How Can Mitigation and Adaptive Capacities to Climate Change Be Best Enhanced in Spain? A Human Values Evolutionary Approach

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Abstract

Given growing awareness of the systemic relationships and interdependency between humans' activities, the economy and the environment, society's preferences are slowly shifting from 'economic growth at any cost' to 'sustainable development'. As a result, the European Union has, as its preeminent goals, climate change (CC) mitigation and adaptation in all the economic sectors. Spain presents a unique setting for the study of optimal CC strategies because its agricultural sector is diverse and highly threatened by CC and especially because Spaniards' preferences compared with those of other Europeans are relatively more self-regarded than other-regarded. This paper develops a continuous dynamic model in order to elucidate the current and emergent relationships and behaviors between the agricultural sector and its direct natural resources, human capital and social capital in order to identify efficient CC mitigation and adaptation strategies for the short and long. The model structure is based on the Spanish AgroSAM (social accounting matrix), extended with natural resource, human capital and social capital satellite accounts, and converted into a general disequilibrium model. Results suggest that in the short run market mechanisms that target monetary incentives are more efficient than mechanisms that influence people's behavior via social values and norms. On the contrary, results indicate that a mix of market, governmental and community strategies are necessary for a sustainable long run behavior that addresses climate change mitigation and adaptation. Specifically, the oblique transmission of social norms, values and knowledge is identified as a key approach for the human and social capital development that would guarantee CO2eq emissions reductions and higher societal adaptive capacities in the long run.

Words: climate change, mitigation, adaptation, human capital, social capital, human values generation, disequilibrium, agriculture, policy impact analysis.

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I. Introduction

During the last two decades there has been a growing concern about climate change (CC) around the world. As a result, supranational and national strategies aimed to reduce green house gas (GHG) emissions and to develop climate change adaptation strategies have been high priorities. The goal of most policy-makers is to ensure economic growth under the new environmental and ecosystems conditions. One of the most important consequences of this new situation is a shift in our fundamental views of the economic system. Specifically, we are seeing a shift from an economic paradigm that values economic growth at any cost to a new economic paradigm based on the concept of sustainable development that recognizes ecosystems thresholds and constraints (Daly 1996).

This new economic paradigm requires a major change in our understanding of how the economic system works. In particular, the current circumstances are challenging the effectiveness of the established CC mitigation and adaptation strategies. The new sustainable development paradigm requires a systemic view of the economic system that connects it to the biosphere and ecosystems upon which the economy is based. Sustainable economic development also demands that the economic system has a strong adaptive capacity to extreme events, inviting hence further exploration of human[2] and social[3] capital generation. In summary, this new view sees the economic system as a system that has inherent properties that allow its self-organization and survival under constantly changing environmental conditions. However, while policy-makers and society in general want to move towards a sustainable development approach, they do not fully understand the economic system as an evolutionary system. As a result, the effectiveness and efficiency of current CC strategies fall far short of our goals. Normally, CC strategies focus on the proximate specificities of CC adaptation, instead of on the ultimate cause of it, human preferences and consequent behavior. Furthermore, strategies tend to focus on short run rather than long run results, and tend to consider first round impacts only instead of the direct and indirect consequences. The increasing demand for sustainable development understanding and materialization underscores the need for further research on CC mitigation and adaptation strategies.

Spain presents a unique setting for the study of optimal CC strategies because its agricultural sector is diverse and highly threatened by CC (Iglesias and Minguez 1997) and especially because Spaniards' preferences compared with those of other Europeans are relatively more self-

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[2] Human capital is generally understood as just knowledge Schultz, T. W. (1961). "Investment in human capital." The American Economic Review **51**(1): 1-17.

However, the broad definition of human capital considers human abilities, knowledge, values and skills.

[3] Social capital is broadly understood as trust level and social networks development Adger, W. N. (2003). "Social capital, collective action, and adaptation to climate change." Economic geography **79**(4): 387-404.

regarded[4] than other-regarded[5] (Ronen and Shenkar 1985; Posner 2000; Allik and McCrae 2004). This research aims to answer from a human values evolutionary approach 'What are the most effective short and long run mitigation and adaptation strategies to climate change in Spain?', focusing the attention on the agricultural sector.

Paper structure is as follows: section II frames human values generation and evolution process and its impacts on and feedbacks from the dynamics of human capital, social and natural capital and the economy; section III reviews CC mitigation and adaptation models and self-organizing models; section IV describes the model developed and its results; finally, section V posits the conclusions.

II. Human Values Generation and Evolutionary Process and its Impacts on and Feedbacks from the Dynamics of Human, Social and Natural Capital and the Economy

As some researchers from multiple disciplines have noticed (Wilson 1978; Boulding 1981; Capra 1997; Huberman and Adamic 1999; Bowles and Gintis 2003; Hofbauer and Sigmund 2003; Gintis 2006; Nowak 2006; Noė 2009), there is a huge benefit in understanding their fields from a Darwinian evolutionary dynamics perspective (Darwin 1888). The elucidation of effective CC mitigation and adaptation strategies from a human' values evolutionary approach requires the understanding of utilities functions as a dynamic entity as well as the economy as a lived system resulting from individual and social preferences. The basic steps depicted by Darwin in any evolutionary process are: a) replication (of both, the genetic or primary information and the structural or strategic information), b) mutation (new information is added to the inherited 'genes' and some original information is not carried on), and c) selection (the information that helps the 'organism' to fit better in the environment is the one that will last). In the social sciences, the selection process goes hand in hand with a continuous cognitive learning process that elucidates the inner and outer information needed to adapt to the new environment more efficiently. As a result, human and social capital levels play an important role in the costs of learning and in the enhancement of human and social adaptation capabilities.

A rational agent is one with consistent preferences, regardless of the arguments in the preference function and their distribution in the indifference curve. As biology and psychology indicate, biological agents and human beings possess an evolved, genetically rooted set of routines that indicate how to effectively respond to internal and external circumstances in order to enhance

[4] Self-regarding preferences are just motivated by the effects of one's actions on oneself.

[5] Other-regarding preferences are not counter-preferential, what distinguishes them is that they are motivated at least in part by a concern about the effects of one's actions on others.

their fitness[6]. Hence, preferences' transitivity is ensured by the natural evolutionary process. Individuals have been having access to more information over time, and have developed a higher ability to convert it into knowledge, and into a new preferences bundle and means to satisfy it that increases the final well-being (Bowles and Gintis 2003). The natural resulting process is the adaptation of preferences given the new knowledge and environment. Hence, preference functions need to be directly associated with the decision maker's current state and evolve with it (Bettman, Luce et al. 1998; O'Donoghue and Rabin 2001). As a result, subjective well-being is associated more with its changes than with its level (Helson 1964; Easterlin 1973; Oswald 1997).

Human Values Evolutionary Theory remarks the importance of acknowledging that individuals' preferences are based on the information that the individual have access to and is able to process. As a result, scholars indicate that humans value what they are conscious of and that they value it more if they have fully integrated its meaning (Gintis 2009). That is to say, people who are not conscious about CC will place no value on mitigation and adaptation strategies and as a result, will adapt poorly to a changing environment. In contrast, people who are fully aware of the impacts of CC and their relationship to human choices and the economy, will place a higher value on CC mitigation and adaptation and will adapt more efficiently and effectively to the new environment.

Neuroscience research supports the modeling of human choices as the maximization of one's payoffs, indicating that the human brain does undertake an optimization process in order to identify the maximum reward in each circumstance. In other words, the brain seeks the best option in order to enhance fitness (Parker and Newsome 1998; Schall and Thompson 1999; Shizgal 1999; Glimcher 2004; Glimcher, Dorris et al. 2005). Humans are always maximizing their subjective well-being given the knowledge, process capacity and energy level that they have and the environment that they face. It is important here to highlight the difference between an objective rational behavior (that follows a logic construction) and a subjective determination of well-being (that follows a logic construction but it also considers emotional states). Individuals are rational, they all maximize their choices following a sequence of logical reasoning, but the resulting behavior can be welfare reducing in somebody's eyes, and welfare enhancing in somebody else's eyes (Baumeister, Sparks et al. 2008).

Individual's preferences also include social preferences. Social preferences are understood as behavior that cares about the well-being of others and value fairness and other norms of decent behavior (Bowles and Gintis 2011). Culture, is the institution that enhances self-regarding

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[6] Originally, fitness was associated with the number of offspring, the basic survival instinct. Nowadays, fitness also includes the emotional and mental contentment of the individual, her general welfare Gintis, H. (2006). "Adapting Minds and Evolutionary Psychology." Journal of Bioeconomics.

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preferences towards other-regarding preferences so that both, individual and social well-being can be enhanced and group survival is ensured. Empirical research indicates that humans are selfishly-altruistic by virtue of their evolutionary process (genetic and cultural) and that they care not just about outcomes but also about the means of the outcomes (De Quervain, Fischbacher et al. 2004; Gintis 2005; Gneezy 2005; Gintis 2009). Hence, the indifference curve of a rational self-interested actor also includes arguments concerning the well-being of others. Research suggests that the most reasonable explanation for the predominance of socially beneficial norms is weak group selection: societies that promote social norms have higher survival and reproduction rates than societies that do not (Bowles and Gintis 2011).

Cultural transmission of preferences allowed humans, exceptionally among animals, to adapt flexibly to rapidly changing circumstances and to modify the results of individual fitness maximization where these are not beneficial on average to members of the group. As Herbert Gintis notices in his book *Gene-culture coevolution and the nature of human sociality* (Gintis 2011), there is a co-evolutionary process between genes and culture where each of them constraints and facilitates the development of the other. Culture and its associated social and legal norms and related institutions, are developed in order to confine and program individuals' behavior into certain society's values. The selection of societal values has evolved towards the ones that promote pro-social emotions of empathy, shame, guilt and such, given humans' evolution as a social specie. As a result, societies have developed a series of rewards and punishments that together with the social norms align behaviors towards the convergence of a dynamic equilibrium of institutions that enhance agents' fitness. Aumann (1987) presented the emergence and development of social dynamics as a correlated equilibrium process in which the complex social norms are the dynamic leader that people follow. Mutations can be of two types. The first mutation considers the incorporation of a cultural norm with higher payoff. The second mutation modifies current institutional strategies by new ones that enhance fitness.

Mutations or changes in values and consequent preferences are originated evolutionary or by force. A behavioral type in the population increases via an evolutionary process if its expected payoff exceeds the average. The so called payoff-montone models. For that to happen, there has to be a critical mass of individuals or social stimuli that overrides the stablished one, as well as the minimal social and cultural institutions that ensure the transmission of the new values to other individuals and institutions (Bowles and Gintis 2003; Bowles and Gintis 2011). However, a behavioral type can be imposed when it causes people to want or feel obliged to do things. Then, cultural transmission can override fitness. Hence, societies may be at a locally unstable equilibrium and have to learn how to move towards a locally[7] or globally stable one.

The degree of consistency in human values demand and supply is related to the degree of the conscious integration of the values. Vertical, oblique, and payoff-based updating all effect the

[7] In locally stable equilibrium there exists a neighborhood of states around the equilibrium state such that if the equilibrium state is displaced to some state in the neighborhood, the population dynamic will return to the equilibrium.

internalization of norms. Individuals who have fully integrated the value of 'truth' for instance, they will not lie no matter what circumstances they face, and hence, there is no behavior inconsistency in them. However, if social values are not fully integrated and are mainly just respected because of the possible punishment, then the agent faces for instance three decision centers that suggest three different choices based on the current physical, emotional and mental needs. Consequently, depending on the circumstances a different decision center will dominate the others and preference transitivity will not be ensured. As Ekman remarks, "*if an objective fitness is associated with each of these choices, Darwinian selection will favor a mutant who suppresses two of the three decision centers or, better yet, integrates them* (Darwin, Ekman et al. 2002)." The distinction of different levels of knowledge or values integration is not normally considered in economic models, but it plays a big role in agents' behavior.

As the literature suggests, human values generation and transmission are the result of an evolutionary process in order to enhance human's wellbeing given their social nature. There is a co-evolutionary process that promotes the development of human and social capital in order to promote social values that ensure the group survival and the achievement of social well-being more efficiently. Human capital is required in order to for individuals to properly process the new information and to develop the adequate skills that ensure one's well-being. Social capital is required in order to coordinate everybody's self-interests with the common higher social well-being goal so that everybody can achieve higher well-being individually and the group can be more resilient to environmental changes (Bowles and Gintis 2011). There is a positive feedback loop between the development of human and social capital with the development of social norms. It is a very slow co-evolutionary process with information flow lags that generates a multi-equilibria pattern.

The development of human capital and social capital needed for the development of social norms and values that ensure more proper coexistence among individuals and higher group survival capacity affects the structure and behavior of the economic system as well as the relationship of humans with nature. Specifically, human values affect consumer preferences and business missions as well as the consumption and production means. As a result, human values guide the structure and relationships of an economy and consequently its relationship with the natural resources that may have capacity constraints and relevant thresholds in their structure.

This paper contributes to the current knowledge on effective CC mitigation and adaptation strategies by exploring the generation and evolution of human values and their relationship with the economic and natural systems. In particular, this paper tests the following hypotheses:

a) *Climate change mitigation and adaptation capacities for Spanish farmers are being constrained by the dominance of self-regarding behavior over other-regarding behavior in the Spanish population.*

b) *The enhancement of social values, norms and knowledge via oblique transmission contributes to the development of human and social capital that allow sustainable long run adaptation to climate change.*

III. Climate Change Mitigation and Adaptation Models and Self-Organizing Systems

The economics field has had relevant contributions from both ends of the temporal dimension—the continuous dynamics evolutionary approach and the static mechanistic one. It is important to realize that both approaches refer to the same economic process and that both shed light on some facets of it. However, as it is well-known, there is a temporal dimension that if not accounted for in a continuous dynamic manner misleading economic interpretations can arise.

The new continuous dynamics method has been introduced in some economic models but it has been barely implemented in the macroeconomic structural models used for policy evaluation. The advantages of structural models are that they represent the whole economy at a period of time and hence allow modelers to see how "everything depends on everything" by the values of their reduced form multipliers. Economic multipliers distinguish and account for the direct and indirect impacts of any action[8]. Another advantage of macroeconomic structural models is that their basic input data is systemically gathered by most countries under their system of national accounts. The main specificities of the different macroeconomic structural models are the following. An input-output (IO) model represents the value of the flows of buyers and sellers industries at a certain point on time (Miller and Blair 2009). During the last fifty years the IO model has been further developed by extending the number of institutions represented in it. This resulting model is called social accounting matrix (SAM). In addition to industries, a SAM also identifies one, or more of the following institutions: households, government, investors, and rest of the world (Keuning and Ruuter 1988). In response to rising environmental concerns, SAMs have been extended with environmental satellite accounts related to the economic process (Keuning 1992). These models are called SAMs with satellite accounts. Finally, general equilibrium models, also known as computable general equilibrium models (CGE), or applied general equilibrium models (AGE), distinguish prices and quantities and define the behavior of producers and consumers in a neoclassical fashion (Dixon and Parmenter 1996).

Structural accounting models are static by nature since they represent the flows of an economy over a period of time (usually one year). Dynamics have been mainly introduced into structural models in a recursive fashion. Recursive dynamics are an adaptation of static equilibrium models, and they do not model the path between one equilibrium state to the next. One does not see how the economy has reached the new equilibrium; hence, one does not understand the full causality or the true process behind the results. There is a need to expand the dynamics of

[8] Rebound effects are not normally contemplated in other models. For instance, when assessing the impact of energy savings by the introduction of more green technology it is necessary to consider the environmental impact of the amount of money saved; since it could be that the new environmental net impact is bigger than the initial one.

structural models to a continuous evolutionary fashion and hence model a system of equations of motion that correspond to the real economic behavior of a disequilibrium economy tending to its moving equilibrium state if we are to enhance CC mitigation and adaptation strategies.

Continuous dynamics structural models were first developed and made popular three decades ago as a response to the limitations of the Leontief dynamic IO model. Thomas G. Johnson presented part the foundations of the EEIS model presented here in his pioneer dynamic IO model (Johnson 1980; Johnson 1985). Raa presented a similar approach with more specificities in the capital accounts (1986). The adoption of a continuous dynamic approach in SAMs or CGE model has a vast potential ahead since it has been barely exploited.

Most of the structural accounting models done for Spain are either I-O or CGE static models. There are two papers that evaluate the level of emissions and their relations to the levels of production and final demand. Alcántara and Roca (1995) use an I-O model to analyze the primary energy requirements and CO2 emissions during the 1980-1990 period. Cadarso and Fernández-Bolaños (2002) introduce private consumption as another pollutant category and calculate Spain's emissions from 1980 to 1995. Llop (2005) extended these models by identifying the underlying factors that contribute to modifying the input-output emissions multipliers using structural decomposition techniques in the I-O model. Manresa and Sancho (2004), estimate sectoral energy intensities and CO2 emissions for the Catalan economy using SAM multiplier analysis.

Llop and Pié, (2007) develop two versions of the I-O price model (competitive and mark-up price formulations) for Catalonia in order to analyze the effects of a tax on intermediate energy uses, a reduction in the final production of energy and a reduction in intermediate energy uses. In the dynamic sphere, Morillas et. al. (1996) make an I-O recursive dynamic model to study the influence of demand structure on economic growth and air pollution in Andalusia.

In the CGE sphere, Cardenete (2005), analyzes the impacts of an environmental tax reform in a regional economy. In addition, there are a number of other CGE models developed for Spain, but for purposes other than evaluating mitigation or adaptation strategies to climate change.

Compared to CC mitigation, less research looks at CC adaptation since its concern rose more recently. Also, there are few accepted models able to assess the consequences of adaptive capacities and behavior (Holland and Miller 1991; Tesfatsion 2003; Smit and Wandel 2006). Adaptation models are normally sector- or region-specific and they have a bottom up approach unlike the structural accounting mitigation models (Reilly, Baethgen et al. 1995; McCarthy 2001; Smit and Skinner 2002; Patino 2010). The recent growth in agent-based modeling and evolutionary game theory and their apparent success suggests potential synergies between top down and bottom up modeling techniques (Hofbauer and Sigmund 2003; Erez and Gati 2004). Ana Iglesias is one of the main researchers of CC adaptation for the Spanish agriculture sector. The main measures identified as relevant in her CC agriculture adaptation research include: 1) crop choice, 2) tillage and time operations, 3) crop husbandry, 4) irrigation, 5) rain water harvesting, and 6) input of agro-chemicals (Iglesias and Minguez 1997; Iglesias, Ward et al. 2003). The main indicators of adaptive capacities related to agriculture evaluated in previous research are: 1) water availability, 2) soil fertility, 3) flexible physical capital, 4) income level, 5) income diversity sources, 6) education level, 7) age, 8) access to credit, 9) public expenditure in agricultural research, and 10) public expenditure in extension (Smith, Burton et al. 2000; Smit and Skinner 2002; Ciscar, Soria et al. 2009).

The issues of climate change mitigation and adaptation are invitations to explore our understanding of the economy as if it were a living system. The recent development of systems thinking and system dynamics methods allow us to model the economy as a living system that self-organizes itself. Hence, the continuous dynamics approach that considers the relevance of path dependence in the current behavior is selected as the one that best represents the observed system structure and dynamics. We can merge the Darwinian and Newtonian perspectives and models of the economy into a coherent whole thanks to the new technology possibilities. As a result, this paper departs from a SAM with satellite accounts and builds a general disequilibrium model of the Spanish economy in order to assess different mitigation and adaptation strategies to CC.

IV. EEIS Disequilibrium Model

EEIS is a general disequilibrium model of the Spanish economy that aims to elucidate effective short and long run strategies that enhance climate change mitigation and adaptation for the agricultural sector via an evolutionary approach of human values. The model is based on the Spanish AgroSAM of 2000 (Mueller and Domínguez 2008) and it is extended with human capital, social capital and environmental satellite accounts. The environmental satellite accounts are: a) CO2 equivalent gases, and b) soil quality.

The extension of the model with the human and social capital satellite accounts enhances EEIS capabilities in two important aspects. The first one occurs at the individual level and allows EEIS to model non-market units and relationships that individuals' value and represent them in their utility function. Hence, EEIS acknowledges the preferences of truth, respect, fairness and compassion for instance in individual's utility function. As a result, it can evaluate the impacts of non-market strategies that enhance human values towards a higher level of individual and society adaptability to CC. The second one occurs in between the individual and social level and allows EEIS to capture the feedbacks between individuals' preferences and social preferences and hence identifies non-market means of utility functions shape evolution.

The model has one household that maximizes a constant elasticity of substitution utility function subject to a budget constraint. There are three firms that produce one commodity each, adjust to demand and face a Leontief production function with capital, labor and inter-industry flows as factors of production. This means that there is no capital and labor movement among sectors and that inputs endowments are exogenously fixed. The three commodities produced are: a) a bundle of organic barley and pig products, b) a bundle of non-organic barley and pig products, and c) other. The model has no savings and investment, no government and the economy is closed.

The model dynamics of the material goods and services produced are driven by producers' desire to reach the equilibrium level of inventories. The desired levels of inventories depend on the demand evolution. The dynamic general disequilibrium model equation is:

$\dot{X}P = \gamma\ (AXP + YP - XP)$ (1)

where XP is the current level of output value that moves towards the equilibrium state: AXP+YP. This adjustment process is graduated by γ, the adjustment rate.

The model dynamics from the consumer side are driven by their values and consequent preferences evolution. Individuals' preferences are distinguished between self-regarding and other regarding, identifying two types of utility functions that differ based on the different levels of elasticity substitution between non-organic and organic barley and pig bundles. The change towards one preference type is induced by its relative higher payoff. Specifically, the percentage change of other-regarded individuals in a population is modeled following the evolutionary preference change equation developed by Bowles and Gintis (2011):

$\Delta p = p\ (1\text{-}p)\ (\delta - s)/(1\text{-}sp)$ (2)

where *p* is the frequency of other regarding individuals in a population, it moves from 0 to 0.9. δ is the rate of oblique transmission, it moves from 0 to 0.9. *s* is other-regarding individuals fitness loss. In sum, the probability that other-regarding will shift to self-regarding depends on the fitness difference of the two types.

The definition and functional form of the above parameters is mainly based on the evolutionary behavioral research done by Bowles, Gintis and Hamilton (Hamilton 1963; Gintis 2000; Bowles and Gintis 2003; Gintis 2006; Bowles and Gintis 2011; Gintis 2011). Relevant research done by behavioral economist and psychologist complements and reinforces the modeling approach followed (Glimcher, Dorris et al. 2005; Baumeister, Sparks et al. 2008; Brañas-Garza, Cobo-Reyes et al. 2010). The initial parameter values and their rates of change for the particular case of Spain have been identified based on cultural research done by Ronen and Shenkar (1985), Posner (2000) and Allik and McCrae (2004). The difficulties faced for properly estimating and testing these intangible parameters indicate the need for a general interpretation of the results. There is a great need and calling opportunities for the collection of and research on data related to human and social capital.

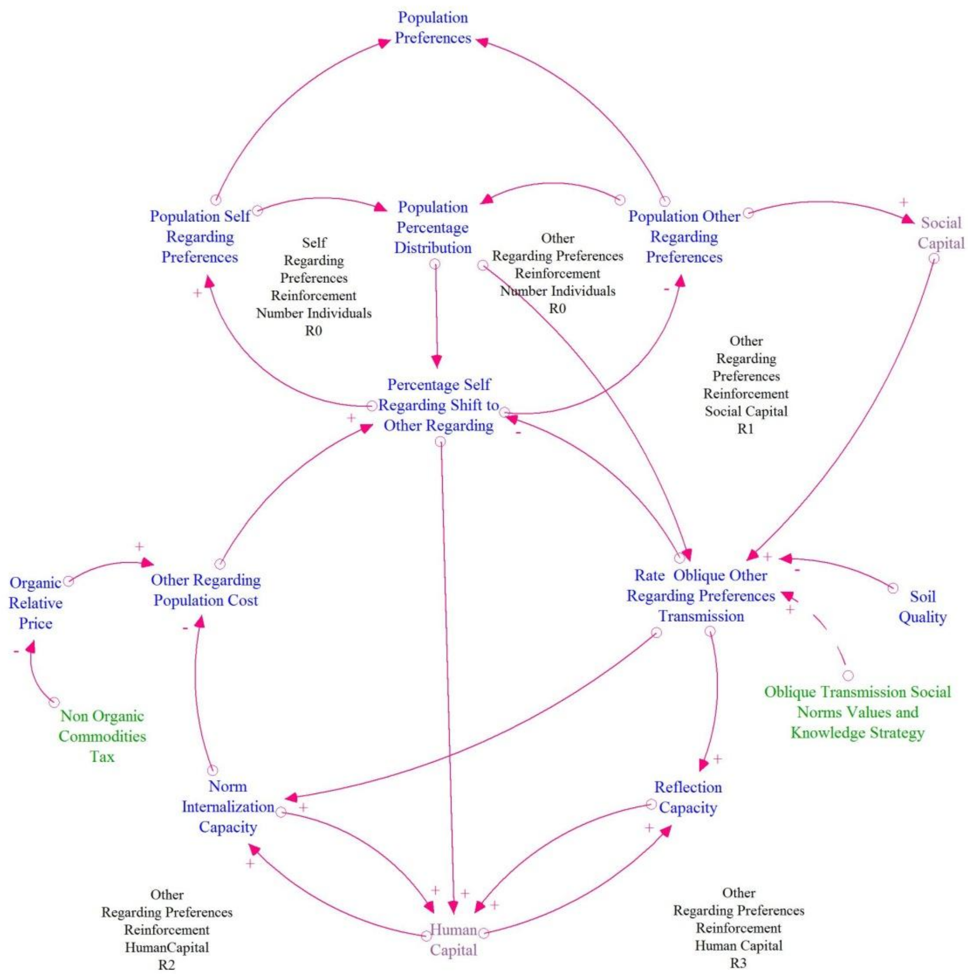
The rate of oblique transmission, δ, depends on the level of individuals with other-regarding preferences. If more than half of the population has other-regarding preferences, the rate of oblique transmission is two points higher. The rate of oblique transmission is negatively affected by the level of soil quality. Finally, oblique transmission rate also depends on the level of social capital, the higher the level of social capital the higher the rate of oblique transmission. All model equations can be found at appendix A.

Other-regarding fitness cost function is negatively related with the level of norms integration capacity and positively related with the relative higher cost of the non-organic bundle. The higher the integration capacity, the lower the fitness cost. The power of change in preferences given payoffs differences, φ, depends on the level of norms integration capacity and the level of reflection capacity. The higher their levels, the lower the power of change in preferences given payoffs differences (Bowles and Gintis 2011). The variables 'norms integration capacity' and 'reflection capacity' are a function of the level of human capital and the rate of other-regarding oblique transmission. Social capital change depends on the change in number of people with other-regarding preferences. Finally, a human capital change is a function of the level of norms integration capacity and reflection level capacity as long as they are positive.

The main challenges faced are how to estimate and model the preferences intangible parameters when data is not available or when data is available but for other populations. The estimation of the duration and impact level of the oblique transmission of social norms, values and knowledge strategy can be improved. Finally, the test and validation of the preferences section of the model has to be done.

The main model causal relationships are represented in the two figures below.

Figure 1: Self-Regarding and Other-Regarding Preferences Dynamics



Source: Author elaboration.

Figure 1 shows the causal relationships that allow the substitution of individuals' preferences between self-regarding and other-regarding. Basically, the shift from one preference type to the other depends on the relative cost/benefit ratio of being other-regarded instead of self-regarded. The relative benefit or cost of being other-regarded is measured via the variables of: a) Other Regarding Population Cost (that is the extra cost that 'altruist' people incur when spending their resources in helping others), b) Rate of Oblique Other-Regarding Preferences Transmission (the intensity by which other-regarding social values, norms and knowledge is transmitted), and c) Population Percentage Distribution (the relative number of people that is other-regarded instead of self-regarded).

Here, Other-regarding population cost is positively related with organic commodities relative price, and negatively related with the capacity of norm internalization. Meaning that the more internalized you has a norm; the less costly it is for you to behave in accordance. In EEIS, the rate of oblique transmission of other-regarding preferences increases with the level of social capital, the level of other-regarding individuals and the level of strategies that support it. It decreases with the level of soil quality, meaning that, the higher the level of natural quality, the lower the need to increase consciousness about it.

Figure 1 identifies the four main positive feedback loops that determine the evolution of individuals' preferences. These are:

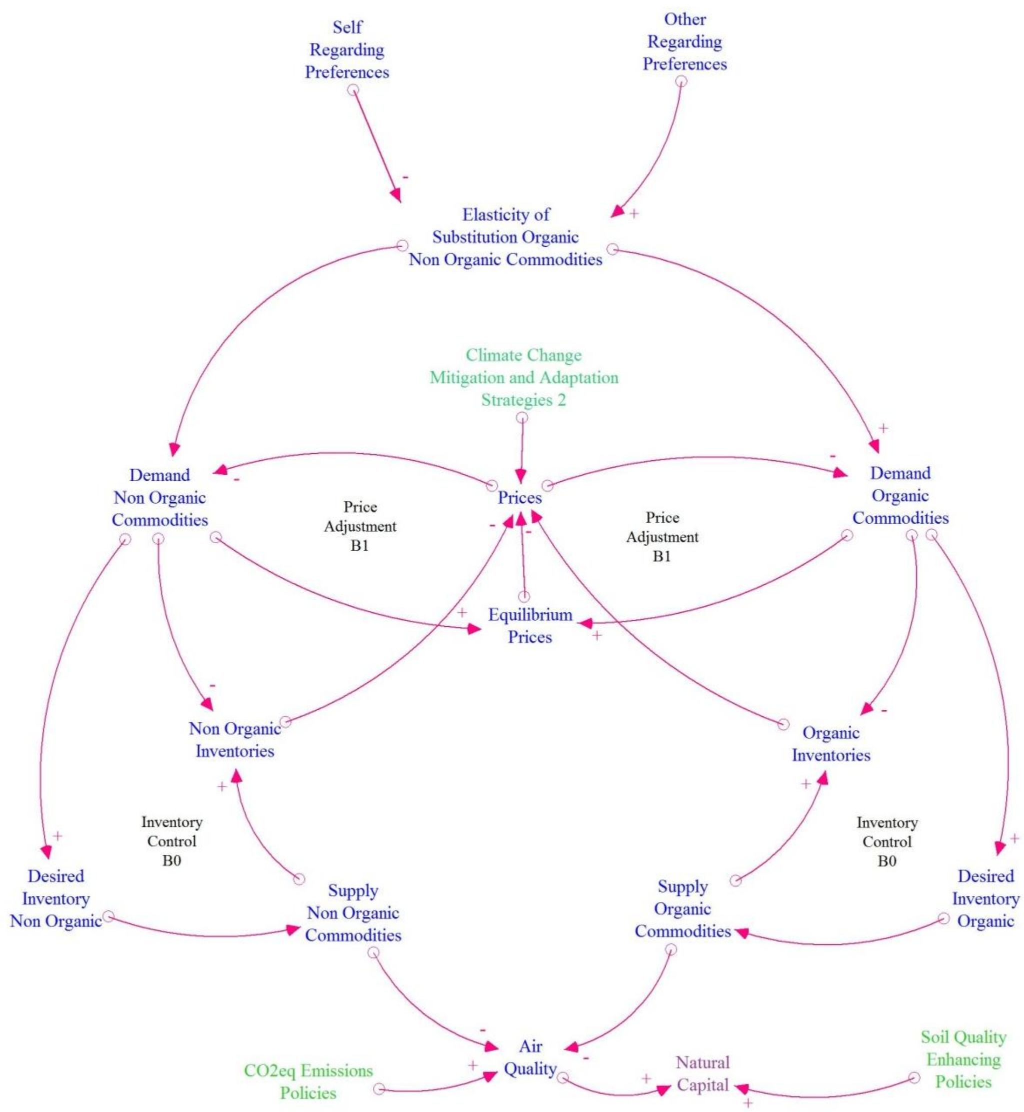
R0, that indicates that The more population with one type of preference, the higher the percentage of conversion towards that preference type. Here, we see that the relative amount of individuals with self-regarding preferences and other-regarding preferences generates a positive feedback loop with the percentage change from one type of preferences to the other.

R1 shows the positive feedback loop that reinforces the conversion of individuals with self-regarding preferences to other-regarding preferences via the level of social capital. Here we see a positive feedback loop between the number of individuals with other-regarding preferences, the level of social capital, the rate of oblique transmission of other-regarding preferences and the percentage of self-regarding shift to other regarding.

Finally, there are two positive feedback loops R2 and R3 that enhance the conversion of preferences towards other-regarding ones via the level of human capital. The first one relates the level of norm internalization capacity with human capital and the second one relates the level of reflection capacity with the level of human capital.

These parameters are estimated based on literature review on the evolution of humans' preferences mainly and my own observation on Spanish population profile. There are also inputs from sociology, psychology and anthropology disciplines.

Figure 2: Preferences, Supply and Demand Dynamics



Source: Author elaboration.

Figure 2 identifies two negative feedback loops that balance the evolution of supply and demand. The first negative feedback loop balances the actual inventory level with the desired one. The second negative feedback loop balances the supply and demand via the adjustment of the actual price with the equilibrium price.

Two main strategies tested are a market oriented one, and a bundle of the market oriented one with the enhancement of social values, norms and knowledge via oblique transmission. The market strategy is a 10% consumer tax on non-organic barley and pig commodities introduced in 2001. The results of each scenario are exposed in the below tables and graphs. The present model is expected to be further developed with more extensions related to human and social capital and with a higher detail of economic sectors and institutions. Hence, a wider range of strategies would be tested.

Table 1: Scenario 1, 10% Non-Organic Consumer Tax

		Percentage Change wrt 2000		
	2000	**2001**	**2020**	**2050**
Other-Reg Pop. Fitness Loss (units)	0.82	-0.280	-0.073	-0.073
Rate Oblique Transmission [0,0.9]	0.50	0.000	0.000	0.000
Pop Other-Regarding (%)	0.25	-0.001	-0.055	-0.129
Pop Self-Regarding (%)	0.75	0.000	0.018	0.043
Organic Quantities Demanded (units)	0.0251	0.869	0.494	0.378
Non-Organic Quantities Demanded (units)	0.0753	0.662	0.571	0.611
Human Capital (units)	100.0	0.000	0.010	0.025
Social Capital (units)	100.0	0.000	0.003	0.007
Soil Quality (units)	0.100	-0.00400	-0.08000	-0.20004
CO2eq gases Atmosphere (units)	4.000	0.000010	0.000105	0.000253

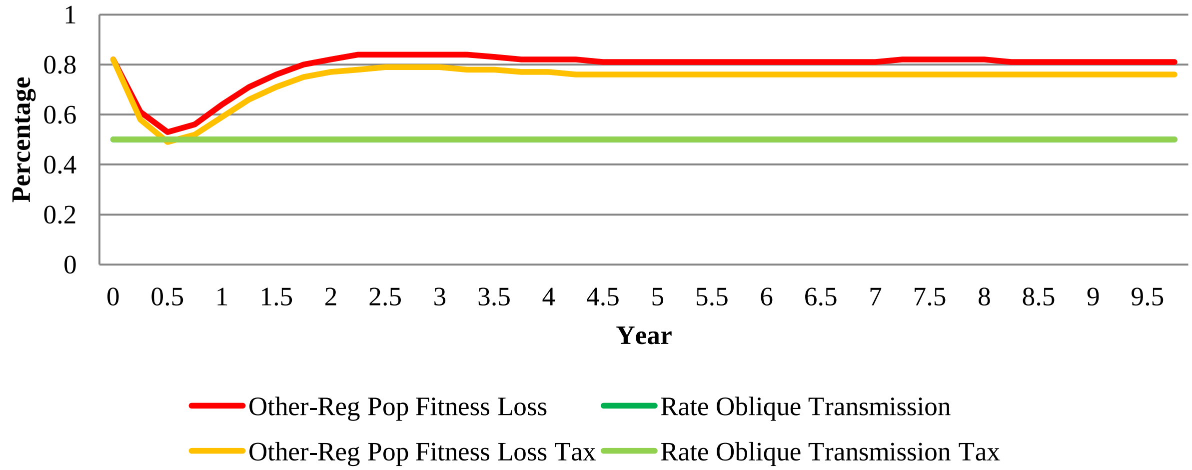
Source: Author elaboration.

Table 2: Scenario 2, 10% Non-Organic Consumer Tax plus Enhancement of Social Values, Norms and Knowledge via Oblique Transmission

		Percentage Change wrt 2000		
	2000	**2001**	**2020**	**2050**
Other-Reg Pop. Fitness Loss (units)	0.82	-0.415	-0.207	-0.207
Rate Oblique Transmission [0,0.9]	0.50	0.600	0.600	0.620
Pop Other-Regarding (%)	0.25	0.003	0.036	0.095
Pop Self-Regarding (%)	0.75	-0.001	-0.012	-0.032
Organic Quantities Demanded (units)	0.0251	0.877	0.635	0.726
Non-Organic Quantities Demanded (units)	0.0753	0.659	0.522	0.490
Human Capital (units)	100.0	0.001	0.019	0.049
Social Capital (units)	100.0	0.001	0.009	0.024
Soil Quality (units)	0.100	-0.00400	-0.08000	-0.20003
CO2eq gases Atmosphere (units)	4.000	0.000006	0.000102	0.000250

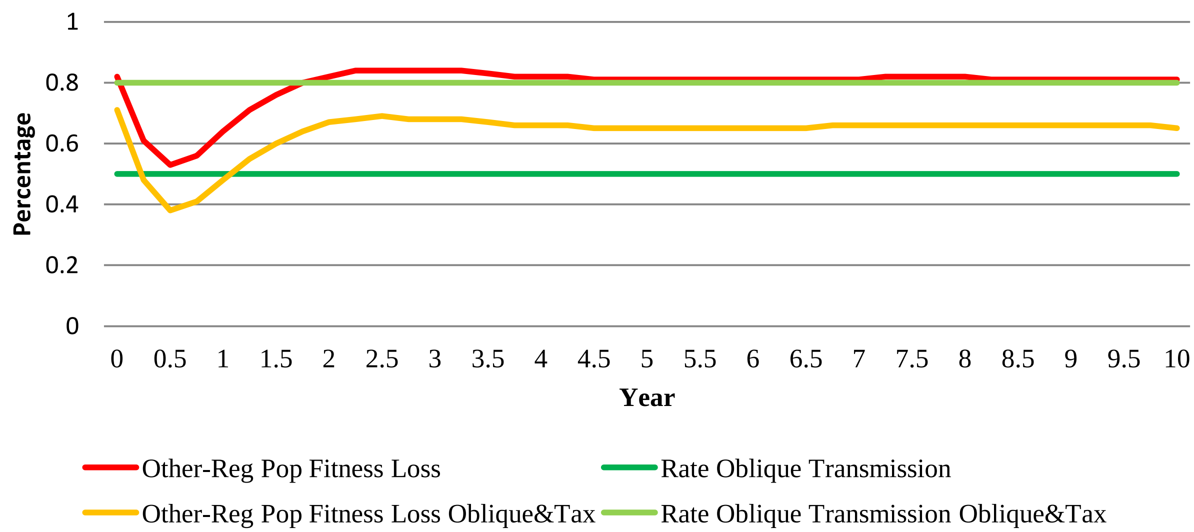
Source: Author elaboration.

Graph 1: Other-Regarding Preferences Factors, Baseline, 10% Non-Organic Consumer Tax



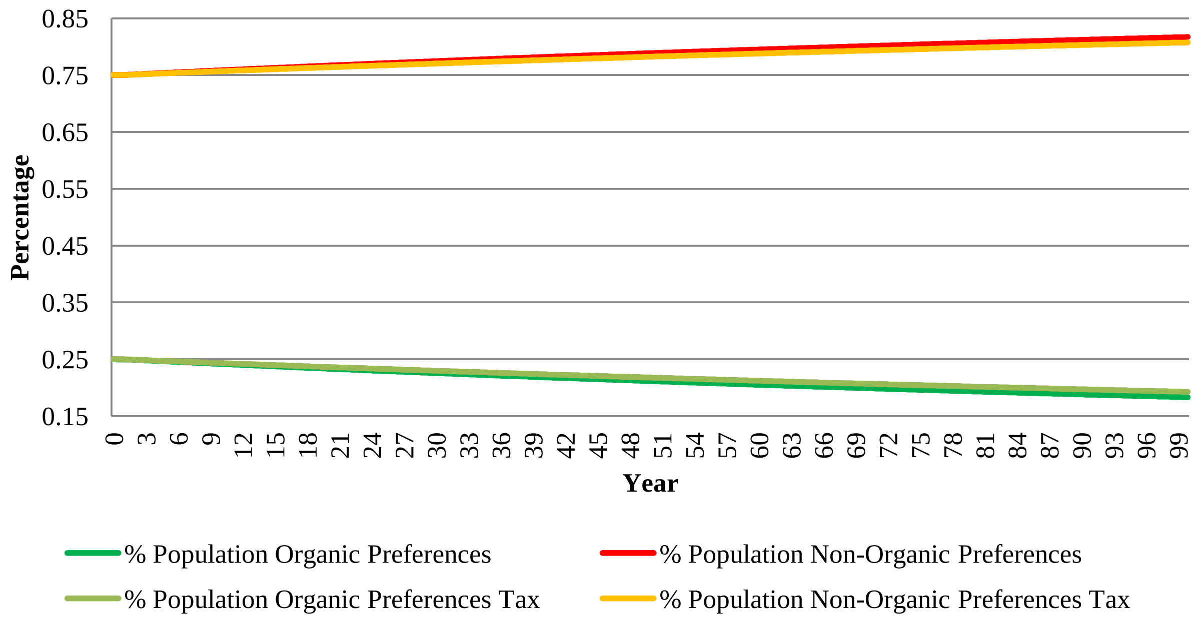
After a 10% consumer tax on non-organic barley and pig commodities individuals with other-regarding preferences see their cost of consuming organic products slightly reduced since now non-organic barley and pig products are comparatively more costly. A market policy does not affect the rate of oblique transmission of social norms.

Graph 2: Other-Regarding Preferences Factors, Baseline, 10% Non-Organic Consumer Tax and and Oblique Transmission Social Norms



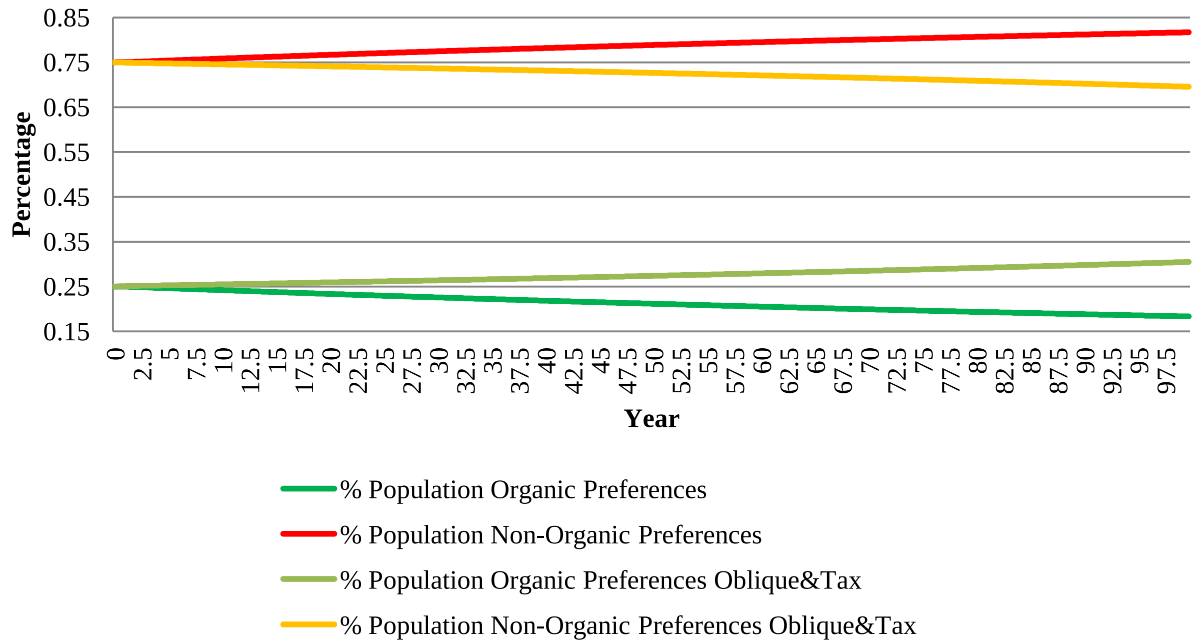
The combination of a 10% tax on non-organic barley and pig commodities and a non-market strategy that reinforces the oblique transmission of social norms, values and knowledge reduces substantially the cost of having other-regarding preferences (of being altruistic). This strategy increases the rate of oblique transmission in .15 points.

Graph 3: Population Preferences Distribution Baseline and after 10% Non-Organic Consumer Tax



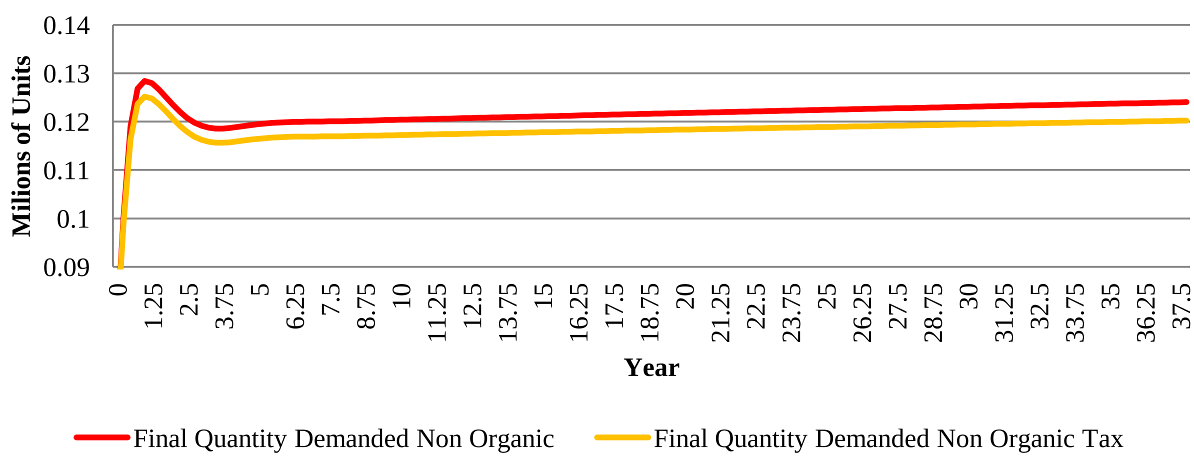
The percentage of population with organic preferences increases slightly after a 10% consumer tax on non-organic barley and pig commodities. On the opposite way, the percentage of population with non-organic preferences is slightly reduced after a 10% consumer tax on non-organic barley and pig commodities.

Graph 4: Population Preferences Distribution Baseline and after 10% Non-Organic Consumer Tax and Oblique Transmission of Social Norms



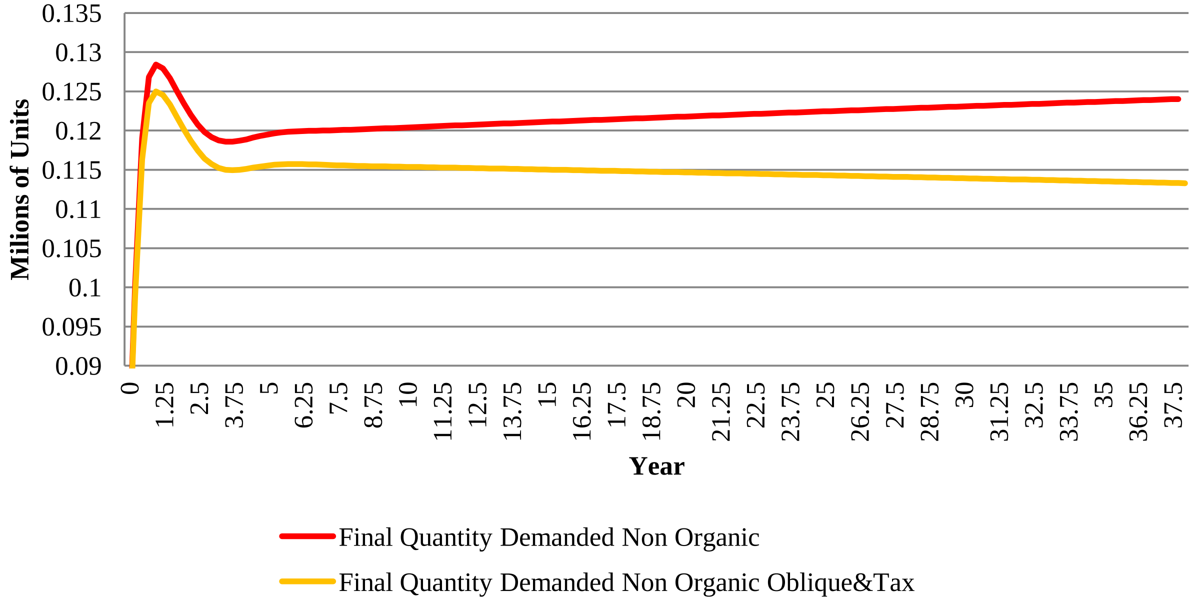
The percentage of population with organic preferences increases considerably after the combination of a market strategy of a 10% consumer tax on non-organic barley and pig commodities and a non-market strategy that enhances the transmission of social norms, values and knowledge via oblique transmission. On the opposite way, the percentage of population with non-organic preferences is considerably reduced.

Graph 5: Quantities Demanded Baseline and after 10% Consumer Tax on Non-Organic



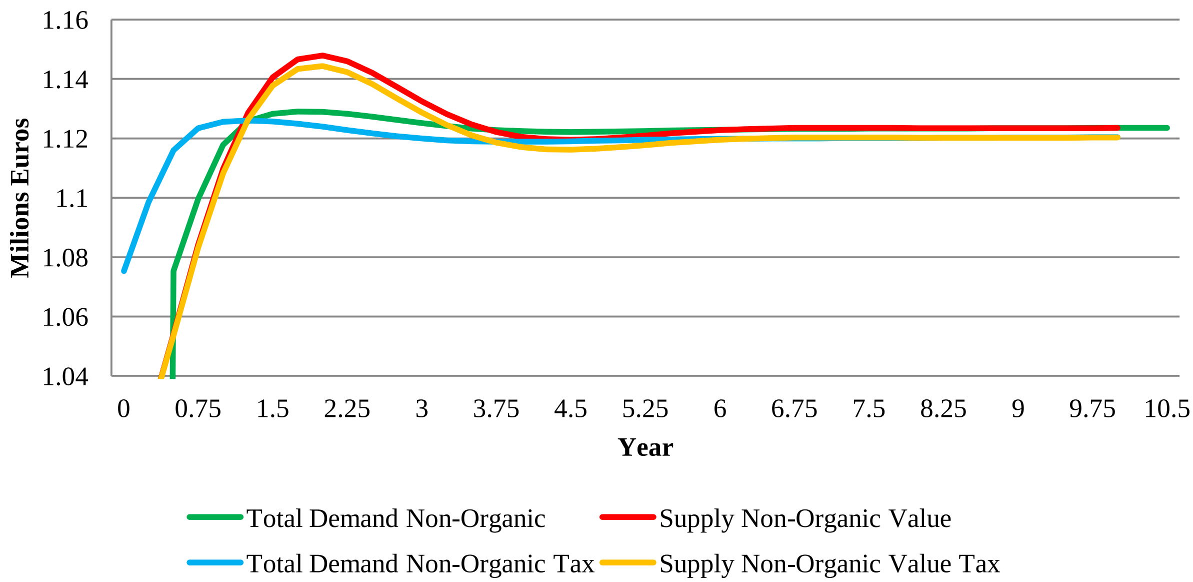
The level of quantities demanded of non-organic barley and pig commodities is slightly reduced after a 10% consumer tax on non-organic barely and pig commodities.

Graph 6: Quantities Demanded Baseline and after 10% Non-Organic Consumer Tax and Oblique Transmission of Social Norms

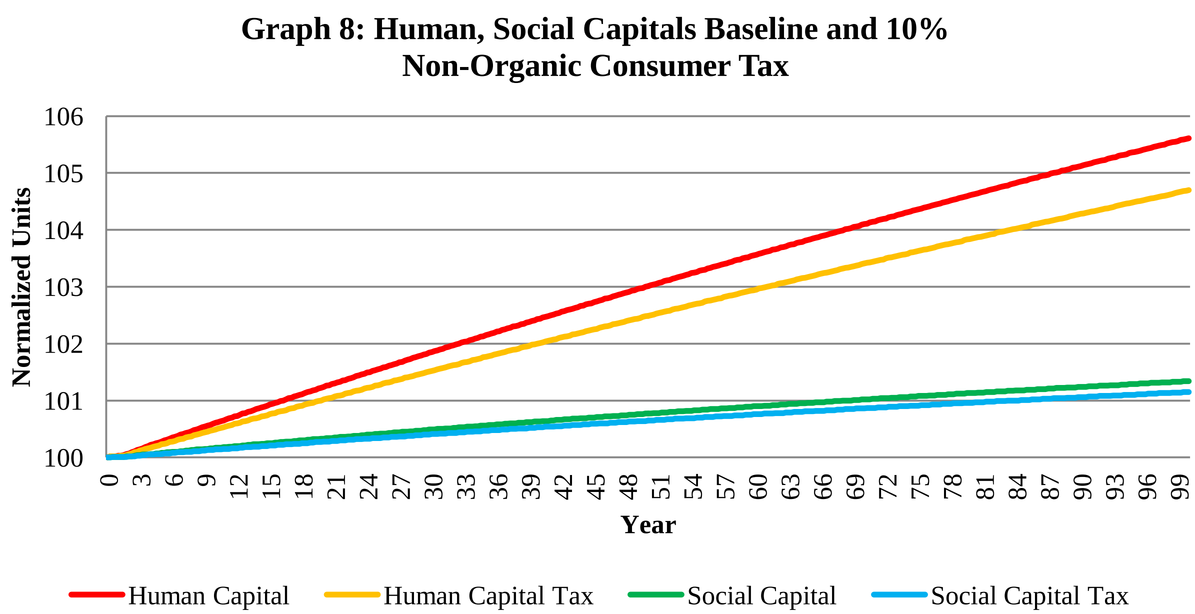


The level of quantities demanded of non-organic barley and pig commodities is substantially reduced after a combination of a 10% consumer tax on non-organic barely and pig commodities and a non-market strategy that enhances the oblique transmission of social values, norms and knowledge.

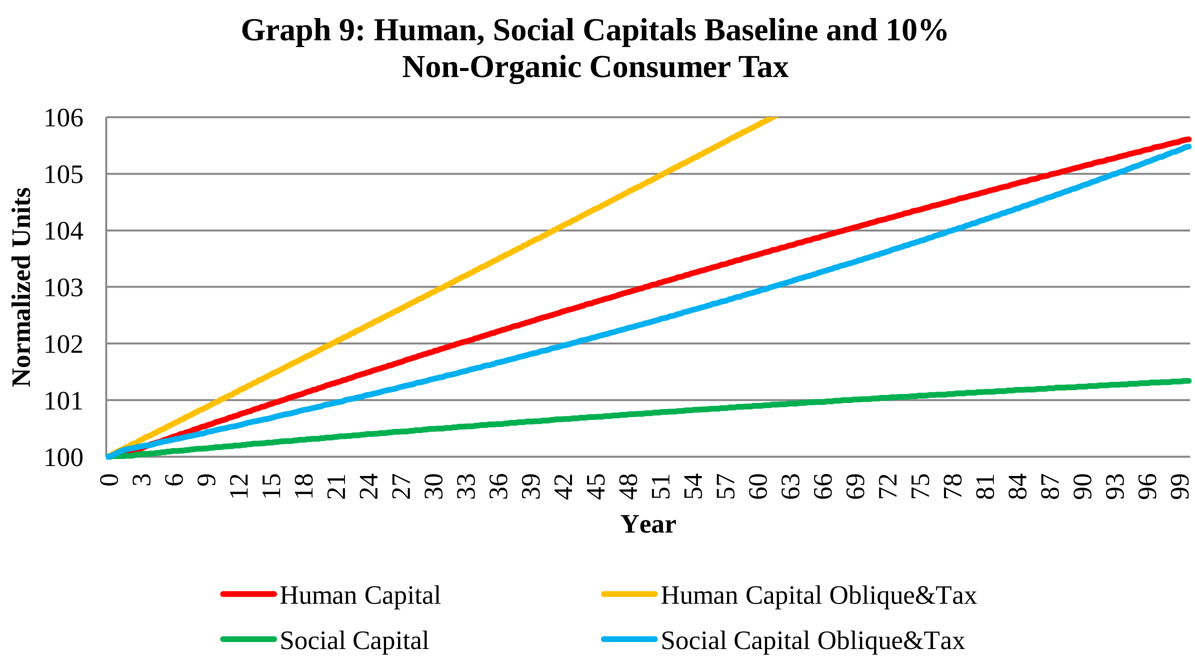
Graph 7: Demand Supply Non-Organic, Baseline and after 10% Non-Organic Consumer Tax



Supplies adjust to the demand level in both markets. Demand for non-organic bundle is slightly reduced after the 10% consumer tax.



The level of human and social capital increase slightly after a 10% consumer tax on non-organic barely and pig commodities. Comparatively, human capital grows faster.



The level of human capital and social capital increase substantially after a combination of a 10% consumer tax on non-organic barely and pig commodities and a non-market strategy that enhances the oblique transmission of social values, norms and knowledge. Comparatively, human capital increases in a faster pace.

V. Conclusions

Spain's ability to respond to its CC mitigation and adaptation commitments from a humans' values approach represents a big challenge and a great opportunity. The majority of Spanish people’s preferences are characterized as self-regarding and Spanish social institutions support the prevalence of such behavior. As a result, the altruistic behavior of contributing to the social benefits of climate change mitigation and the collective behavior that makes climate change adaptation more efficient are comparatively less developed than in the rest of EU countries. Results suggest that in order to enhance CC mitigation and adaptation in the short run market mechanisms that target monetary incentives are the most efficient ones. Results also suggest that a mix of market, governmental and community strategies are necessary for a sustainable long run behavior that addresses climate change mitigation and adaptation. Specifically, the oblique transmission of social norms, values and knowledge is identified as the key approach for the human and social capital development that would guarantee CO_2 emissions reductions and higher societal adaptive capacities in the long run. There is a great need for elucidating the ultimate causes of our social systems. The present model is expected to be further developed with more extensions related to human and social capital and with a higher detail of economic sectors and institutions. Hence, a wider range of strategies would be tested. Further data collection and research on the nature of human and social capital and their relationship is needed in order to properly illuminate non-market strategies that are every time more demanded in the development of regional adaptive capacities to the upcoming more changing scenarios.

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VI. Appendix

Appendix A: Model Equations

Total output (XP) equation is defined as the sum of intermediate demand (AXP), final demand (FP), inventory change ($\dot{N}$P), unplanned inventory change (UP), less inventory (NP) (all variables are a function of time, (t), for simplicity from now onwards (t) will be omitted)[9]:

$$X(t)P(t) = AX(t)\,P(t) + F(t)\,P(t) + BV(t)\,P(t) + \dot{N}(t)P(t) - N(t)\,P(t) + U(t)\,P(t)$$

$$XP = AXP + FP + BVP + \dot{N}P - NP + UP \quad (1)$$

where A is the technical coefficient matrix of 4x4 from the SAM. AX represents intermediate demand. AX follows a Leontief production function. P is the actual price.

Inventory change is defined as (environmental impact on firms' fitness goal):

$$\dot{N}P = L'XP - NP + UP \quad \text{where } \dot{N}P \geq 0 \quad (2)$$

L is the equilibrium inventory vector (an intermediate fitness goal) and the unplanned inventory change is (environmental mutation impact on firms' fitness goal):

$$UP = XP - [AXP + FP + BVP + \dot{N}P - NP] \quad (3)$$

Finally, output change (firms' selected strategy response to the new environment) is defined as:

$$\dot{X}P = \theta\,[AXP + FP + B(DXcP + \dot{X}cP) + L'XP - NP - XP] \quad (4)$$

where $\dot{X}P \geq -DXcP$

where θ is the production coefficient lag.

Producers' equilibrium and change equations are defined as follows:

For the Black commodity (in order for the sub-index to be easily read 'black and green' are used instead of organic and non-organic. The 'o' sub-index is used for the 'other' commodities), producer demand (in structural models it is called intermediate demand) is:

$$X_bP_b = A_{bb}X_bP_b + A_{bg}X_gP_g + A_{bo}X_oP_o + \dot{N}_bP_b \quad (5)$$

Black producer demand change is:

$$\dot{X}_bP_b = \theta[A_{bb}X_bP_b + A_{bg}X_gP_g + A_{bo}X_oP_o + L_bX_bP_b - N_b\,P_b - X_b\,P_b\,] \quad (6)$$

Producers supply is based on the final demand and the inventory change. Its equilibrium and change equations are:

$$X_bP_b = F_bP_b + B_bV_bP_b + \dot{N}_bP_b \quad (7)$$

[9] A list of the variables definitions can be found at the Appendix B.

$F_b P_b = HH_b P_b$ (8)

$\dot{X}_b P_b = \theta[F_b P_b + B_b V_b P_b + L_b X_b P_b - N_b P_b - X_b P_b]$ (9)

where θ is the production lag coefficient and where HHP is the households final demand value.

The equilibrium and change income household receipts equations are:

$X_h P_h = A_{hb} X_b P_b + A_{hg} X_g P_g + A_{ho} X_o P_o + F_h P_h + \dot{N}_h P_h$ (10)

$\dot{X}_h P_h = \theta[A_{hb} X_b P_b + A_{hg} X_g P_g + A_{ho} X_o P_o + F_h P_h + L_h X_h P_h - N_h P_h - X_h P_h]$ (11)

where θ is the production coefficient lag.

The quantity demanded of Black products from households is determined from a constant elasticity of substitution (CES) function:

$X_{hb} = (P_b^{\delta-1} * M_{bg})/(P_b^{\delta} + P_g^{\delta})$ (12)

where M_{bg} is the income spend on green and black commodities:

$M_{bg} = A_{hb} X_b P_b + A_{hg} X_g P_g$ (13)

δ is the elasticity of substitution between Black and Green goods. δ for consumers with other-regarding preferences is estimated as follows:

if Norms_Integration_Capacity < .7 then
(0+(.999*(Pop_Preferences_Frequency__Distribution[Organic]))) else 0.01 (14)

Meaning that once the integration of norms is very felt and deep, the consumer is not going to change to black commodities regardless of the external constraints. Before this integration level is achieved, the level of elasticity substitution of other-regarding consumers depends on the level of population that is other-regarding. The more other-regarding consumers, the higher the elasticity of substitution.

Other consumer types are assumed to have an elasticity of substitution of 0.01 in a constant elasticity of substitution utility function, meaning that their inclination to substitute black for green commodities is very low.

The same demand function applies for the green commodities but with the opposite sub-indices.

Equilibrium prices are formed by the interaction of supply and demand functions.

$P_e = \frac{AXP+FP}{X}$ (15)

AXP + FP is the total demand value at actual prices and X is the total quantity produced.

Price change is a function of the equilibrium price and the actual price:
$\dot{P} = \varphi (P_e - P)$ (16)
where φ is the price lag coefficient.

Finally, outputs produced are converted to CO2 equivalent gases emitted via a CO2eq gas converter. The CO2eq gases emitted are:

$CO2_{eq} gases\ emitted = XP * \vartheta$ (17)

where ϑ is the converter of total output to CO2eq gases.

From the above conceptual model we assume the following process:

1) actual commodities supply is increased by production (which responds with a lag to changes in inventories);

2) actual supply and actual demand determine equilibrium price;

3) actual price changes, with a lag, to reduce the difference between actual and equilibrium prices;

4) actual demand preferences change based on the change in the benefit cost ratio of having other-regardingn preferences instead of self-regarding ones;

5) change towards production of "green" commodities reduces the CO2eq gasses emitted.

This creates a number of causal loops and the following dynamic system:

1)

$\dot{X}P = \theta [AXP + FP + L'XP - NP - XP]$
$\dot{N}P = L'XP - NP + UP$ where $\dot{N}P \geq 0$

2) $P_e = \frac{AXP+FP}{X}$

3) $\dot{P} = \varphi (P_e - P)$

4) $X_{hb} = (P_b^{\delta-1} * M_{bg})/(P_b^{\delta} + P_g^{\delta})$

5) $CO2_{eq} gases\ emitted = XP * \vartheta$