick winners.
- The further we delay the implementation of measures, the more likely and persistent the carbon lock-in.
- The lock-in process makes it unlikely that traditional cost-efficient measures (such as carbon taxation or tradable emission rights) will be sufficient to bring about the required radical changes, i.e., inertia and rigidity reduces the effectiveness of economic instruments.
- The efficiency and effectiveness of market-based instruments is overestimated in traditional economic analysis and policy-making (Faber et al 2005).

What are the climate policy implications of an Evolutionary Economics perspective?

- Not simply cost-effectiveness, but intertemporal cost-effectiveness. Traditional cost-effectiveness can be counterproductive and focused too much on short-run effects (van den Berg 2007). Technology policies should focus more on the *diversity* of technologies, strategies and business rather than on economic efficiency as the key goal (Faber et al 2005).
- Potential trade-off between short and long-term efficiency, between efficiency and diversity (del Río 2008, van den Berg 2007). Maintaining diversity has long-term benefits (and short-term costs).
- The lock-in can be broken down: exogenous factors.
- Instrument combination to escape lock-in
- Approaches to break the lock-in:
 - strategic niche management.
 - transition management.
 - Setting-up innovation networks

What are the climate policy implications of an Evolutionary Economics perspective?

- Instruments which achieve emissions reductions at low costs in the short-term (taxes, ETS) may not provide a sufficient incentive for technological change in the long-run:
 - Unlikely to be stringent enough to break lock-in in complex technological abatement systems (del Río 2008, del Río and Labandeira 2009).
 - Innovation is affected by many factors (del Río 2002).
 - credibility of future carbon price (Foxon 2007).
 - uncertainties, risks of options and timescales
 - under-investment due to spillover effects.
- They do not yield tax rates or allowance prices that are high enough to force radical innovation. They do not promote diversity.
- These technologies will be needed in the future to achieve emissions targets at moderate costs.
- Acknowledges institutional and non-economic barriers.

What are the climate policy implications of an Evolutionary Economics perspective?

....systems thinking is key!!!!

....long-term thinking is key (stable policy frameworks)!!!

...policy learning is key!!!

INDEX

- Aim
- What is Evolutionary Economics?
- What is special about Evolutionary Economics?
- What makes it a useful approach for climate policy analysis (value added)?
- What are the climate policy implications of an Evolutionary Economics perspective?
- What are the main problems of the approach when applied to CPA (modelling)?

What are the main problems of the approach when applied to CPA (modelling)?

- A substitute or a complement to existing models?
- Traditional economic modelling of CPA: able to offer a theoretical framework that allows for a policy assessment based on metric values, which are highly appreciated by decision-makers (Marechal, 2000).
- Two possibilities:
 - General models.
 - Specific models:
 - a. One specific technology
 - b. One specific mechanism
 - c. One specific population of agents
 - d. To follow a modular approach in which different parts of a technological system are modelled in separate models with clear interfaces among them

What are the main problems of the approach when applied to CPA (modelling)?

	ADVANTAGES	DRAWBACKS
General models	<ul style="list-style-type: none"> -Take into account all relevant aspects of TC (coevolution). -Serve to describe and understand the integrated <i>context</i> of large scale technological developments. 	<ul style="list-style-type: none"> -A high level of aggregation: many parameters present due to the large number of mechanisms of social processes included. -Validation significantly more difficult than simpler models.
Specific models	<ul style="list-style-type: none"> -Focus on understanding a specific aspect of technological innovation, thus greatly reducing the complexity of the modelling. -These specific models usually have less parameters and lead to more conclusive insight 	<ul style="list-style-type: none"> -Run the risk of lacking a clear perspective on the broader framework in which technological development takes place.

Source: Based on Frenken et al (2006).

What are the main problems of the approach when applied to CPA (modelling)?

- Formalising the co-evolution of technological and institutional systems is quite problematic and is in a very nascent stage of development (Unruh 2000).
- There are few policy-oriented evolutionary models.
- There is no complete scientific consensus yet on a single modelling paradigm (i.e., no convergence), but a number of examples of evolutionary economic models on micro-level problems is available as a useful starting point (Frenken et al 2006).
- It is impossible to build a generic model for the economic development of our society at large (op.cit.).
- “How to model” issues (van den Berg et al 2005):
 - Modelling interaction among phases? RDD&D. Lock-in at individual or across levels?
 - Are there currently models of lock-in that are policy relevant (enough detailed mechanisms to link policy instruments to)?

What are the main problems of the approach when applied to CPA (modelling)?

- Two essential recommendations for further development of evolutionary modelling with respect to environmental policy analysis (Frenken et al 2006):
 - 1. focus on a specific issue (a technology or a mechanism or a population), rather than taking into account all complexities;
 - 2. make sure that the empirical base in terms of mechanism and data is sound.

*Climate change mitigation:
Relevant
insights from evolutionary
economics*

Pablo del Rio

Instituto de Políticas y Bienes Públicos

Consejo Superior Investigaciones

Científicas (CSIC)

What are the main problems of the approach when applied to CPA (modelling)?

- Recommendations on evolutionary economic modelling to support policy studies (op.cit.):
 - It is important to identify the relevant stakeholders, underlying mechanisms and dynamics, and the relevant technologies (foresights);
 - Evolutionary model builders should therefore work in close association with experts in a particular field, as well as experts in different kinds of (technology) foresight studies.
 - Statistical and empirical information on populations, psychological, sociological and economic theory is needed to provide an adequate input to the model. It is therefore advisable to start with a well-known and well-described (in terms of mechanisms and data availability) problem.
 - An interesting approach might be to link the evolutionary model with other types of models: e.g. describe system options with an Input-Output approach using the DIMITRI-model (Idenburg and Wilting, 2004), and then simulate pathways to that system with an evolutionary economic model.
 - For the longer term, it is considered important to have a number of different model (concepts) available dealing with similar phenomena or questions. Within such model diversity one can envisage some level of model competition, which could enhance learning and insight in modelling approaches.