GAMIFICATION AND EXPERIMENTAL ECONOMICS: MODELLING ENERGY EFFICIENCY AND SPILLOVER EFFECTS IN A NONLINEAR PUBLIC GOOD GAME

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Overview

Transforming energy systems gives rise to new roles of market acteurs and governments as well. Renewable energy sources in the electricity system can also be used to replace conventional ones in other parts of the system such as the markets for heating and transportation. When energy efficiency technologies are developed to achieve more flexible and smart solutions to balance supply and demand on electricity markets traditional sector boundaries become permeable and energy consumers begin also to adopt the perspective of producers and investors. Individual production and investment decisions of market actors create spillover effects which are either to the benefit or to the worse for other parts of the system. Economic theory highlights two questions for the social design of this transformation process which are closely related: First, as the whole society has to bear the cost of transforming the energy system, the question has to be answered, how to distribute these costs among individual market participants and tax payers. And secondly, as individual decisions to invest, to produce or to consume on energy markets create economic, technological or environmental spillovers for the rest of society, one has to deal with the problem of how to internalize external effects. Empirical studies of consumer preferences show that bare and abstract theoretical positions how to internalize external effects cannot be translated directly to recommendations for political action when behavioural effects are ignored. For example: experimental research shows that societal acceptance for the political goals of Germany's Energiewende is heavily impacted by its distributional consequences. Heterogenous households reveal a strong preference for the ability-to-pay principle, but cost uncertainty makes the ability-to-pay principle less attractive and tends to crowd-out social preferences. Moreover, subsidizing investments into energy efficiency directed to stimulate co-operative behaviour may lead to unintended counterproductive reactions (Beyer et al. 2018). However, as such kind of economic experiments concentrate primarily on the theoretical accuracy of the underlying behavioural model and its application in a public good environment, one might critizise that these methods lack real world interrelations and do not account for experiences and feedbacks individuals face when they act. Hence, alternative approaches such as seriours games focus more on creating innovative adventures and stories which enable players to gathter more realistic hands-on experiences in an interactive environment with other players (Müller et al. 2017). These approaches are primarily directed to enable players to get in touch with real world phenomena and learn about the consequences of individual and collective decisions, but they do not deliver a methodological basis for measuring individual preferences. In this paper we present an innovative approach which integrates the theoretical accuracy of behavioural and experimental economics into a professional serious game. The project is financed by the German Ministry of Education and Research (BMBF). Gamification is used to highlight the dilemma of co-operative investments in energy-related infrastructure such as energy efficiency, which gives rise to positive externalities in a well-designed regional vicinity.

Methods

The theoretical frameework is based on an incentivized, non-linear public good experiment. The underlying model is a derivative of the impure public good model as suggested by Cornes and Sandler (1996) and used in previous studies (Paetzel & Traub 2017, Menges & Beyer 2014). It features three core attributes of investments such as energy efficiency, which are expressed in a payoff function: opportunity costs in terms of reduced private consumption (1), private benefits of efficiency investments such as local quality improvements or reduced energy expenditures (2) and public benefits reflecting the positive spillovers of efficiency investments such as improvements of environmental quality. When modelling energy efficiency in this multiplicative payoff function we follow Chan et al. (1999), who state that in the energy efficiency case all involved parties have different sizes, different interests, and different abatement cost structures. This leads to non-linear payoff structures of individual decisions. Heterogeneity of parties is modelled by assuming that three subjects with different endowments form a community. The investment problem is non-linear in the sense that each optimal individual investment almost certainly is greater than zero and lies in the interior of the choice set of each agent. Note, that the incentive structure of such kind of model is characterized by the motivation of free-riding. Even in the absence of regulation, it is in the private interest of all individuals to invest at least certain quantities of their endowments, given the expected investments of all other individuals (Nash equilibrium). However, all individuals would benefit if they would cooperate and invest in a way which maximizes the sum of all individual payoffs (welfare maximization). Hence, the gap between the optimal investment in the Nash-equilibrium and the welfare maximizing investment can be interpreted as energy efficiency gap. The model also predicts that subsidies for energy efficiency investments can be used to to internalize external effects. The implementaion of this model within a professional full-computerized and animated gamification approach is based on the following story (gameplay, see figure 1): Three players adopt the role of mayors in neighboured cities. Each urban landscape is depicted by animated fiures representing everyday life scenes. The whole experiment consists of 10 subsequent rounds. Each round takes 3 minutes. In each round the mayor can invest parts of his endowment in energy projects which changes the appearance and amenity of his city (game-world). As a consequence of the investment cities become more (or less) attractive and the population changes because of an influx of new citzens. Each round consists of 3 minutes and at the end of each round the mayors are invited to sightsee also their neighbouring cities in order to visualize the results of their decisions. Each mayor has the objective to create a city which maximizes the number of its citizens. He knows about the effects and spillovers of each investment decision, but he does not know the decision of the other two mayors, when investing. The mathematical relation between investment and the resulting number of citizens in each city is defined by the nonlinear payoff function described above. The number of citizens will be converted in cash. At the end of the experiment a lottery mechanism will select one of the the ten rounds, which results will be paid out to the players. The model also delivers the hypotheses which are needed for preference elicitation. The experiment finally includes a questionnaire concerning sociodemografic variables and certain attitudes of each player towards environmental and energy policy.

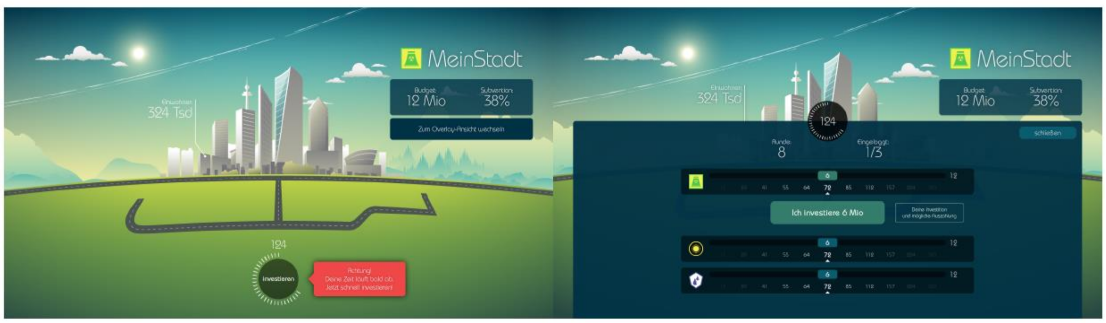

Figure 1: Game-Play "Energy City"

Results and Conclusions

The experiment will be conducted at the University of Hamburg in February 2018 with 288 participants. To our knowledge this will be the first economic experiment which combines experimental game theory and professional gamification. We will ask, wheter gamification which lays greater emphasis on a realistic framing of tasks in order to stimulate motivation and immersion of players tends to influence the results of standard experiments conducted in this field of research. Moreover, based on a well-defined treatment structure, the experiment will deliver answers how the skewness of endowments affect individual and collective investment behavior and how to design subsidies to prevent free-riding in the energy efficiency case.

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