# Utopia competition: A new approach to the micro-foundations of sustainability transitions

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**Abstract.** We present a new evolutionary political economy approach to the study of transition dynamics based on a co-evolutionary model of differential citizen contributions to competing 'utopias'—market fundamentalism, socialism, and environmentalism. We model sustainability transitions as an outcome of 'utopia competition' in which environmentalism manages to coexist with the market, while socialism vanishes. Our simulation-based framework suggests that the individual economic contributions of citizens to the battle of ideas—both the distribution within a utopia, and the interaction between different utopias—are crucial but much overlooked micro-factors in explaining the dynamics of sustainability transitions.

**Keywords:** Utopia, Sustainability transitions, Idea competition, Climate change, Citizens, Co-evolution, Evolutionary political economy.

## 1 Introduction

The scale and importance of environmental problems has given rise to new large-scale multi-disciplinary fields of research such as 'sustainability science' (Kates et al 2001) and 'sustainability transitions' (Geels 2002, 2004, 2010; van den Bergh et al 2011). These approaches largely reject simple economic models of market failure, and the corresponding policy solutions of Pigovian taxes, and instead build multi-level evolutionary and complex systems-based frameworks of socio-technical transitions that seek to understand "the factors that lead to the destabilization of existing regimes and the emergence of new regimes … [including] the question of how to deliberately reorient regimes and manage transitions toward sustainability" (Markard et al 2012: 957). In these systems-based approaches (Bergek et al 2008), regime transitions come about through interacting processes between different levels of the multi-dimensional complexity in socio-technical systems. Policy, in turn, is the process of instigating transitions in socio-technical regimes and guiding them onto sustainable trajectories.

However, a basic although little acknowledged weakness of the systems-based sustainability transitions approach is that it tends to presume consensus about the scale and importance of the problems, and almost entirely eschews Political Economy and Public Choice type concern with collective action mechanisms such as democracy. In consequence, little attention is given to analysis of conflict about the priority of environmental problems in relation to other large global externality problems (such as poverty, disease, war or terrorism), or how this plays out at the level of the individual economic agent as a citizen. The approach we develop in this paper seeks to build an *evolutionary political economy* approach to regime transitions by examining a new micro mechanism. In our new framework, individual economic agents are engaged in mutual competition to influence the ideas of other economic agents, seeking to bring about the socio-economic changes necessary to build up their 'ideal world' (which we characterize as a utopia).

We call this evolutionary conflict 'idea competition'—or utopia competition, as we will style it—and we characterize a *sustainability transition* occurring when an environmental utopia sufficiently dominates other utopias –or, at least, it manages to reach a significant strength in society against competing utopias. In this paper, this mechanism does not work through a public policy process (e.g. environmental regulations or public spending), nor through a market process (e.g. environmental-

friendly consumer preferences), but through the emergent consequences of individual economic citizens using their own resources to seek to influence the ideas of other agents. Therefore, we characterize the microeconomics of sustainability transitions as a battle of *ideas* (Keynes 1936, Leighton and Lopez 2012; Montgomery and Chirot 2015) which seek to bring about the corresponding socio-economic changes in society.[1] This focus on ideas as the organizing principles of a society (Dopfer and Potts 2008) enables us to create a model in which ideas compete for dominance as socio-political and socio-technical ordering principles, and in which agents contribute economic resources toward their preferred societal vision -or utopia (Berkhout 2006).

The role of what we call economic citizenship is only relevant in a world in which idea competition matters. In a world in which government power can impose a single vision of relative priorities, then idea competition is null. Likewise, idea competition presumes that: (1) there are different opinions over dominant ideas (utopias) in a society; and, (2) these opinions can endogenously change through persuasion and social learning. In our model, diversity of opinions means that different agents have different circumstances and know different things, whereas opinion change lies in the domain of social influence and political learning. None of these assumptions, all of which point to a complex and engaged civil society, feature strongly in mainstream policy models. This broad mistrust of civil society action (Ostrom 1990) has led to a characteristic portrayal of public goods problems being properly addressed only through market mechanisms or government mechanisms[2].

In this paper, we propose a co-evolutionary model over just three utopias—market, state and environment (a more general model has been developed in Almudi et al 2015 with five utopias)—in order to illustrate the dynamics that may result from heterogeneity in citizen contributions to promote their ideas, and the importance of initial conditions, learning, competition and non-linear dynamic feedbacks.

[1] Let us note that citizens may not only devote their resources (efforts, money, etc) to persuade others in the so-called *Public Sphere* (Habermas, 1989). Citizens can also devote their resources to direct engagement in other promotional actions (becoming members of civil activist organizations, founding new firms, etc.). In this sense, the conception of Dopfer (1991) considering ideas as time-less and space-less entities with *morphic* power, comes to our mind. In fact, extending our proposal along Dopfer (1991) conception of ideologies (or entire world-views and utopias) as "closure judgements" leading to real actualizations, is an exciting line for future research.

[2] Think of consumer preferences (Gowdy 2008, Sexton 2011), Pigovian taxes (Goulder and Pizer 2008), price and output constraints (Pizer 2002), or trade agreements (climate clubs, Nordhaus 2015).

More precisely, we develop a replicator dynamics model in which multiple intra- and inter-sub-systemic selection pressures coexist and bring about emergent properties in the form of social distributions of ideas regarding the "good society". We examine some properties through simulations, based upon historical data related to the rise of the environmental movement. Thus, we examine the sort of dynamics that our co-evolutionary frame can generate. We show that evolving differential *citizen contributions* toward favored utopias, can replicate the sorts of dynamics that a large-scale societal transition to a sustainable economy would entail. We also carry out a local robustness analysis and -considering the nonlinear and complex nature of the model- we spotlight future research lines and extensions.

Let us remark that most models that seek to understand sustainability dynamics with micro-foundations tend to focus on the economic choice behaviors in consumer markets or in political markets (Arrow et al 2004, Brekke and Johansson-Stenman 2008, Gowdy 2008, Sexton 2011, Ortega-Egea et al 2014). One acknowledged criticism of the sustainability transition literature is its lack of choice-theoretic micro-foundations (Geels, 2010). Our new approach introduces citizen behavior as a class of micro-economic behavior that is modeled as driving idea-competition. This enables us to study how specific behavioral and interaction assumptions underlying utopia competition may shape sustainability transitions.

This conception of the economic agent as a citizen can also be conceptualized as a new approach to *evolutionary political economy* that is based around a conception of an overarching social order built around a small number of fundamental *ideas*—e.g. the idea of the free market, the idea of democracy, the idea of communal property, the idea of environmental constraints, and so on. What we call idea competition (Leighton and Lopez 2012, Montgomery and Chirot 2015) means, first, that there are multiple fundamental ideas that constitute any social order; but second, that in any particular society the relative visibility and effects of these ideas may endogenously change as time goes by.

Additionally, let us mention that we use the term 'utopia' here in a slightly different way to that used in other literature (Hodgson 1999, Berkhout 2006). The notion of a coherent, worked out, and moralized vision is retained, but that is usually inferred in a totalizing sense. Rather, our conception of a utopia is that of the relative rank of an idea in relation to other ideas in society. A utopia is when your preferred

idea—or social subsystem, as we will elaborate below—dominates other ideas. In this sense, utopias compete for dominance within a complex society.

We suppose that each of these fundamental ideas forms a sub-system, as conceived in the manner of Boulding (1978) and Gowdy (1994). In a market utopia, for example, the ideas of the free market are the dominant ordering principle in society, and those of the state, and the environment are subordinated. In an environmental utopia the idea of nature is the dominant ordering principle in society, with the state and the market subordinated. Each citizen contributes to their own utopia to the extent that they contribute effort and economic resources to build up institutions, change laws, exert pressure and so on, and therefore benefit others with a similar conception of utopia. By choosing a utopia, and then committing effort and resources to it, each citizen plays a role in the co-evolutionary process of utopia competition. So preference over *ideas* as ordering principles define a *utopia,* with *citizens* differentially contributing to these utopias generating utopia competition and *societal structural change*. Thus, in our frame, economic agents are citizens that live in a world defined by *subsystems* of interrelated ideas that, taken together, compose a complex and co-evolving socio-economic order.

As we will see later on, following Page and Shapiro (1992), citizens in our framework build opinions and beliefs by gathering information from their peers –those who support the same utopia (Stern and Dietz 1994, Costa and Kahn 2003), as well as from citizens who support competing utopias. Each agent's utopic vision of the world is not always dogmatic, and can be changed through persuasion based on new information and new thinking (Ortega-Egea et al 2014). Citizens can change their own ideas in response to the persuasion of others, or can work to change the ideas of others; they can be disappointed or satisfied with their peers' contributions. In fact, citizens can change their minds (e.g. by changing their level of effort in support of a particular utopia), or they can even change their envisioned utopia. In turn, as citizens change their minds and act accordingly, they influence (and still are influenced by) other citizens and overall societal change.

Now, the rest of the paper is organized as follows: Section 2 develops a model of utopia competition with three competing utopias: Market, State and Environment. Citizens can actively contribute to promote any of these three utopias. Citizens also learn, change their opinions, influence (and are influenced by) others, and their

heterogeneous actions shape the social distribution of competing ideas regarding the "good society". Section 3 presents some numerical simulations of this model based on qualitative data on historical conditions. We further analyze the conditions under which an environment utopia can arise and sustain through time. Moreover we show that, under certain conditions, this utopia may dominate other visions as a set of principles to rule society; or, at least, it can reach and maintain a highly influential role in society. We present a robustness and sensitivity analysis in section 4 that elucidates future research lines around some particularly interesting and surprising properties of the model. In section 5, we use the outputs of the model to reflect on lessons for managing sustainability transitions, focusing on the role of both intra-group diversity in contribution effort, and inter-group competition.

## 2 The model

This section elaborates a multi-population dynamic model driven by coupled[3] systems of replicator equations. This model represents the whole society as composed of three different subsystems (utopias) –the market, the State and environmentalism. These subsystems/utopias appear in the model represented by the share of citizens in society that support each utopia at any time. As we will see, these shares may change as citizens support their ideal vision of society (utopia), and they try to persuade (or end up being persuaded) by others.

Additionally, we will distinguish (within each subsystem) citizens which contribute resources at low, medium or high levels to foster their societal view. More precisely, we will represent the intra-subsystem realm for each utopia by visualizing the share of citizens (within said utopia) contributing low, medium or high levels of resources to that utopia promotion. The intra-subsystem shares of citizens -contributing from low to high levels of resources- also evolve, both, through intra-subsystem citizen interactions and learning, and depending on the overall coupled dynamics of the alternative utopias.

[3] In fact, we set a model in which several population dynamics systems are interwoven (coupled). Some technicalities and definitions regarding "coupled replicator equations" -although in an evolutionary game-theoretic context- can be seen in Sato and Crutchfield (2003).

The full original model (for five utopias) is provided in Almudi et al (2015). Now, in this paper, we will consider just three utopias. We proceed in this way in order to leave aside dynamics not related to environmental issues. In any case, we present the model in a sufficiently general way so that future analysis for larger numbers of utopias should be easy to pose (although somewhat harder to explore). It should be noted that the proposed simplified version of the model has twelve (coupled) non-linear differential equations. Therefore, both, obtaining general analytical results, or carrying out a global simulation analysis, exceeds the scope of a single paper; it is a general research endeavour in itself. Nevertheless, we perform a local simulation and robustness analysis that, at least, provides a solid *proof of existence* for certain path-corridors in the model for which *sustainability transitions*—in the sense defined above—*emerge*.

Thus, our model assumes that citizens are pursuing different envisioned utopias according to their own opinions in terms of how the 'ideal world' should be, and we exemplify our framework by assuming that there are: i)market-oriented citizens (who prefer that Society is organized under the logic of market); ii)state-oriented citizens (who prefer to order Society under the logic of the State); and iii) environmentally-oriented citizens (who prefer that Society prioritizes the logic of Nature and environmental sustainability). The outcome of this competition may, we suggest, shape the dynamics of sustainable transition pathways.

## 2.1 Degrees of citizenship within subsystems

In the model, we assume that society is composed of boundedly-rational citizens who support a specific utopia, and defend it by spending a share of their total economic resources. We assume low contributions ($x_1$), medium ($x_2$) or high ($x_3$) contribution levels, such that $0 < x_1 < x_2 < x_3 < 1$, and $(x_1, x_2, x_3)$ are identical in all subsystems. The level of commitment to foster a specific utopia defines what we call each *agent's level of citizenship.* Moreover, to reduce to a minimum the number of parameters, we set $0 < x_1 < \cdots x_i\big(x_i = x_1 + a(i-1)\big) < 1,\ a > 0$, with the three aforementioned levels of contribution $(x_1, x_2, x_3)$ being identical within utopias.

If we denote as $\Pi = \{\mathrm{M}, \mathrm{S}, \mathrm{E}\}$ the set of alternative utopias/subsystems (market-oriented citizens within M, state-oriented citizens within S, and environment-oriented in E), we can define the corresponding distribution of citizens *within each subsystem* at

*t*, placed among the (three) alternative levels of commitment $(x_1, x_2, x_3)$ as follows: for each subsystem $\pi \in \Pi$ at time *t*, we denote by $s_{jt}^{\pi}$ the share of citizens within subsystem $\pi$ whose level of citizenship (level of contribution in pursuit of the corresponding utopia) is $x_j$. Therefore, $0 \leq s_{jt}^{\pi} \leq 1$, and within each subsystem $\sum_j s_{jt}^{\pi} = 1$. For the simplified case of three behavioral patterns we have ($j = 1,2,3$) within each subsystem/utopia $\pi \in \Pi$.

## 2.2 Citizen payoff

Formally, we represent the payoff function for citizens in each subsystem $\pi \in \Pi$, as follows:

$$u_{jt}^{\pi} = \left(\gamma_t^{\pi} + (s_{j+1t}^{\pi} - s_{j-1t}^{\pi})\right)x_j \qquad (1)$$

$\gamma_t^{\pi}$ is the share of subsystem $\pi \in \Pi$ in society (in terms of share of supporters of said utopia in society at *t*), $0 \leq \gamma_t^{\pi} \leq 1$, $\sum_{\pi \in \Pi} \gamma_t^{\pi} = 1$; that is to say, the sum of the proportions of supporters of the three utopias in society adds up to one.

The term in brackets $(s_{j+1t}^{\pi} - s_{j-1t}^{\pi})$ captures the local permeability to peers opinion—positive and negative local externality effects—depending on the intra-subsystem share of peers contributing more or less than those citizens contributing $x_j$.

The payoff in (1) depends on:

(i) the level of individual citizenship (contribution $x_j$), which is a good for the citizen although it bears opportunity costs;

(ii) the relative size of the citizens' favored subsystem ($\gamma_t^{\pi}$);

(iii) a double-externality effect through which citizens assess their costly level of effort with respect to that of their subsystem peers; term in brackets.

Following the discussion and theoretical proposal in Fatas-Villafranca et al. (2011) and Almudi et al. (2015), we include in (1) gains and (implicitly) costs in each citizen's payoff. Regarding (i), we assume that the level of commitment in pursuit of a utopia is a source of satisfaction which also implies opportunity costs, as resources devoted to this activity are not available for other activities.

With respect to factor (ii), it is reasonable to suppose that agents devote their resources and ideas to improve and extend the utopia associated with their favored

subsystem—e.g. building up new organizations and institutions to support the utopia's ideals, appearing in media, shaping other citizens minds, and so on. We propose that when the favoured utopia increases its relative size and presence in society by gaining supporters, this represents a source of satisfaction for the agent owing to a perception of self-realization and efficiency in action.

Regarding (iii), we incorporate indirectly the opportunity cost of citizenship into the citizen payoff. We suppose that citizens try to avoid their peers' free-riding (they perceive dis-satisfaction from the share of less-committed peers) while gaining satisfaction from even-more-committed peers. As justified in Fatas-Villafranca et al (2011), there exist behavioral and psychological evidence in favour of considering local externalities in the payoff-functions in this respect (we leave for future research the more complex case of global externalities).

For the specific case of *three level of commitments* within each subsystem it is clear that expression (1) would result:

$$u_{1t}^{\pi} = (\gamma_t^{\pi} + s_{2t}^{\pi})x_1$$

$$u_{2t}^{\pi} = (\gamma_t^{\pi} + (s_{3t}^{\pi} - s_{1t}^{\pi}))x_2$$

$$u_{3t}^{\pi} = (\gamma_t^{\pi} - s_{2t}^{\pi}))x_3 \ .$$

We allow that citizen payoffs endogenously change, both as the intra-subsystem distribution of peers evolves, and as the social share of the defended subsystem changes (we discuss this below). In addition, we can define the average level of citizenship within each subsystem as $x_t^{\pi} = \sum_j s_{jt}^{\pi} x_j$. The average payoff within each subsystem at any time is $u_t^{\pi} = \sum_j s_{jt}^{\pi} u_{jt}^{\pi}$. And, finally, it follows that the average level of citizenship in the society as a whole at time *t* will be $x_t = \sum_{\pi \in \Pi} \gamma_t^{\pi} x_t^{\pi}$.

## 2.3 Intra-subsystemic evolution (learning and boundedly-rational adaptation)

Citizens in our model can endogenously change, both, their level of citizenship (contribution of resources) in pursuit of a utopia, and they can also change their minds by choosing a different utopia. Consider, first, the possible change in the level of citizenship (intra-subsystem/intra-utopian change). We assume that heterogeneous

boundedly-rational citizens coexist within each subsystem. Thus, citizens differ in their commitment levels and, as we have seen, receive a specific payoff attached to this contribution level. Since they feel the gains and costs associated to their behaviour—see (1)—they may assess and revise the possibility of maintaining or changing their level of citizenship contribution.

We assume that citizens interact with peers and as they see more or less committed peers, they may revise whether they are contributing too much or little in pursuit of their worldview. Citizens reflect and may update their commitment level through peer interaction (word-of-mouth communication; mass media; common social spaces, etc.). Of course the process we are modeling is a stylized representation of real communication processes. In any case, in the model, we assume that in those cases in which the specific citizen payoff turns out to be too high or low as compared to alternative behaviours (i.e. those observed in subsystem peers), the citizens may update their levels of citizenship.

More precisely, let us denote by $f_{ij}^{\pi}$ the rate at which citizens contributing $x_j$ switch to behavior $x_i$ (within subsystem $\pi$) in pursuit of more satisfactory behavioral patterns. The switching rate is:

$$f_{ij}^{\pi} = \theta max\left(u_i^{\pi} - u_j^{\pi}; 0\right),\ \theta > 0$$

In this function, $\theta > 0$ captures the ease with which citizens may change their behaviour. We assume that, given the valuation criteria in (1), when a citizen with commitment $j$ meets another with commitment level $i$ within subsystem $\pi$, she discovers the possibility of adopting behaviour $x_i$. Then, by comparing her present satisfaction $u_j^{\pi}$ with the level $u_i^{\pi}$ enjoyable in case of contributing $x_i$, the citizen may decide to change their behaviour. These are boundedly-rational citizens, so we have a certain flow of citizens gradually moving in the (endogenously-changing, non-unique) "better-valuation" direction, rather than having a representative agent making rational choices. If we assume that $(\delta\, s_i^{\pi}\, s_j^{\pi}),\ \delta \in (0,1)$ gives the probability for a random and independent interaction between one citizen with behaviour $i$ (share in the population $s_i^{\pi}$) and other one with behaviour $j$ (share $s_j^{\pi}$)in a small interval $\Delta t$, the flow of citizens from $j$ to $i$ would be given by (Hofbauer and Sigmund 1998):

$$\delta s_i^{\pi} s_j^{\pi} f_{ij}^{\pi} \Delta t$$

and the change in the proportion of citizens with behavior $x_i$ would be:

$$\Delta s_i^{\pi} = \sum_j \delta s_i^{\pi} s_j^{\pi} \left( f_{ij}^{\pi} - f_{ji}^{\pi} \right) \Delta t$$

where

$$f_{ij}^{\pi} - f_{ji}^{\pi} = \theta \left( u_i^{\pi} - u_j^{\pi} \right)$$

Therefore, the continuous time-evolution of the proportion of citizens with contribution $i$ may be described by the equation (Fatas-Villafranca et al. 2011):

$$\frac{ds_i^{\pi}}{dt} = \sum_j \delta s_i^{\pi} s_j^{\pi} \left( f_{ij}^{\pi} - f_{ji}^{\pi} \right) = \delta s_i^{\pi} \sum_j s_j^{\pi} \theta \left( u_i^{\pi} - u_j^{\pi} \right)$$

$$= \theta \delta s_i^{\pi} \left( u_i^{\pi} - \sum_j s_j^{\pi} u_j^{\pi} \right)$$

Equivalently, by changing velocity, we can represent the evolving intra-subsystem distribution of citizen contributions—through learning and adaptation—by the replicator dynamics system:

$$\dot{s_{it}^{\pi}} = s_{it}^{\pi}(u_{it}^{\pi} - u_t^{\pi}), \forall i$$

In this formulation of *intra-subsystem dynamics* changing commitment levels emerge, as do different trajectories for the average level of citizenship within each subsystem. In this way, intra-subsystem dynamics is a social learning mechanism for the three different subsystems (utopias) that co-exist, i.e. $\Pi = \{\mathrm{M}, \mathrm{S}, \mathrm{E}\}$.

To sum up, we can define three intra-subsystem dynamics by using three replicator systems through which citizens adapt and re-adapt their contributions depending on their relative payoffs. Drawing on the three co-existing utopia-subsystems, we arrive at the following three (replicator) systems of (three) differential equations each (Fatas-Villafranca et al. 2011) for the three utopias:

$$\dot{s_{jt}^{\pi}} = s_{jt}^{\pi}\left(u_{jt}^{\pi} - u_t^{\pi}\right) \quad \forall j, \forall \pi \in \Pi \qquad (2)$$

If we look at (1) and (2), we have three subsystems with non-linear internal interactions (replicator plus local externalities in the payoffs (1)). We complete the model by assuming that all citizens in society observe the distinct evolutions of average commitment (or citizenship) levels emerging from the competing utopias/subsystems. The average levels of citizenship emerging from the different subsystems is defined as $x_t^{\pi} = \sum_j s_{jt}^{\pi} x_j$.

Therefore, these average citizenship levels may play the role of proxies to the intensity with which citizens supporting the alternative utopias are able to persuade others through their efforts in the social arena. Of course, as citizens get involved in these debates, they may change their utopia thinking by changing from one subsystem to another. This means that equations (2) together with the payoffs (1) will not be independent in our model, but interconnected through the endogenous components $\gamma_t^\pi$ in (1)—which evolve according to the dynamics explained below.

This is where co-evolution—meaning interdependent selection pressures among subsystems—enters our model. We have three intra-utopian debates engendering different trajectories for the distribution of behavioural patterns and for $x_t^\pi = \sum_j s_{jt}^\pi x_j$, and then influencing the share of the different utopias in society $\gamma_t^\pi$. In turn, the changing distribution of utopia supporters in society affects the payoff functions (1), thus affecting the three intra-subsystemic dynamics, and so on.

## 2.4 Inter-subsystemic dynamics and co-evolution

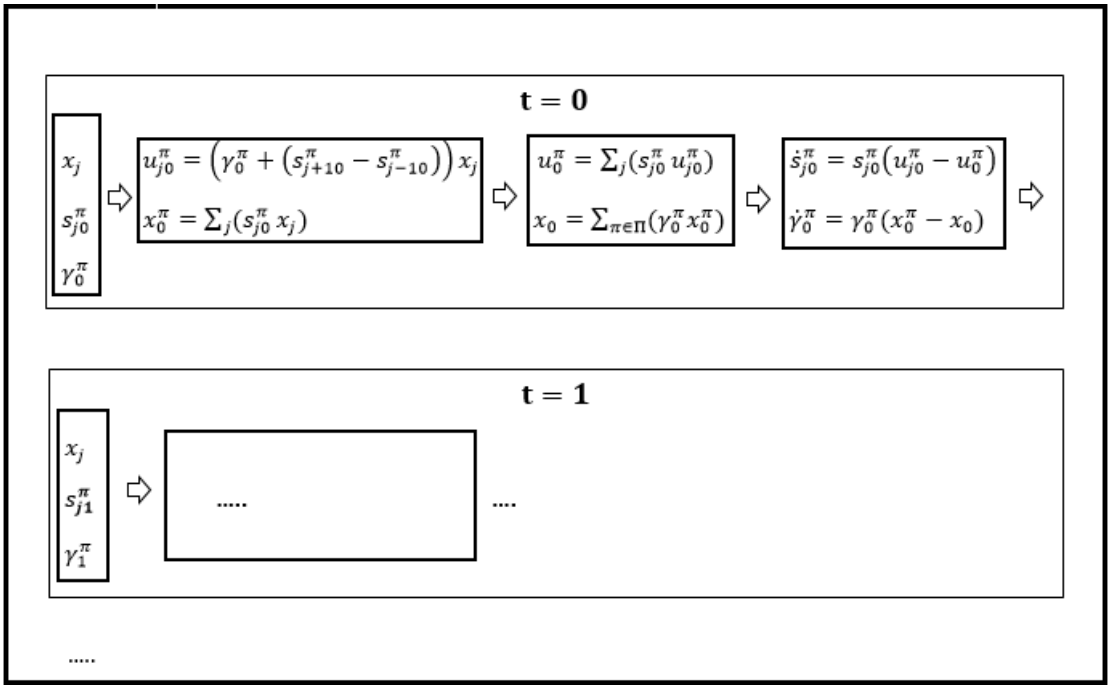
Now, subsystems that engender stronger levels of citizenship in support for the corresponding utopias will tend to gain relative presence in society as the number of supporters grows, and with it citizen contributions to persuade others. This effect will take place as long as citizens may change their minds and change their utopias because of the influence of the relative frequency, intense persuasion, and visibility of other citizens' opinion, for example through mass media or social media. We synthesize this relative visibility/persuasive intensity of the different utopias competing in society through the joint effect of the subsystem averages of citizenship $x_t^\pi = \sum_j s_{jt}^\pi x_j$ (see below). In turn, the emergent uneven prevalence of the alternative utopias $\gamma_t^\pi$ will enforce, in a higher or lower level, the payoff of their related individual citizens (see (1) and below). As we see in (1), we assume that those citizens perceiving the relative success of their favoured utopia (increasing values of $\gamma_t^\pi$ as a result, among other things, of their levels of citizenship and commitment) will experience reinforcement of their behaviours and ideas. On the other hand, citizens that perceive that their utopias have lost social prevalence may, eventually, change their minds. Formally, we can complete our co-evolution model by proposing a replicator system of three differential equations, coupled (in a bi-directional way) with the intra-subsystemic dynamic systems presented

above, which drives the evolution of utopia/subsystem shares in society. This last evolving system for the subsystems' shares is expressed as follows:

$$\dot{\gamma_t^{\pi}} = \gamma_t^{\pi}(x_t^{\pi} - x_t) \qquad \forall \pi \in \Pi \qquad (3)$$

Recall that $x_t^{\pi} = \sum_j s_{jt}^{\pi} x_j$, which does not depend on $\gamma_t^{\pi}$. On the other side, we have $x_t = \sum_{\pi \in \Pi} \gamma_t^{\pi} x_t^{\pi}$. System (3) means that those utopias managing to deploy and maintain higher than average levels of citizenship and contribution tend to gain social presence share and support. Those with a level of effort that is lower than the social average will lose support. Clearly, all else being equal, the subsystem(s) with the greatest $x_t^{\pi}$ would dominate the rest. In general, subsystems/utopias with higher than average commitment gain social presence. In turn, increasing social presence as measured by $\gamma_t^{\pi}$ enforces intra-subsystem payoffs in (1), thus affecting (2) and then the whole system operates on (3), and so forth. The Scheme 1 (below) shows a flow diagram for the model.

As a result of the processes in (1) to (3), several emergent properties appear. We can observe endogenous change in the relative social presence for each utopia; the path for the average level of citizenship in society; and evolving trajectories with different profiles (including smoothness towards conformity; irregularity towards the co-existence of a few utopias; and permanence of extremely different utopias). With this model in place, we can now exemplify how the emergence and posterior consolidation of a particular utopia—namely an environmental utopia associated with climate change concern, and in which many citizens actively seek to raise the status and value of environmental ideas in competition with those of economic and state ideas—can occur. We can also find situations in which this evolution pattern does not emerge, tracing this back to characteristic features of the model.




***Scheme 1: Flow Diagram***

In section 3, we seed the initial distributions of citizens within each subsystem (and for each subsystem) by trying to reproduce historical conditions, and then run the model for different values of the parameters -to check whether the model dynamics replicate the historical experience. Afterwards we check the robustness of the results. We might also design counterfactual analysis, explore the model in specific regions of the parametric space, and so forth (but always keeping in mind that we are working with a stylized representation of a proposed evolutionary political economy process).

## 3 Citizen contributions in the battle for the idea of climate change

Among all environmental concerns to have emerged in the past half-century or so, perhaps the most socially divisive issue has been climate change. In this section we illustrate—using our co-evolutionary model of utopia competition—how the major impact of climate change concerns in society can be explained in terms of a battle of ideas, where a small but highly committed proportion of the population can convince society to change its political actions, its laws, and its markets, by a mutual process of citizens influencing other citizen's behaviours.

As an example, to highlight from our model some of the mechanisms underlying this process, we set out the initial conditions in Table 1 characterized by:

(i) very different levels of citizen involvement and contribution (high dispersion in $x_i$) within the different subsystems (highly committed citizens co-existing with medium and low committed ones);

(ii) an initially very small environmentalist subsystem (five percent of the population) co-existing with a majoritarian market-oriented utopia preference (70 percent), and a significant state subsystem (25 percent);

(iii) intra-subsystem distributions of behaviour in which environmentalists are very active (65 percent of citizens supporting this utopia are very high-level contributors: see "$s^e_{i0}$", state-partisans are less committed, and market-supporters do not contribute too much to foster their utopia (50 percent of market-friendly citizens devote two percent of their resources to support their utopia; represented in Table 1 by the column for the distribution $s^m_{i0}$).

The setting in Table 1 could represent Western societies toward the end of the 1980s characterised by the final phase of the Cold-War, rising support for Chicago School economic models, and the beginnings of climate change fights in international politics. During this period of consolidation by the Thatcher-Reagan revolutions, pro-market principles were sufficiently well-established that little effort was needed to maintain a market utopia as the dominant idea in society. Moreover, communist parties and nations were beginning to collapse, so it was harder to legitimate radical state positions. And while still a small niche political issue, environmental concerns were experiencing growing awareness (Almudi et al. 2015).

Besides the central point in Table 1 (the *centre* of the base scenario) from which we will run the model, we also present the intervals of parameter values and initial conditions for which the simulation results hold. Thus, note that what we represent as a standard setting is not a unique point from which we get what we want. On the contrary, as it can be seen from the intervals in Table 1, there exist infinite scenarios around the one we set out as the *base setting* which, also representing the same qualitative features mentioned above, generate the same qualitative emergent properties that we discuss below. As we will see, the model results are robust within relevant intervals around the central setting (see the intervals in brackets beside the central

points in Table 1, and the reflections on the robustness analysis below). Moreover, since we are running a deterministic model, each specific setting always generates the same experimental result. Thus, we do not have to run thousands of simulations for each case, as is normal in stochastic models.

| ***i*** | $x_i$<br>$x_i = x_1 + a(i-1)$<br>$x_1$ =0.02 (0;0.07]<br>$a$=0.48 [0.18;0.49] | $s^m_{i0}$ | $s^s_{i0}$<br>$s^s_{i0} \cong \frac{1}{3}$, $i$=1,2,3 | $s^e_{i0}$ | **Utopias** |
|---|---|---|---|---|---|
| 1 | 0.02 | 0.5 [0.35;0.55] | 0.3 [0.3;0.4] | 0.3 [0;0.34] | 0.7 (M) [0.4;0.704] |
| 2 | 0.5 | 0.35 [0.3;0.5] | 0.4 [0.3;0.4] | 0.05 [0;0.05] | 0.25 (S) [0;0.4] |
| 3 | 0.98 | 0.15 | 0.3 [0.3;0.4] | 0.65 [0.61;1] | 0.05 (E) [0.046;0.35] |

***Table 1: Initial setting and intervals.***

We will present the results now and, later on, in section 4, will briefly discuss the details of the robustness analysis. In section 5 we will close the paper with a global discussion of our proposed framework and further search.

Thus, by running the model from Table 1, we obtain the simulations shown in Figs. 1 to 4. Let us insist in that the results we are going to analyse, qualitatively hold for the whole set of infinite scenarios within the intervals presented in Table 1. Of course, the specific simulation that we depict in the Figures is the one corresponding to the central *base-scenario* in Table 1. As can be seen in Figure 1, the model produces the gradual emergence and consolidation of climate change issues (coloured green)—an environmentally sustainable society view, the prevalence of market-supporters (coloured blue), and the quick disappearance of state-utopians (coloured red). Figure 1 shows the time evolution of the three subsystem utopias as shares of the total population ($0 \leq \gamma_t^\pi \leq 1,\ \sum_{\pi\in\Pi} \gamma_t^\pi = 1,\ \Pi = \{\mathrm{M}, \mathrm{S}, \mathrm{E}\}$) departing from the initial setting in Table 1.

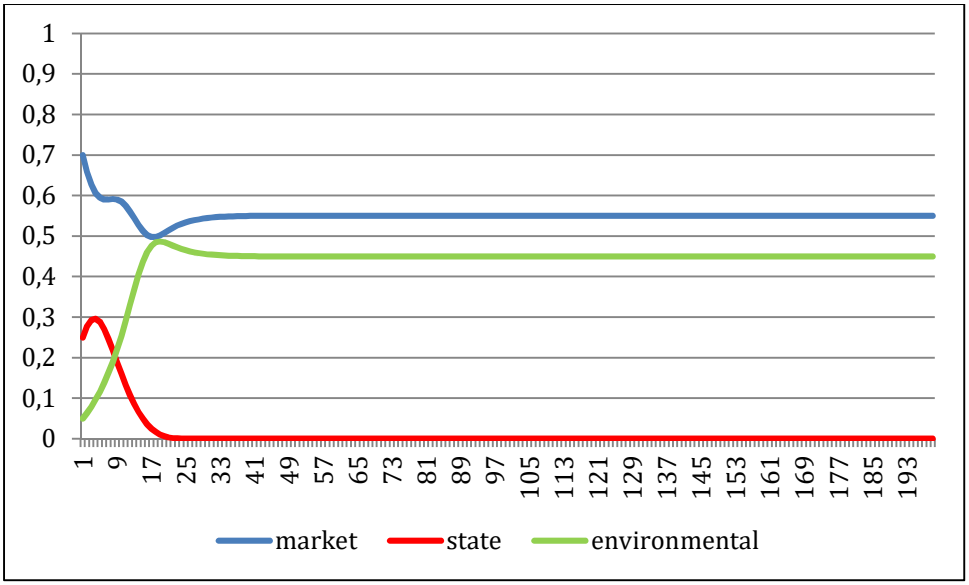



***Figure 1. The rise of an environmental utopia.***

How do our co-evolutionary model -and the mechanisms behind it- explain the dynamics represented in Figure 1? As it is shown in Figures 2 and 3, this dynamic transition path can be explained in terms of the *intra* and *inter* sub-systemic debates engendered in society when we depart from Table 1 (and the corresponding robustness intervals). In terms of our model, a co-evolutionary battle of ideas may have led to fundamental structural socio-economic and political changes in the distribution of social utopias/subsystems of ideas. Let us elaborate and explain this conjecture in terms of the model. As a guide to what underlies Figure 1, we show the corresponding intra-subsystem debate—taking place within the environmental utopia as Figure 1 emerges—in Figure 2 (we explain this by considering the mechanisms in equations (1), (2), (3); see also Scheme 1). Initially in Figure 2, a small share of the total population (5 percent, as it is shown in Table 1 and in the initial level of the green line in Figure 1) supports environmental issues, but because they are highly committed (65 percent are high level contributors), they are persuasive on others, and soon grow as a utopia population. It is remarkable that, despite of the crucial initial role of this very highly commited people in unchainging the environmental undertaking, it is through the later efforts of the medium-comitted defenders as climate change and other environmental issues consolidate its position into the public sphere (medium green line in Figure 2).

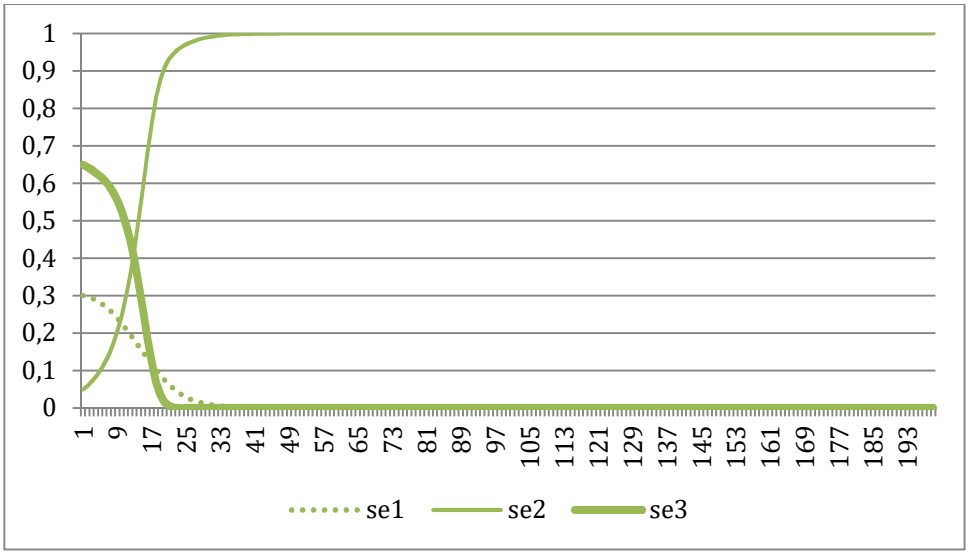



***Figure 2. Level of citizen's contribution in the environment subsystem***

To be clear, note that it is not always the case that medium-contribution defenders prevail in the intra-subsystem dynamics. For example, the parallel-to-Figure 2 intra-subsystem evolution in the State subsystem (which we show in Figure 2*) shows that, in the State subsystem, low-commitment citizens share (ss1) are the ones that eventually prevail.

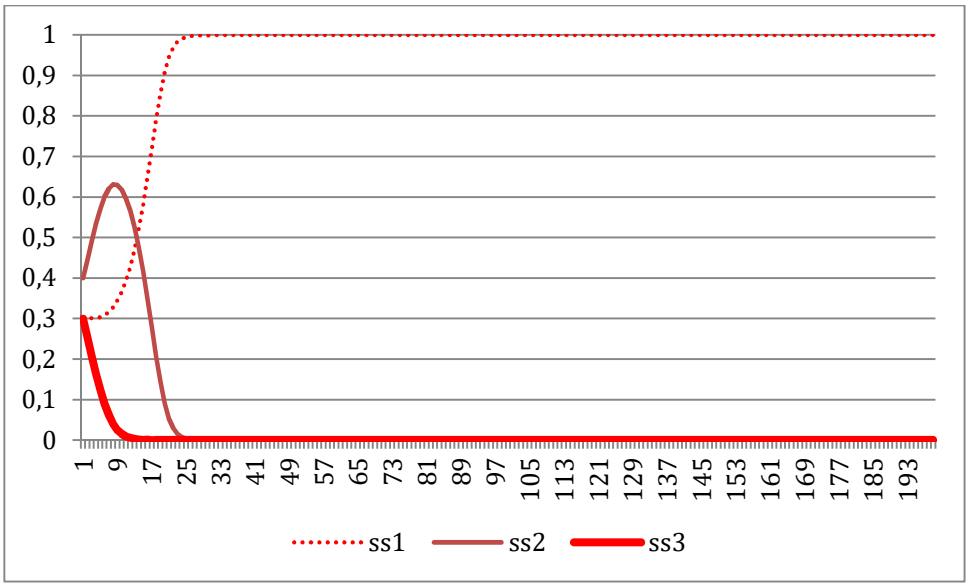



***Figure 2*. Level of citizen's contribution in the state subsystem***

Going back to the global dynamics in Figure 1, we show in Figure 4 how, at the intersubsystem level, all the afore-mentioned dynamics emerge from idea-competition between environmentalists and pro-market supporters that ends up generating a similar average contribution level (whereas citizen commitment on the part of radical state supporters decline; as we observe in Figure 2*). Systems of equations (2) and (3), together with the payoff functions in (1), allow us to systematize formally these explanations and the evolutions depicted in Figures 1, 2 and 4. The joint effects of intra-subsystem externalities from peers (see Table 1 payoff function (1) and trajectories depicted in Figures 2 and 2*), together with the endogenous evolution of the distribution of global opinions and actions shown in Figure 1 (subsystems shares time paths with its effects in payoffs (1)), generate coevolving processes of intra- and inter-subsystem evolutions—driven by systems of equations (2) and (3)—all of which engender the sustainability transition towards an environmental utopia. The Scheme 1 (above) can also be of help in order to follow these causal mechanisms.

Can these results—obtained from our model initiated in Table 1—be consitent with the history of certain events related to climate change? Let us say that the initial achievements for climate change activists date from the first half of the 1990s—specifically the First Assestment Report from IPCC in 1990; the Earth Summit Rio in 1992; and the Second Assesment Report from IPCC in 1995. These debates led to the the 1997 Kyoto Protocol, as both an official institutional recognition of the reality of global climate change problems, and as an institutionalized commitment in pursuit of solving the problems. The Kyoto Protocol became International Law in 2005, recognising by general agreement that climate change is a major problem for industrialized countries. Likewise, note that the entrenchment of the idea into the political machinery, could at least partially explain the relaxation in the levels of commitment by environmental activists—from strong to medium positions—that our model generates (as shown in Figures 1 and 2, environmental activists control a higher share of population—45 percent—but with a medium level of citizen commitment).

Let us emphasize that climate change (environmental) activism not only changes intra-subsystemically (environmental utopia), but it also drives and reveals a transformation at the inter-subsystem level. As it is shown in Figure 1 (and corroborated by Figure 3 and the rationale underlying equations (3)), climate change environmental supporters gain visibility because they convince and capture citizens from other subsytems which end up switching towards their utopia and sociey view. Thus,

environmentalists deploy a high average level of commitment (see Figures 1, 3 and 4) which leads to a gradual change of other citizen minds. Notice also that the payoff for climate change supporters increases until stabilization, whereas their average commitment declines but ends in a high and stable level (Figure 4).

According to equation (1), the evolution of environmentalist payoffs is due to two reasons: (i) the small initial share of medium and low-supporters which do not substantially erode the enthusiam of strong and, later, medium supporters during the whole time path; and (ii) the environmental fight turns out to be effective, with climate change issues gaining visibility with time, thus reinforcing the feeling of being effective in the fight (see (1)). These mechanisms are reflected into the payoff's funtions (1) and lead—according to systems (2) and (3)—to a favorable evolution of environmentalist citizenship (Figure 4). They have the effect of attracting new supporters to the climate change cause, mostly migrating from the state utopia. In this regard, it is interesting to recall that the end of the 1980s were bad times for communism and state defenders (fall of the Berlin Wall and the de-integration of communist countries); other utopias (like ecology defenders and/or market utopians) captured new adepts. This explains the decrease in the payoff for the state utopia, and the increase (to a high level for the market and environmental payoffs in Fig. 3 and 4).

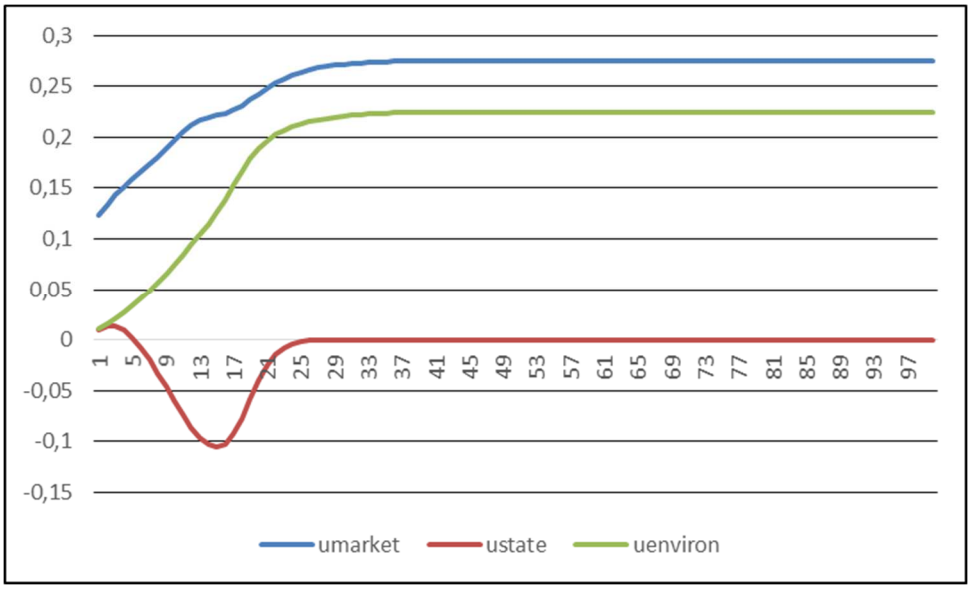



***Figure 3. Average subsystem-level payoffs***

Comparison of Figures 3 and 4 also reveals something unexpected. We can see that level of effort by citizens becomes identical in both dominant subsystems (0.5), but

the payoff for market supporters is higher than that for enviromental utopians (see the final situation in Figures 1, 3 and 4). The reason is that the market subsystem stabilizes for a higher level of presence in society (55 percent of market utopia, 45 percent for environment in Figure 1). We may say that environmental defenders keep a strong couter-movement degree of citizen effort that blocks the social advance of pro-market supporters, although they do it by bearing a lower payoff level, since they are important, but not majoriatiarian.

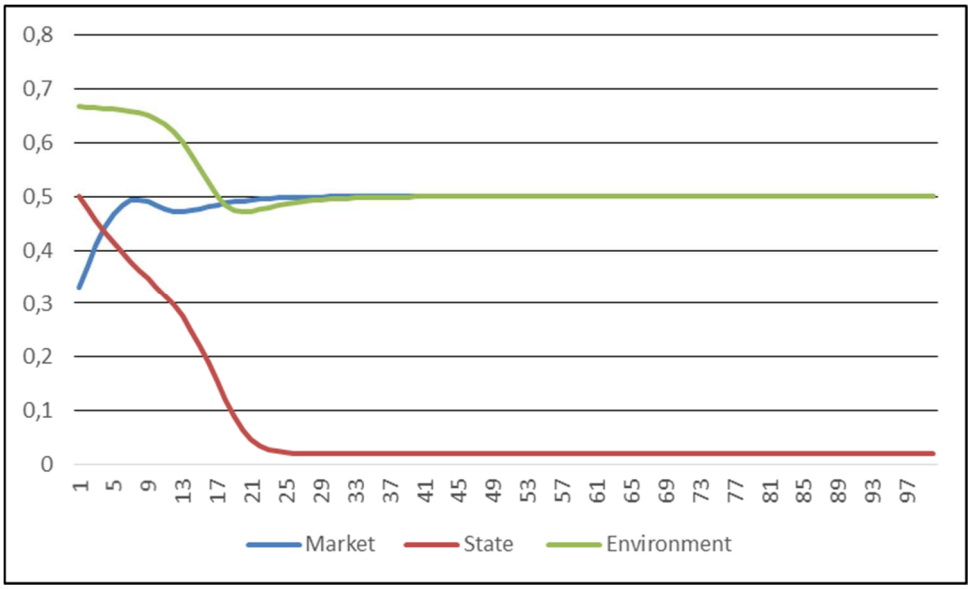



***Figure 4: Average level of citizen effort in each subsystem.***

Some final remarks follow from the model. First, both environmental and market utopias survive in the socio-politcal arena with a medium-level of effort, but with an important final share of the suporters (55 percent for market and 45 percent for environment). Second, the success of climate change supporters in convincing peers and competitors from other utopias rests on strong debate and action that finally ends up changing the structure of public opinion, laws, attitudes, and politics. Third, for this time path to emerge it is essential that, in an initial phase, environmentalist supporters display very strong commitment, even to the extent of causing other utopias to almost disappear. Finally, if we realize that the main achievement of Climate change supporters has been the Kyoto Protocol, which is a kind-of-market mechanism to manage the evolution of climate conditions, this real fact seems consisten with our

illustrative modal result of 'two-winners'—market and environmnet in the stationary state. Obviously, it is not the only possible sustainable transition path. Nevertheless, we leave for future research the emergent coexistence with other subsytems in extended versions of the model (as the State, the representative democracy, traditional group identities, and so on.). These more complex scenarios may shed some new light regarding new, or more convenient, solutions for sustainable transition economies (see Almudi et al. 2015).

## 4 Robustness analysis

We also conducted a robustness analysis on the intervals shown in Table 1. The robustness intervals presented around the central setting in Table 1 seek to show that the sustainability transition and the climate change undertaking analyzed above are not exclusive for the (central) parameter setting initiating Figures 1 to 4. On the contrary, the sustainibility transition is obained within a sizable set of parametric and initial condition values in the model. Considering that a sustainibility transition occurs when, departing from conditions resembling the qualitative scenario that inpires Table 1, the emergent (initially small, around 5 percent) environmental subsystem ends up consolidating a very significant position in society: a social share of supporters higher than, and even much higher than 1/3 of society, in a time span of 200 periods.

The aim of the robustness analysis has been to delineate a wide range of parameter values for which this process emerge on the basis of what we have explained above. The analysis has consisted of departing from the central (default) setting in Table 1, and then changing the value of each of the parameters and initial conditions of the model—one at a time whilst keeping everything else being equal—in order to compute the range of values for which the description of sustainability transition and climate change undetaking above remain valid. The intervals beside each central value in Table 1 show the results. We observe that the amplitude of the intervals around the central setting (while maintaining the qualitative despription of the intial situation that we wanted to represent) is significant (i.e. notice the size of the intervals in relative terms with respect to the corresponding parametric values).

Regarding the *parameters*: In the case of parameter $x_1$ (0;0.07] the robustness is complete downwards and highly significant upwards (an increase of the 250 percent of the central value), and for parameter $a$=0.48 [0.18;0.49], the robustness is total upwards (up to the economically significant value in the model) and very significant downwards

(a decrease of 62.5 percent the value). Regarding the *initial conditions*: Firstly, we carried out the robustness analysis by re-sharing the environmental *intra-subsystem shares*. As shown in Table 1, we can move up and down the central value 0.65 within the interval [0.61;1] and still obtain the simulation results (always keeping in mind that we must re-arrange the intra-share values so the sum equals 1). Regarding the market and the state subsystems, we proceed in the same way, obtaining the intervals in Table 1. In the case of the market, we re-arranged the shares between contribution levels 1 and 2, and obtained robust simulation results. In the case of the state, our results hold as long as we have even intra-subsystem distributions $s^{s}_{i0} \cong \frac{1}{3}$, $i=1,2,3$.

Secondly, we checked the robustness when modifying initial *inter-subsystem* distributions and also show the results in Table 1. Remember that we want to reproduce the initial conditions in which the market subsystem is clearly prominent and the environmental utopia is around 5 percent (i.e. relatively small in society). Regarding the state, we can modify the initial share 0.25 by re-arranging the shares (evenly) among the other subsystems (so that they all sum to one) within the range [0;0.4]. Finally, if we keep the (central) initial value of the state 0.25, and re-arrange among the market and the environment their respective shares—while seeking an initial situation in which market is prominent and environment is small—we get the intervals in Table 1.

## 5 Discussion and conclusions

Our co-evolutionary subsystems-based model of utopia competition differs from the broad suite of institutional and political economy approaches by the simple expedient that our approach is built around an agent of change—the economic actor as citizen who chooses a utopia that they promote through their economic contributions. A citizen is engaged in the battle of ideas by seeking to influence the balance of the subsystems by contributing resources toward their own conception of utopia. It is this citizen activity in our framework that causes the changes in the balance of subsystems (and so in the institutional conditions) of a socio-economic order.

In the institutional approach to economics such changes are due to historical exegesis or to political leadership, in that institutional changes that ultimately determine long-run economic outcomes are explained as natural accidents (e.g. wars, empires, and migrations, North and Weingast 1989) or by the choices of political elites (Acemoglu

and Robinson 2012). Missing from this approach is a framework built on the power of citizenship through collective action (Dietz et al 2003), or one in which politics is simply an enabling mechanism (Barrett 2003, 2007). The upshot is the need to focus analytic attention on the co-evolution of the subsystems of the socio-economic order as driven by differential citizen contribution and promotion. By specifying a socio-economic order as made of subsystems, and a utopia as a preference for the dominance of a particular subsystem, and citizenship as the act of contribution to a subsystem to seek progress toward a utopia, we can model the long run dynamics of socioeconomic systems embedded in a political, cultural and natural environment through the lens of idea competition (Montgomery and Chirot 2015).

This paper has presented a worked example, based on a qualitative approach to historically observed patterns, for a new class of evolutionary political economy model over three utopias: market, state and environment. We have used this replicator model as a way of understanding the rise of environmentalism as a battle of ideas in which an environmental utopia is competing with other forms of utopia (market and state). We suggest that this model can be used to guide strategic thinking about managing the transition to a sustainable economy as affected by climate change. The key insight of our model is to indicate the important role played by citizens using their own economic resources (time, money, skills) to affect the balance of ideas in a society. This is a different mechanism from market-based activity (environmentally-conscious consumption) as well as political activity (voting for environmentally friendly policies and political parties). Our approach suggests that the standard dual strategy of trying to effect market change (changing consumer preferences) and political change (through strategic voting) needs to recognize a third prospect, which arises from a competitive co-evolutionary process of citizen contribution in the battle for the dominant ideas that govern a social order.

The analysis here is only a preliminary simulation of a stylized model, and awaits a more robust and detailed undertaking. It is simply proof of concept. However, even this simple analysis immediately raises at least two points with interesting implications. The first concerns the importance of consensus and unanimity. A political program that would seek solutions to climate adaptation through political enforcement must always aim for consensus in order to minimize the use of force, and the adverse consequences of that. But the impossibility of consensus is the major political

stumbling block in the pathways from various global treaties and nation state engagement. However, our citizen contribution model suggests that consensus might not be so important. What seems to matter more is marginal citizen engagement and contribution. Intuitively, when an agent chooses to switch utopias (say from market utopia to an environmental utopia) their own private utility gain is a potentially overlooked mechanism by which the pathway to a sustainable economy might be achieved. This shows up powerfully, albeit suggestively, in our simulations over a range of behavioural parameter values.

The second point is that the mechanism of citizen-driven utopia competition avoids the basic problems inherent in either market-based approaches to climate adaption through Pigovian taxes—namely market failure in the provision of global public goods—or government based approaches—namely the concentrated power that generates rents and invites corruption (as with industry-targeted legislation, favoured technologies and government contracts). The externalities problem, the free-riding problem, the tyrannies of majorities and of organized minorities all plague effective market or government-based transition pathways. These approaches rely on consensus mechanisms to enforce what is essentially a collective action problem. But utopia competition is an evolutionary competitive model. It is not about force—i.e. it does not work through consensus mechanisms, but through adjustment. The relevant action here is not voting or shopping, although changes in those will be endogenous, but choice of utopia and citizen contribution to its promotion. Choosing an environmental utopia automatically displaces market or state utopias in citizen mind. An agent may at some point switch their utopia as a welfare-enhancing decision. Furthermore, citizens who contribute to a utopia also benefit when others switch.

There has been much study of the extent to which other-regarding altruistic preferences or social discount rates matter in the estimation of the effects of climate change and in the formulation of plans to transition to a sustainable economy. The presumption is that first ‘we’ need to arrive at a consensus, and then ‘we’ can make a collective plan that will be enacted through government or market mechanisms. But less attention has been given to the co-evolutionary dynamic mechanism that works through idea competition through which agents try to persuade other agents to shift their utopia. In practice this sort of process is quotidian, and a significant part of the rise of environmentalism. Yet to date we have not had an effective way to integrate that

mechanism into a coherent political economy model. We suggest that the co-evolutionary model of competitive utopias provides that missing mechanism.

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