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Alternative scenarios of green consumption in Italy: An empirically grounded model

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ABSTRACT

Any transition towards a more environmentally sustainable world will strongly depend on people's willingness to adopt the best available practices. We present here the *Consumption Italy* (*CITA*) model, an empirically grounded agent-based model designed to represent household consumption in Italy and to estimate the related greenhouse gas emissions under different environmental policy scenarios. We explored the effect of a price increase for high impact goods and services (e.g., because of the introduction carbon taxes) and of a change of agents' environmental concern (e.g., because of information campaigns). We found that both kind of actions can orient people consumption in the desired direction. However, their target and intensity should be carefully calibrated to produce significant effects at an acceptable cost.

1. Introduction

Shaping a sustainable path of development represents a major challenge that will lead to important changes in the production and consumption processes of the upcoming decades (e.g., Jackson, 2009; Rockström et al., 2009; Stern, 2007; Volk, 2008). While many environmental issues, including climate change, can be addressed by available technologies (Pacala and Socolow, 2004; Patrinos and Bradley, 2009), any transition towards a more sustainable world will strongly depend on people's willingness to adopt the best available practices. However, research showed that environmental concern does not directly translate into actual green behaviour and that consumption patterns often present strong lock-in features (e.g., Dietz et al., 1998; Diekmann and Preisendörfer, 1998, 2003; Jager, 2000). The problem here is that people's behaviours are interdependent and that changes are costly. Individuals affect each others in their consumption choices and social comparison is an important factor in decision making processes. Moreover, structural and institutional constraints often prevent significant behavioural change even when a clear willingness is present.

Due to these self-reinforcing processes, it can be difficult, although not impossible, to motivate people to change their usual behaviours and to adopt existing green alternatives. Indeed, past research on the impact of green consumption policies on consumers' behaviour led to mixed findings. On the one hand, some studies argued that economic incentives and structural arrangements are more efficient in reducing environmental impact than intervening on environmental consciousness or ecological knowledge, especially when the costs linked with the transition towards more sustainable behaviours are significant (Diekmann and Preisendörfer, 1998, 2003; Polhill et al., 2013). Moreover, Dunlap and McCright (2008) and Schultz (2000) showed that a significant part of the western population has little sensitivity to informational or educational campaigns, making price-based policies more effective.

On the other hand, Jackson (2005), reviewing the outcomes of current environmental policies, argued that the evidence for a significant effect of environmental taxes on consumer behaviour is weak. For instance, it has been estimated that achieving significant and steady reductions in energy use would require a rise in prices

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by 3–5% per year (Michaelis, 1997). More generally, a sustained reduction in resource use at the global level would require price levels that are even difficult to propose in the current political arena (ECMT and OECD, 1995).

Jackson and Michaelis (2003) held a more optimistic view of public policies based on information and persuasion. They reported about the effects of a UK public campaign that led to a significant rise in the awareness of the link between individual behaviour and the environment. Other authors similarly argued that informational and normative-based policies are more effective than economic stimuli in producing behavioural change (Dobson, 2007; Sheth et al., 1991; Sutcliffe et al., 2008). Nevertheless, the value-action gap remains a widely recognized issue, suggesting that a raise in environmental awareness could have little effect in producing an actual change in consumers' behaviour (DEFRA, 2006; Stern et al., 1996; Young et al., 2010) and recommending more focused information campaigns—along with the change of structural limits, e.g., through increased availability of green products—to obtain significant results (Jackson, 2005).

To better understand the link between consumers' attitudes and behaviours, social influence, and green policies, it is hence crucial to design credible models of the consumers' response to green stimuli. In this paper, we tested the effect of alternative policy options on a virtual sample of Italian households. Through an empirically-grounded agent-based model (ABM), called *Consumption Italy* (*CITA*), we studied whether price-based or information-based policies are more effective in motivating people to reduce their greenhouse gases (GHG) emission in three domains, namely food, transports and energy consumption.

The remaining of the paper is organized as follows. Section 2 defines the model. Section 3 grounds it into empirical data. Section 4 presents the model calibration and the outcomes resulting from a number of different policy scenarios. Finally, Section 5 discusses the results.

2. Methods

Agent-based models are simulated systems including the following elements: (i) an environment, i.e., a set of objects which may be displaced, created, deleted or modified by the agents; (ii) a set of active agents; (iii) a set of relationships linking objects and/or agents together; (iv) a set of operators allowing the agents to interact with the objects. Agents are entities able to perform autonomous actions within their environment and to interact with other agents. Their decision making process is not necessarily based on rational choice and their representation of the environment may be inaccurate (Ferber, 1999; Gilbert, 2008; Grimm, 1999).

ABMs represent a valuable alternative to represent complex systems formed by a large number of heterogeneous agents, where traditional forms of modelling (e.g., mathematical, statistical) present significant shortcomings like analytical intractability or unacceptable assumptions (Railsback and Grimm, 2005). Due to their flexibility, ABMs are especially well adapted to model social-ecological systems (Filatova et al., 2013; Janssen and Ostrom, 2006; Poteete et al., 2010; Schreinemachers and Berger, 2011). They are especially useful to integrate the influence of micro-level decision making into the system dynamics and, hence, to study the emergence of collective responses to policies (Balbi and Giupponi, 2009; Hare and Deadman, 2004; Matthews et al., 2007). One particular advantage of using ABMs in the study of consumers' behaviour is the possibility of modelling agents holding heterogeneous preferences and following a broader pattern of decision rules than simply the profit-maximization one (Jager, 2000). Moreover, agents can be developed to reflect the empirical distribution of preferences, motivations and environmental concern resulting from surveys or other studies based on statistical samples of the target population (Boero and Squazzoni, 2005; Janssen and Ostrom, 2006; Gilbert, 2008; Smajgl et al., 2011).

2.1. Model overview

Within the larger framework of the *Green Economy Research on the Mediterranean Environment* (GERME) project of the Collegio Carlo Alberto, two complementary models were developed: a hybrid Life Cycle–Environmental Input Output Analysis (*LCA–EIOA*) tool to assess GHG emissions and *CITA*, an empirically grounded agent-based model to estimate Italian household consumption under different environmental policy scenarios. The two models work in synergy to assess the effect of different environmental policy scenarios on Italian households' GHG emissions.

The first model is the *LCA–EIOA* tool, developed by Padovan et al. (2012) starting from the work of Wilting (1996). This method quantifies the total energy demand of households for a given population (e.g., a city, a region or an entire country) as a proxy of their environmental pressure. As highlighted in the international literature (e.g., Hertwich, 2011; Wiedmann, 2009), hybrid LCA–EIOA methods are preferable to standalone methodologies because they benefit both from the completeness of EIOA (Environmental Input Output Analysis), which uses a "top-down" approach, and from the specificity of LCA (Life Cycle Assessment), which instead adopts a "bottom-up" approach. Within the GERME project, the *LCA–EIOA* model has been applied to quantify the environmental requirements of specific household metabolic patterns (Kok et al., 2003), including the ones used by the *CITA* model.

The second model, *CITA*, takes inputs from the social and political realms and maps them into consumers' choices, hence creating variable scenarios depending on assumptions about future environmental policies and/or changes in the environmental concern of consumers.[1] The model is based on agents choosing between alternative "consumption patterns" (hereafter CP) depending on their own preferences, social influence and the relative price of the different patterns. A CP is here an *a priori* defined style of food, transport or energy consumption, which represent three separate aspects of a specific lifestyle that were selected according to their weight on households' GHG emissions (Hertwich, 2011). Note that the same CPs are used in both the *LCA–EIOA* and the *CITA* models, hence representing the direct interface between the two models.

Agents have preferences based on the ones expressed by real individuals in the Eurobarometer Survey, Wave 68.2 (hereafter EB 68.2) (see Eurobarometer, 2008). Politics enter the model by changing the relative price of different commodities (e.g., via carbon taxes or incentives for green products) or by modifying agents' preferences (e.g., via information campaigns) (Section 4.2). *CITA* hence represents a tool that can be used both to improve our understanding of the drivers of consumption and to create scenarios about the effects of alternative environmental policies.

2.2. The agents

Agents in *CITA* are based on Janssen and Jager's model of green product diffusion (Janssen and Jager, 2002). Each agent i possesses a set of preferences $P_i = \{p_{i1},\ldots,p_{im}\}$ including $m = 4$ dimensions. Here, p_{i1} refers to the environmental dimension of food production, p_{i2} to food health and safety, p_{i3} to sustainability in transportation and p_{i4} to sustainability in energy consumption. Each agent maps one of the Italian respondents of the EB 68.2 survey, with its preferences deriving from the answers given by the corresponding individual in the survey (see Section 3.1).

In each time step, agents choose among the available CPs in three different "domains": the first one concerning food, the second transportation and the third energy consumption. Agents have both personal and social needs, whose satisfaction is affected by their CPs. Personal need satisfaction depends on the difference between the dimension d_{jk} of CP k (note that each domain j can include a variable number of patterns) and the corresponding agent preference. Formally, the personal need satisfaction of agent i consuming pattern k of domain j is defined as

$$N_{ik}^{p} = 1 - \frac{\left|p_{ij} - d_{jk}\right|}{m} \tag{1}$$

Note that, while CPs referring to transports and energy have only one dimension (environmental sustainability), CPs referring to food consumption hold two different dimensions, namely environmental sustainability and health (see Section 3.2). In this case, the agent satisfaction is simply computed by averaging Equation (1) over the two dimensions.

Agents are embedded in a social network. To build it, we followed a principle of homophily, i.e., agents have a higher probability to be linked with other agents having similar preferences (see Section 3.1). The underlying assumption is that agents are more likely to be influenced in their consumption choices by other agents sharing similar worldviews on environmental (or health) issues. More specifically, each agent created $l = 3$ undirected links with other agents having the lowest Euclidean distance over the m dimensions of the preference array. The above linking procedure produced a clustered network with similar agents closely linked together. Subsequently, a small proportion $p = 0.05$ of agents established random links with other agents to create the small-world like network that was also used in Janssen and Jager (2002) (for the details of the small-world network construction, see Watts, 1999; Watts and Strogatz, 1998).

Following Janssen and Jager (2002), we assumed that agents derive social satisfaction from their relations and prefer to have CPs similar to their neighbours'

[1] The *CITA* model is based on the Netlogo platform (Wilensky, 1999). Interested readers can download a copy of the model from the OpenABM (http://www.openabm.org/model/3708/version/1) repository, along with a complete description following the ODD protocol (Grimm et al., 2010).