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Which conceptual foundations for environmental policies? An institutional and evolutionary framework of economic change.

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Abstract

This paper draws on institutional and evolutionary economics and contributes to an approach to environmental policy which diverges from mainstream prescriptions. The 'socio-technical system' is the core concept: this is a complex made of co-evolving institutions, technologies, markets and actors that fulfils an overall societal need (such as housing, production, mobility, etc.). A systemic and dynamic analysis of those structural changes which are needed to create more sustainable socio-technical systems is provided; actors – and their ability to influence politics and policy – are explicitly taken into consideration. Unsustainable socio-technical systems feature a relevant resistance to change, because they are embedded in the very structure of our society and because of the conservative action of dominant stakeholders; this is why no environmental policy will be effective unless it aims at 'unlocking' our societies from their dominance. But also a constructive side of environmental policy is needed in order to establish new and more sustainable socio-technical systems; consistently, environmental policy is viewed as a combination of actions that can trigger, make viable and align those institutional, technological and economic changes which are needed to reach sustainability. Again, actors (for change) are at the heart of this vision of environmental policy: as subject, because the creation of new and sustainable socio-technical systems is made possible by (coalitions of) actors for change; as object, because environmental policy – to be effective – must actively support the empowerment, legitimation and social networking of such coalitions. A 'chicken and egg' problem remains: who comes first? Actors for change advocating policies for sustainability or policies for sustainability supporting actors for change?

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1. The quest for a systemic and dynamic approach to sustainability[1]

Most of our needs – in terms of food, housing, energy, mobility, etc. – are fulfilled by systems which have proved to be environmentally unsustainable. Such systems feature two relevant characteristics which should be seriously taken into consideration when aiming at the ambitious goals of curbing greenhouse gas emissions and reducing all other environmental impacts of human activities. First characteristic: these systems are embedded in the very structure of our society. Behind each good and service we produce and consume every day one can find several interconnected elements: individuals, values, regulations, infrastructures, organizations, and so forth. Thus the functioning of these systems involves all dimensions (cultural, institutional, technological, and economic) of social life. Any attempt at reductionism (for example to the technological or economic dimension) is bound to fail. Second characteristic: these systems generate change in unpredictable ways. Their dynamics is made possible by the action of individuals, which generate causal sequences involving the change of many constituents of the system itself, thus conditioning the future action of individuals. This is why intentional action co-exists with unintended effects. In this context, no rational choice between given alternatives is possible ex-ante: alternatives are created – if they are – through action. If we keep in mind these two characteristics of systems, we realize that an effective approach to sustainability must be: 1) systemic, that is, able to simultaneously consider all dimensions of change, not only technologies or markets, but also rules, behavior, policies, etc.; 2) dynamic, that is, able to make change viable, by assuring the alignment of all new elements as they are created.

Standard environmental economics does not help to build an effective approach to sustainability precisely because it is not systemic, nor dynamic.[2] In the standard approach all non-market variables (rules, technologies, preferences, etc.) are exogenous and there is no room for purposefulness and uncertainty. Even when institutions are explicitly considered – as in the new institutional economics – they still depend on exogenous variables (preferences, powers, etc.) and on market-based transaction costs. All this means that sustainability is conceived without analytically considering a genuinely systemic and dynamic process of change. It is therefore not a surprise that standard environmental policy – whether it makes use of green taxes, tradable emission permits or new environmental markets – is nothing but an attempt to correct failures in the competitive mechanism and to restore market equilibria. Summing up: standard environmental economics is market-centered (that is, not systemic) and static (that, is not dynamic); for these reasons it is not adequate as a positive nor as a normative theory of sustainability.

So we come to the second founding idea – and main heuristic – of this paper: in order to build a systemic and dynamic approach to sustainability, one should look at other streams of economic theory, that is, to (classic) institutional economics and evolutionary

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[1] This paper is based on my contributions to the book: G. Marletto (Ed.) (2012). *Creating a sustainable economy. An institutional and evolutionary approach to environmental policy*, Routledge. It is also available as CREI Working Paper no. 1/2012: *http://host.uniroma3.it/centri/crei/pubblicazioni.html*

[2] Throughout this paper 'standard', 'mainstream', 'orthodox', etc. are considered as synonymous. To understand what is meant by 'standard environmental economics' is sufficient to refer to the more diffused handbooks such as the classical Baumol and Oates (1988) or the much more recent Callan and Thomas (2010).

economics.[3] Evolutionary and institutional economists have diffusely argued that a market-centered and static approach – precisely because of its conceptual limits – is inappropriate to represent change at a societal level. At the same time they have demonstrated the ability to manage the analysis of complex socio-economic systems, and of all that follows in terms of out-of-equilibrium processes, irreversibility, strong uncertainty, bounded rationality, etc. (Nelson and Winter 1982; Witt 1992; Hodgson 1993; Amendola and Gaffard 1998; Arthur 1999; North 2005; Metcalfe and Ramlogan 2006). These considerations have been applied to environmental matters too: unsustainability is nothing but the result of multiple societal lock-ins in high-carbon systems, and environmental policies take the form of intentional actions aimed at triggering systemic change and making the creation of low-carbon systems viable (Unruh 2002; Rammel and van den Bergh 2003; Nill and Kemp 2009). Power – nearly a missing issue in standard environmental economics – is centre stage in this approach: both because powerful actors are interested in the reproduction of existing unsustainable systems, and because institutions must be designed which ease collective action and overcome every resistance to change towards sustainability (Ostrom 1990).[4]
While a deeper analysis of how institutional and evolutionary economics consider environmental issues can be found in the relevant literature (Hodgson 2000; van den Bergh and Gowdy 2000; Vatn 2005), the rest of this paper is mainly aimed at sketching an institutional and evolutionary framework of economic change, which might be useful as a conceptual basis to design and implement effective policies for sustainability. In particular: the next two paragraphs consider how economic change is treated by institutional and evolutionary economics, respectively; the following paragraph draws on institutional and evolutionary basic concepts (uncertainty, lock-in, structured action, coevolution, group selection, etc.) and goes into the details of a framework of economic change; the last paragraph concludes and provides some hints for an institutional and evolutionary approach to environmental policy.

2. Institutional economics and change

Institutional economics dates back to the contributions of Thorstein Veblen, John Commons and other scholars, and it is today experiencing a revival, mainly due to Douglas North's studies (Vanderberg 2002; Hodgson 2004; Vatn 2005); a revival which was definitively set out by the 2005 birth of the Cambridge *Journal of Institutional Economics*. In this theoretical approach, studying the processes of institutional conservation, innovation and change is crucial to understanding the functioning of the economy.[5] Institutions – that is, systems of rules – are not exogenous, nor do they

[3] Institutional economics is sometimes called 'classic' or 'old' institutional economics to avoid any confusion with the 'new' institutional economics of Coase, Williamson and others; here we will simply call it 'institutional economics'. This terminological issue is further complicated by the fact that it is under dispute if Douglas North is an institutional or new institutional scholar; I agree with those who consider his work as a theoretical evolution from the latter to the former (e.g.: Zweynert 2009).

[4] Elinor Ostrom is not an economist, but a political scientist. More exactly, she is one of those scholars of environmental issues who have drawn concepts and inspiration from institutional economics. The fact that she won the 2009 Nobel Prize in economics indicates that criticisms to orthodoxy are more shared than one may think.

[5] For a recent comparison of theories of institutional change, see Kingston and Caballero (2009).

derive from the market: institutions coevolve with other endogenous variables (such as values, individual preferences, power relationships, technologies, and so forth) and the market is just one institution among others (Hodgson 2000). Moreover, 'markets and other economic institutions do more than allocate goods and services: they also influence the evolution of values, tastes, and personalities' (Bowles 1998: 75).

Institutional economists deeply and thoroughly criticize the spontaneous order and market failure metaphors that are at the heart of standard environmental economics (Bromley 2007). In particular, the very weak (if not illogical) conceptual foundations of the standard treatment of both environmental externalities and internalization policies are stressed.[6] William Kapp, with his book *The Social Cost of Private Business* (1978), paved the way to a multifaceted interest of institutional economics in many other environmental themes[7]; among these, one deserves more attention: environmental governance, that is, 'the establishment, maintenance and change of institutions to foster coordination and resolving conflicts over environmental resources' (Vatn 2009: pp. 61-62). Several scholars have contributed to the understanding of this issue and the resulting research stream has provided a positive and normative approach to the regulation of the access to – and use of – environmental resources which goes far beyond Hardin's still so influential 'tragedy of the commons' (McCay 2002; Vatn 2005; Paavola 2007).[8] A relevant corollary of this approach is the design – and experimentation – of participative procedures on environmental issues (Stag, 2007): these procedures are explicitly based on a criticism of the standard metaphor of the selfish 'economic man' and accordingly give room to ethical values as a basis for deliberation, learning and decision (Soderbaum, 200).[9]

But what is more relevant here is to understand how institutional economics has contributed to the analysis of change, and above all, of economic change. To accomplish this task I will mostly refer to the 2005 Douglas North's book: *Understanding the Process of Economic Change*. The starting point of this book is that 'the economic paradigm – neo-classical theory – was not created to explain the process of economic change' (ibid.: vii); the ending point is not a consistent theory of economic change, but rather the humble acknowledgement that human societies are continuously conditioned by uncertainty and exposed to the risk of sclerosis. This is why North's final suggestion to ensure the progress of mankind is adaptive efficiency, that is, 'an ongoing condition in which the society continues to modify or create new institutions as problems evolve' (ibid.: 169). North's approach to the analysis of economic change is genuinely dynamic: uncertainty is not an exception; on the contrary, it is one of the

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[6] For more details and references on the criticisms to standard environmental economics, see Marletto (2009).

[7] For a recent contribution to understand William Kapp's thought, see his posthumous book, edited by Berger and Steppacher (2011).

[8] Once and for all it should be acknowledged what Hardin wrote thirty years after his seminal paper: 'To judge from the critical literature, the weightiest mistake in my synthesizing paper was the omission of the modifying adjective "unmanaged". In correcting this omission, one can generalize the practical conclusion in this way: A "managed commons" describes either socialism or the privatism of free enterprise. Either one may work; either one may fail: "The devil is in the details" But with an unmanaged commons, you can forget about the devil: As overuse of resources reduces carrying capacity, ruin is inevitable. With this modification firmly in place, "The Tragedy of the Commons" is well tailored for further interdisciplinary syntheses' (Hardin 1998: p. 683).

[9] The debate on the conceptual foundations of standard welfare economics has generated an almost infinite literature; for an updated analysis and reference and for the introduction of moral motivation as a key component of environmental policy, see Hodgson (forthcoming).

permanent features of the environment where humans act. Taking stock of Herbert Simon's theory on bounded rationality, North explicitly considers institutions as social rules that have been devised just to take decisions in an uncertain world. But North goes further: institutions are based on beliefs – that are both a positive and normative model of the very structure of the society; but also this very structure may change. In other words, the world is more than uncertain, it is non-ergodic; thus there is no other solution than the continuous implementation of a collective evolutionary process of trial, error and learning. North's representation of economic change explicitly incorporates the notion of path-dependence, not only in the sense of new choices being constrained by what (culture, cognitive patterns, beliefs, institutions, etc.) is inherited from the past, but also as the result of the intentional conservative action of organizations which are linked to existing institutions; in North's words: 'We may well know a lot about how to make adaptable, efficient institutions; but if the people making political and economic decisions […] think that it would threaten their survival, they are not going to change' (North 2003: 8).

A relevant add-on to the Northian vision comes from the explicit consideration of the link between culture, interests and strategic action: 'In societies in which cultural factors seem to hamper economics and/or political development, it is important to "un-lock" cultural legacies by making them the object of public debate' (Zweynert, 2009, P. 57). In such a vision, the uneven distribution of power among individuals and groups is a potential source of societal lock-in; this is why North considers democracy as a collective process which is continuously open to innovation, thus creating the conditions for further progress. The core concept of societal lock-in is shared by many scholars of environmental issues; among the others: Gregory Unruh, who in 2000 and 2002 published two seminal papers on understanding and escaping 'carbon lock-in', and Timothy Foxon, whose work is mainly dedicated to the analysis of the 'coevolution of ecosystems, technologies, institutions, business strategies and user practices' (Foxon, 2011, p. 2258), which is at the heart of the transition process from high- to low-carbon societies. Foxon also refers to Pierson (2000) to show that North's core concepts of social path-dependence and lock-in have gained a foothold in political science too. The crossing of this disciplinary border is consistent with the long-lasting debate on transitions, policies and politics (Shove and Walker 2007; Genus and Coles 2008; Voss et al. 2009; Frantzeskaki and de Haan 2011; Meadowcroft 2011) such a debate signals that the political and power dimension of transitions should not be neglected, as the creation and diffusion of sustainable novelties is the result of a 'battle over institutions' between opposing coalitions: those defending the status quo and the others who advocate innovation (Walker 2000; Jacobsson and Lauber 2006; Sovacool 2008). James Meadowcroft goes further in stressing the political dimension of transitions: 'Transition management can contribute to the process by opening out the decision space, establishing new coalition of actors, and encouraging societal learning about various alternative. (…) But once it comes time to commit large scale public resources to particular technologies, or to tilt regulatory or political frameworks to favor particular approaches, it is to be expected that issues will be trashed out through broader societal debate and resolved by established political mechanisms' (Meadowcroft 2009, p. 337).

All these arguments imply that change – and the relation between institutions and change – cannot be understood without an explicit conceptualization of power (Avelino and Rotmans 2009; Safarzynska and van den Bergh, 2010). Moreover, what emerges from all the contributions is a representation of change as resulting from the coevolution

of cultures, institutions and organizations, with the structured action of powerful individuals and groups playing a driving role. Inter alia, this means that time has come to get a better understanding of the specific contribution of evolutionary economics to the analysis of societal change.

3. Evolutionary economics and change

Evolutionary economics mainly derives from the idea that – at a high level of abstraction – Darwinian principles may cover both natural and social domains (Hodgson and Knudsen 2010).[10] This is not the place to enter the interesting debate on generalized Darwinism; but there is one point that must be stressed *ab initio*: Darwinian principles – and, in particular, the mechanism of self-organization – are consistent with human choice. In complex evolutionary systems, intentional action co-exists with unintended (and sometimes unwanted) effects (Hodgson and Knudsen 2006). Purposefulness is not finalism. The fundamental mechanisms of Darwinian evolution – variation, selection and inheritance – are at the heart of several different economic research streams; among the many, just to indicate the most important fields of investigation: technological innovations (Freeman and Pavitt 2002), models of capitalism (Aoki 2001), behavior (Manner and Gowdy 2010; Bowles and Gintis 2011). Even North's work on history and institutional change may be considered as an application of evolutionary thinking to economics.[11] Some of these streams have generated a specific interest in environmental issues, in particular with reference to 'green' innovations (Sartorius 2006) and the management of the commons (Dietz et al. 2003).[12]

Two basic concepts of evolutionary economics are crucial for understanding economic change: coevolution and multilevel selection.

'Coevolution is the evolution of two or more populations through the action of reciprocal selective pressures and adaptation between them' (Winder et al. 2005: 355); this implies that coevolution should not be confused with simple mechanistic interactions, nor with more general co-dynamics processes. But, much more relevant here, coevolution generates processes of change which feature unpredictability, non-reversibility, non-ergodicity and complexity; referring again to the same researchers: "coevolutionary systems are evolutionary systems that may run far from equilibrium. (…) Each of the reciprocally linked evolutionary sub-systems has the potential to change the selection regime experienced by the others. When the selection regime changes, the dynamic rules of interaction change with them (…)" (ibid.). More accurately, the concept of equilibrium itself is not analytically relevant because 'Populations do not evolve towards a predetermined system state but in response to partly stochastic changes in each other' (ibid.). A coevolutionary approach has been applied to several domains: industries and technologies (Malerba et al. 2005; Safarzynska et al. 2011), demand-supply coevolution (e.g., Windrum and Birchenhall

[10] For a stimulating attempt to build a taxonomy of the different approaches to evolutionary economics, see Witt (2008).

[11] Actually North (2005: pp. 65-66) is explicitly fascinated by the evolutionary metaphor – mainly because it is able to integrate time and change – but then he diverges from it because, in his opinion, Darwinism is not consistent with human intentionality.

[12] For a review of the actual and potential applications of evolutionary concepts to environmental economics, see van den Bergh (2007).

2005), behavior and institutions (e.g., Bowles et al. 2003; Hodgson and Knudsen 2004), etc. Even the relation between human socio-economic systems and ecosystems can be considered as a coevolutionary one; Richard Noorgard is certainly the preeminent scholar of this relevant issue: his coevolutionary framework of the interactions between cultural and biotic systems probably is the most structured answer to the transdisciplinary claims of ecological economics (Gual and Norgaard 2010; Kallis and Norgaard 2010).[13] A coevolutionary representation of human-nature systems has also been applied to the management of natural resources; Rammel et al. (2007) and Kallis (2010), among others, study the interactions between the base of natural resources, the behavior of human agents, the emergence of institutions and policies, the developments of technologies, the supply and demand of goods and services, and so forth.

The other crucial concept of an evolutionary representation of economic change is the link between multilevel selection and power: multilevel (or group) selection theory of evolutionary change involves selection operating at both individual and group levels and 'addresses the formation, growth and interactions of groups and offers arguably the best available framework for thinking about dynamics within and between groups' (Safarzynska and van den Bergh, 2010, p. 747). Such a theory considers mechanisms which refer to individuals, both within a group (conflict, complementarity, cooperation, imitation, etc.) and between groups (formation of new groups, entrance into – or exit from – existing groups, migration from one group to another, etc.); as well as referring to groups (competition, splitting, re-assorting, spatial clustering, etc.). (van den Bergh and Gowdy 2009). The mechanisms of multilevel selection may apply to natural and socio-economic domains; here we are interested in understanding: the interaction between the mechanisms of 'cultural' group selection (that is, when individuals are human agents[14]) and the exercise of power, and how this interaction affects economic change. Safarzynska and van den Bergh have recently proposed a framework which shows that 'explaining the relation between power and institutional change using a [cultural] group selection approach may provide insight into how stable institutions arise, how institutional change can be stimulated or slowed down, and how this in turn affects the behavior of individuals' (Safarzynska and van den Bergh 2010, p. 749). Even if these considerations on the interaction between individuals, groups, power and institutional change may be extended as such to the wider domain of economic change, it is worth specifying two issues. First: intentionality, learning and power – however they are defined – become attributes of both individual agents and groups; second: individual agents may be defined also in terms of (changing) group membership (members or outsiders; leaders or followers; first-movers or laggards; etc.). Also crucial to the understanding of the interaction between cultural group selection and the exercise of power is the self-reinforcing process which links the abilities of a group to increase its material and immaterial endowments, to gain higher legitimacy, and to expand its network of relationships (Bergek 2008a and 2008b). To complete the picture on the issue of cultural group selection, we consider the recent contribution of Breslin (2011), where the evolution of individuals and groups is analysed also in terms of space; in particular, in terms of divergence between local practices and wider changes.

[13] But it must be stressed that if the Norgaard's coevolutionary approach definitely shares the field of ecological economics, not all ecological economics makes use of a coevolutionary approach to represent human-nature interactions. See again van den Bergh (2007) on this point.

[14] Obviously, human population is exposed to the mechanisms of both genetic and cultural group selection.

4. An institutional and evolutionary framework of economic change

4.1. What is specific to this framework

Now we begin to build a conceptual framework which relies on the findings emerging from institutional and evolutionary economics, in particular from their application to the analysis of economic change. Many other scholars have tried to accomplish such a task by referring to one of the above streams of heterodox economics, or to the cross-fertilization of both. It goes beyond the scope of this chapter to review all these contributions, but we acknowledge that the conceptual framework presented here extensively draws on the multi-level perspective (MLP) and on other systemic and dynamic approaches to the analysis of economic change[15]. This paragraph will stress what is specific of our attempt.

The first specificity is that our framework is not reductionistic: complexity is explicitly considered as a relevant feature of the process of economic change; this is why the overall picture is never explained by looking at – or by starting from – one or more specific elements. In particular – even if we will repeatedly refer to the literature on technological innovation – we will not yield to the temptation of technological reductionism: technology is just a structural element of the functioning of the economy which interacts with other institutional and economic constituents, and with agency. It is not considered as the core driver of change, not even as an analytical 'entry point' (Geels 2005).

Another specificity is that rather than focusing on functions, the model focuses on actions.[16] At the heart of the framework one can find the purposeful action of individuals and groups. All relevant attributes which connote action stay at the centre of the analytical scene: power, interests, agendas, conflicts, intentional pressure for – and resistance to – change, etc. As repeatedly stated above, this does not mean that the framework is deterministic, with individual and collective action as the cause and all changes in technologies, markets and institutions as the intended effects; it only means that genuinely evolutionary and coevolutionary dynamics are made possible by agency: there is no economic change without human action.

A final specificity is that the model considers politics as a crucial issue. Political discourses, interactions between political and non-political actors, policy-makers' agendas and – last but not least – laws, regulations and policies in force, are all constituents of economic changes that should not be ignored.

In the following, the explanation of most of the concepts will be supported by some examples mainly related to urban mobility.[17]

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[15] For critical reviews of this research field, see: Geels (2005), Markard and Trufferd (2008), Foxon (2011) and van den Bergh et al. (2011).

[16] The most structured and developed approach to the study of the functions of innovation systems is that of Anna Bergek, Staffan Jacobsson and other scholars; see, Bergek et al. (2008a and 2008b) and Jacobsson and Bergek (2011).

[17] For more details on a socio-technical analysis of urban mobility see Kohler et al. (2009) and Marletto (2011b).

4.2. Socio-technical systems[18]

The socio-technical (ST) system is the basic concept of the framework.
Societal functions (housing, feeding, production, provision of energy, etc.) are fulfilled by one or more ST systems. For example, the societal function of urban mobility is fulfilled by several ST systems: the internal combustion car, public transport, the bicycle, car sharing, etc. All ST systems are (more or less) stable configurations. The ST system is a meso-concept: at the micro level we find its individual constituents (rules, artifacts, knowledge, actors, preferences, financial resources, etc.); at the macro level (which is considered exogenous) socio-economic phenomena and trends can be found.[19] The functioning of ST systems can be conceptualized as structured agency (Giddens 1984): a structure of three coevolving sub-systems – that is, institutions, technologies and markets – is replicated and changed through individual and collective action and learning, which in turn are enabled and constrained by the above structure.[20] In other words: the complexity of ST systems is coordinated by its structure of coevolving constituents, and it is made possible by adaptive agency.[21] Institutions are considered here as a coherent and relatively stable set of general rules that (together with other structural variables) structure agency; such a set of rules is also called 'ST regime' (Geels 2005). Consistently with this definition, each sub-system features a specific set of rules, that is, a sub-regime.
Two more basic concepts complete the framework: 1) the dominant ST system, that is, a stable and powerful ST system which strongly influences the dynamics of all other subaltern or residual ST systems. A dominant ST system generates pervasive lock-in phenomena;[22] 2) the ST 'niche', that is, a space which is partially or totally protected from the interaction with other ST systems (Kemp et al. 1998; Schot and Geels 2008).[23] ST niches are particularly relevant for the generation and experimentation of novelties and for the gradual structuring and empowerment of new ST systems (Avelino and Rotmans 2009). For example, still with reference to the societal function of urban mobility: the internal combustion car is the dominant ST system; public transport is a stable ST system which co-exist with – and is subaltern to – the car ST system; the battery electric vehicle is an unstable ST system, located in a ST niche.

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18 The content of this paragraph has been partially revised after a stimulating discussion with Frank Geels; I thank him and I take full responsibility of what is written.

19 This is the 'landscape' in the terminology used by Geels (2002) and others scholars who share the MLP.

20 Similar representations based on the interaction of institutions, technologies and markets – even if named differently – can be found in: Perez (2002); Murmann (2003); Geels (2005); Gual and Norgaard (2010).

21 For a detailed analysis of the structure of a ST system and the coevolution of its three sub-systems, see Marletto (2011a).

22 The idea of co-existing – and both relatively stable – dominant and subaltern ST systems fill a conceptual void of the MLP. Some scholars use hybrid concepts – such the 'niche-regime' or the 'empowered niche' (Haxeltine et al. 2008; Frantzeskaki and de Han 2009) – which are not satisfying because they still refer to the low level of structuring featured by systems located in a niche. Only recently the concepts of dominant and subaltern regimes have been introduced by Kemp et al. (forthcoming).

23 The Bounded socio-technical experiment (BSTE) is a similar concept (Brown et al. 2003; Brown and Vergragt 2008).

4.3. Actors and power

As already stressed, (structured) agency is an essential element of the complex dynamics of ST systems. Actors – all featuring bounded rationality – are the engine of a coevolutionary process of change: through action and learning, they replicate the structure of the ST system, whilst generating – directly or indirectly, intentionally or unintentionally – the variation and selection of structural variables. Every actor features a vector of material and immaterial endowments (physical and financial resources, knowledge and skills, social capital and legitimacy, etc.) and is motivated by his interests, ideas and visions. Every actor's power – hence her/his ability to influence the dynamics of ST systems – is a function of the above vector. In this framework, power is cumulative; in particular, because increasing power is generated by action and learning (Avelino and Rotmans 2009), and because power, legitimacy, coalition building and access to resources are linked by a self-reinforcing process (Bergek et al. 2008a and 2008b).

Actors may be individual or collective (that is, groups). The role of collective actors in the functioning of ST systems is stressed by the literature, so that some authors explicitly consider ST systems as groups (however they are named) and institutions as rules shared by that group.[24] Actors' membership is then crucial to understand the dynamics and interactions of ST systems; in particular: 'core-actors' are those actors who are interested in – and actively act for – the reproduction of an existing ST system. Core-actors of a dominant ST system feature high levels of power, legitimacy and networking ability, and they are able to use their endowments to influence institutions, politics and policy; (Smith et al. 2005; Avelino and Rotmans 2009); 'enactors' are those actors who are interested in the emergence and establishment of a new ST system (Suurs et al. 2010).[25] Usually starting from a ST niche – and through empowerment, legitimation and the creation of an advocacy coalition – successful enactors are able to gain an increasing ability to influence informal rules, political discourses, agendas and formal norms and policies. For example: the automotive industry is one of the core-actors of the car dominant system; local authorities are among the core-actors of the public transport system; grassroots movements were among the enactors of the bicycle system in many European cities.

Other kinds of actors may be considered: non-core actors (or 'fringe' actors), that is, those actors who take part in a ST system without assuming a relevant role in its reproduction and outsiders, that is, those actors who are external to a given ST system. It must be stressed that both non-core actors and outsiders of a given ST system may be the core-actors of another ST system (Smith et al. 2005).

4.4. Actors and change

The dynamics of ST systems may be grouped into two large families: adaptation of

[24] For example: Holtz et al. (2008) refer to 'alignments' of actors; Avelino and Rotmans (2009) to 'constellations' of actors; Geels (2010) to networks of actors.

[25] I use the term 'enactor' because I feel it represents effectively an actor who is trying to transform a new idea into a social practice. I also think it is more general than the alternative terms, such as: 'social entrepreneur' (Brown and Vergragt 2008); 'entrepreneurial actor' (Bergek 2008b); 'cultural entrepreneur' (Zweynert, 2009).

existing ST systems and the creation of a new ST system.[26] Adaptation can be conceptualized as a cumulative process: innovations in institutions, markets and technologies take place along a dominant trajectory; the alignment of such innovations is granted by the incremental alteration of the structure and it is sustained by actors that are internal to the system and are committed to its survival (Unruh 2000). Things radically change in the case of the creation of a new system: new institutions, technologies and markets must be built; a process of extrication is needed to free resources, knowledge, actors, etc., that are locked into dominant systems; intentional and unintentional forces that generate their inertia must be overcome; a new process of multidimensional alignment must be triggered and made viable (Amendola and Gaffard 2006; Foxon 2011). But no structure is available to coordinate all these efforts, because the structure itself is created through change; in such a situation, one can even doubt if the creation of a new system is possible without the purposeful and increasingly coordinated action of enactors committed to change. ST niches may play a relevant role in both kinds of dynamics: in the case of adaptation, novelties emerging from niches may be incorporated into an existing ST system; in the case of creation, novelties emerging from niches contribute to the threats to the existing ST systems and to the establishment of a new one. (Schot and Geels 2007)

A taxonomy of the dynamics of dominant ST systems, in which the role of actors is explicitly considered (Geels and Schot 2007), is at centre stage of this framework: 'transformation' occurs when core-actors gradually adjust a dominant ST systems after pressures coming from the macro level or from outsiders, in particular from social groups and grassroots movements; 'reconfiguration' takes place when core-actors are able to respond to external or internal pressures by partially changing the structure of the dominant ST system, in particular by linking to (or by incorporating) non-core actors and the innovation they developed in one or more ST niches; 'substitution' is the result of a 'battle': actors coming from other ST systems, profit from the pressures on the dominant ST system and – after taking over the old core-actors – radically change it; 'de-alignment and re-alignment' involve enactors – usually coming from one or more ST niches – who, whilst the dominant ST system is destabilized by major external pressures, experiment radical innovations and eventually establish a new dominant ST system.

Some scholars (Hodson and Marvin 2010; Geels 2011) have recently hinted at the interaction between ST systems and space, suggesting that the local/urban level may have three different roles in the dynamics of the dominant ST system: 1) local ST systems may co-exist with a national/international dominant system (e.g., in the case of urban mobility); 2) ST niches may be located at the local/urban level, but then the dynamics of the dominant system takes place at the national/international level (e.g., in the case of energy networks); 3) the local/urban level is not relevant for the reproduction and change of the dominant ST system (e.g., in the case of ICT mass products).

[26] I refer purposely to the creation of – and not to the transition towards – a new ST system. Indeed I feel that the concept of 'transition' – well established in the relevant literature – implicitly refers to two basic ideas which are not shared by the framework proposed here, that is: a) the idea that both systems at the beginning and at the end of the transition are in equilibrium (whilst here we explicitly consider that systems – being complex configurations – usually are out of the equilibrium); b) the idea that the ending point of the transition is somehow known ex-ante (whilst here we explicitly consider that systems usually change in an unpredictable way, especially in the case of radical changes). I am aware that scholars of transitions do not indulge at all in finalism, but I am also convinced that the concept of creation (of ST systems) wipes out any possible misunderstanding.

Examples taken from three alternative scenarios of urban mobility may help to understand the above considerations (Marletto 2011b).[27] The first scenario ('Automobility') is based on the reconfiguration of the dominant car system and is generated by the integration of producers of batteries, electric engines and new materials, into the global automotive industry; the second scenario ('Electricity') results from an increasing number of experiments in urban niches and generate a substitution process: the (electric) car becomes nothing but an element of an energy system whose core-actor is the electric industry; in the third scenario ('Eco-city') coalitions of urban enactors support the alignment of new and existing elements (that is, new urbanism, public transport, bicycles, bike- and car-sharing schemes, electric propulsion, etc.): as a result, in several medium and big cities around the world, the car is nothing but a residual element of a new ST system of mobility, but the car ST system still reproduces itself at a global level.

5. Conclusions and hints for environmental policy

This paper has provided an institutional/evolutionary framework of economic change which is based on the dynamics of socio-technical (ST) systems, that is, complex configurations which fulfil a societal function (housing, mobility, feeding, etc.). The functioning of these systems is coordinated by the co-evolution of institutional, technological and economic constituents and is made possible by adaptive agency. The issue of power is central to the framework: dominant ST systems are actively reproduced and adapted by core-actors and generate pervasive lock-ins, whilst new ST systems may emerge as a result of the cumulative empowerment of coalitions of enactors. The creation of new ST systems usually starts in protected niches and can not fully deploy without enactors gain a substantial influence on politics and policy.

An institutional/evolutionary approach to environmental policy can draw on the proposed framework. As stressed above, dominant ST systems generate pervasive lock-in phenomena. Obviously this is also true for high-carbon dominant ST systems for energy provision, housing, transportation, industrial production, etc. And this is why no policy for sustainability may be envisaged without a prolonged, multidimensional, multi-scale and intentional effort aimed at overcoming all lock-ins into unsustainable ST systems. This implies that a policy for sustainability must have a dual nature: it must be de-constructive, that is, aimed at unlocking existing ST systems and constructive, that is, aimed at creating new – and more sustainable – ST systems. The verb 'create' is not used by chance: a sustainable economy will only emerge from the self-reinforcing alignment of several structural changes, that gradually give rise to a stable and powerful configuration of actors, institutions, technologies and markets, that is, to a new and more sustainable ST system.

It is apparent that this is not an easy task for policy: first of all because both the unlocking of the old and the creation of the new must be played on all the institutional, technological and economic dimensions of change; secondly, because approaches to change may need to be tailored to different local and supra-local levels; and finally because actors must be both the object and the subject of an intentional action for change: as acknowledged by many scholars, the building of a coalition for change

[27] For examples taken from the electric sector, see Verbong and Geels (2010).

should be one of the objectives of a policy for sustainability. Inter alia, this is why ST niches are also essential to gradually build up – and legitimize – coalitions of actors, who share new rules, interpretive frames and visions, and advocate all changes needed to create more sustainable ST systems.

But here we have a 'chicken and egg' problem; more precisely we have a problem of 'actors for change and policy for change': who comes first? The school of transition management implicitly suggests that they must be built simultaneously through reflexive governance and societal learning (Loorbach 2007; Foxon et al. 2009; Nill and Kemp 2009; Voss et al. 2009). Other scholars stress that change is usually triggered by actors who foster social, institutional, technological and economic innovations (Genus and Coles 2008; Bergek 2008b; Foxon 2011); in particular, Brown and Vergragt (2008) stress the role of grassroots movements. Others suggest that the answer should be researched in the political dimension of change (Smith et al. 2005; Frantzeskaki and de Haan 2009; Meadowcroft 2011). Further analysis is needed to get a better understanding of this point which is crucial for the design and implementation of effective policies for sustainability. The in-depth study of national and local success stories may be a fruitful research path.[28]

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[28] For example Jacobsson and Lauber (2006) and Buehler et al. (2011) are a good starting point to analyze Germany's 40 years experience with policies for 'greening' the economy and look for valuable hints on actors, policy and politics for sustainability.

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