Energy Efficiency-Enhancing Investments in Experimental Oligopoly

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Abstract
We present results from experimental price-setting oligopolies in which green firms undertake different levels of energy-saving investments motivated by public subsidies and demand-side advantages. We find that consumers reveal higher willingness to pay for greener sellers' products. This observation in conjunction to the fact that greener sellers set higher prices is compatible with the use and interpretation of energy-saving behaviour as a differentiation strategy. However, sellers do not exploit the resulting advantage through sufficiently high price-cost margins, because they seem trapped into "run to stay still" competition. Regarding the use of public subsidies to energy-saving sellers we uncover an undesirable crowding-out effect of consumers' intrinsic tendency to support green manufacturers. Namely, consumers may be less willing to support a green seller whose energy-saving strategy entails a direct financial benefit. Finally, we disentangle two alternative motivations for consumer's attractions to pro-social firms; first, the self-interested recognition of the firm's contribution to the public and private welfare and, second, the need to compensate a firm for the cost entailed in each pro-social action. Our results show the prevalence of the former over the latter.

Keywords: corporate social responsibility, energy savings, public good, experiments, vertical differentiation, altruism.
JEL Classification: C91, L11

Introduction

Milton Friedman (1970) argued that "only people can have responsibilities. This critical position towards corporate social responsibility is also apparent in neoclassical economists' recent statements[1]. Other economists argue, in contrast, that within a context of globalization, nation states and their agencies are severely constrained in their ability to monitor and protect the rights of

[1] See Henderson (2001), Jensen (2002) and Sundaram and Inkpen (2004).

their citizens and to provide sufficient public goods[2]. Consistent with economic theories of the firm, McWilliams and Siegel (2001) suggest that the economic case is not to reject CSR entirely, but to find an optimum level of CSR. Husted and Salazar (2006) extend these arguments to say that a strategic approach to CSR may help business firms to improve profitability and enhance social performance at the same time. They describe the context in which it may be possible to maximize social profit so that both society and business firms benefit. Distinguishing among strategic CSR, altruistic CSR, and even coerced CSR, McWilliams, Siegel, and Wright (2006) describe a variety of perspectives on CSR, which they use to develop a framework for consideration of the strategic implications of CSR. Baron's (2001) define strategic CSR as the use of CSR to attract socially responsible consumers, in the sense that firms provide a public good in conjunction with their marketing/business strategy. Attending to product differentiation, we can divide papers about strategic CSR into three different groups. The first group considers ethical consumption as a source of vertical[3] product differentiation assuming that all the consumers prefer buying the product with a CSR characteristic than the product without such a characteristic. The vertical differentiation represents the CSR aspects of the production process that are perceived as a quality improvement of the final product by socially conscious consumers. The second group presumes horizontal[4] product differentiation assuming that only some consumers prefer a particular product, but the preference is based on taste, rather than quality. The third group[5] is a mix of the two former groups, assuming that consumers' population is split into two different exogenously given groups of consumers with different preferences: the group of convinced standard consumers and the group of potentially ethical consumers.

Our paper relates to the aforementioned first group where product variants differ in their quality and consumers differ in their willingness to pay for quality, following the pioneering work of Mussa and Rosen (1978), Gabszewicz and Thisse (1979), and Shaked and Sutton[6] (1982, 1983). Unlike Crampes and Hollander (1995) we model the cost of quality as an increase in firm's fixed cost, constraining its subsequent actions, and hence the actions of its competitors. This insight applies to the regulatory arena as well as Lutz et al. (2000) show when they find that corporate leaders may strategically commit to modest environmental improvements that constrain regulators' ability to set tough standards. A paper by Reinhardt (1998) finds that a firm engaging in a CSR-based strategy can only generate an abnormal return if it can prevent competitors from imitating its strategy. In competitive markets this is unlikely, since CSR is highly transparent.

[2] See Beck (2000), Kaul et al. (2003) and Scherer et al. (2007).

[3] See Amacher et al. (2004), Uchida (2007), Calveras et al. (2007), Mitrokostas and Petrakis (2008), Baron (2009), Bottega and De Freitas (2009), Casadesus-Masanell et al (2009), Toolsema (2009) and García-Gallego and Georgantzís (2009).

[4] See Becchetti and Solferino (2003) and Conrad (2005).

[5] See Davies (2005) where the size of groups of consumers is exogenously given and Fanelli (2008) where is not.

[6] Arora and Gangopadhyay (1995) apply this model to voluntary over-compliance of firms with established government standards. In their model the market gets segmented by income levels and firms with different levels of environmental-friendliness are able to charge different prices and achieve a positive profit. Choi and Shin (1992) modify the vertical differentiation model by Shaked and Sutton (1982) allowing for an uncovered market based on "taste diversity".

Other theoretical studies (Dutta et al., 1995; Hoppe and Lehmann-Grube, 2001) show that any early mover advantages that might be gained by offering higher quality products are eroded when competitive strategies are observable.

Previous experimental work by Barreda et al. (2011) has established that consumers tend to support sellers with some pro-social activity and that this motivates firms to make socially beneficial investments in an effort to differentiate themselves from other, less generous sellers. In fact, it had been shown there that firms may end up in a prisoners' dilemma leading them to lower profits than if they had not become pro-social. However, in that paper, the consumer was treated as a black box. No motivation was clearly identified as to why consumers are willing to pay more for products sold by socially responsible firms. For example, it was not clarified whether a consumer supports a pro-social seller because he appreciates the costs incurred during the pro-social activity, or because the activity itself has a direct utility-increasing effect for the consumer.

While some oligopoly models predict that firms producing a higher quality product earn 'abnormal' returns, these findings hinge on the assumption that costs are constant and independent of quality. Furthermore, some economic models of CSR (Baron, 2001; Fedderson and Gilligan, 2001) identify an important countervailing force on the ability of companies to engage in strategic CSR in oligopolistic industries: activists who target leading firms. This countervailing force makes it difficult for oligopolistic firms to achieve a competitive advantage through the strategic use of CSR.

Bagnoli and Watts (2003) study the feasibility of CSR by private firms with "warm-glow" (in Andreoni's (1989, 1990) sense) preferences for public goods. They conclude that, when firms explicitly link provision of a public good to sales of the private good they offer, the provision of the public good is inversely related to the competitiveness of the market. Specifically related to our framework, they find that if provision of the public good is not explicitly linked to the sales of the private good and there is free entry, too little of the public good is privately provided. The reason is that even firms enter until profits are zero, they are only able to capture the participation benefits that accrue to consumers but not the common benefits of having a positive quantity of the public good available. Kotchen (2006) develops a general model of private provision of a public good that includes the option to consume an impure public good. This paper shows that, if a green market is not sufficiently large or environmental quality is not a gross complement for private consumption, introducing a green market may actually discourage private provision of an environmental public good and diminish social welfare. Besley and Ghatak (2007) find that firms that use CSR will produce public goods at exactly the same level as predicted by the standard voluntary contribution equilibrium for public goods, hence always leads to an excessive level of public goods.

Our paper relates with another two experimental papers. First, taking eco-labelling as an example of CSR, Cason and Gangadharan L. (2002) study sellers' incentives to offer products of differing environmental quality. The authors conclude that the regulator can improve environmental performance by providing the option of certified green labeling. Second, Rode et al (2008) study ethical differentiation of

products in triopolistic experimental markets with an exogenous determination of whether a producer is pro-social or not.

Experimental Design

Nine sessions were conducted, with a total of 324 participants. Experimental subjects were students at the University Jaume I, Spain. Using standard procedures, subjects were recruited among voluntary undergraduate students from different economics and business-related courses. Before the session started, subjects were randomly distributed into two separate rooms, one for consumer-subjets and one for firm-subjects. Inside each room, an experimentalist gave to each subject an identification number, read the corresponding written instructions and answered any remaining questions[7].

At the end of each session, subjects were privately paid in cash. A session lasted 150 minutes approximately[8] and average earnings were 30€. Specific software, based on PHP programming, was created for this experiment. All sessions were carried out at our Laboratori d'Economia Experimental in Castellón, Spain (LEE, http://www.lee.uji.es/).

Five treatments were implemented, respectively denoted as T0, T1, T2, T3 and T4. The main characteristics of each treatment are described in Table 1. Each market consists of 9 firms and 9 consumers. Firms produce a homogeneous commodity at a constant unit cost equal to 100 ExCUs (Experimental Currency Units). The market lasts for 37 periods. Each period, the consumer must purchase a unit of the good and has to decide which company to buy from. To buy the product, each period the consumer starts with an initial endowment of 200 ExCUs. We use T0 as the baseline treatment. In the baseline treatment T0, each period, firms simultaneously decide the selling price for the product. Once the 9 firms have taken their price decisions, this information appears at the same time in the computer screens of all consumers. Consumers then must decide from which company to buy the unit of product. For consumers, per period earnings are calculated as the difference between the period endowment and the price paid for the unit. The total profits of the experimental subjects are equal to their accumulated earnings in the 37 periods.

In treatments T1 to T4, in addition to price, the firms have to choose the level of investment which has a positive externality to the environment represented as contribution to a pubic good, shared equally among all the consumers in the market. This variable has 5 possible levels, numbered 0 through 4, so that level 0 means no contribution, and level 4 involves maximum contribution to the public good. The fact that a company invests to become green has implications not only for firms but also for consumers. For firms, a higher level of contribution involves, in the actual period, a higher fixed cost of being 'different' but also a lower variable cost. Before the session starts, subjects are told that the government is prepared to subsidize part of the firms' investment. In a market in which firms invest in contributing to a public good, a higher level of investment implies, for consumers, a higher part from the contribution from the Public Fund (PF), independently of whether the consumer purchased from that firm or not. The time structure of the experiment for treatments T1-T4 is as follows. Firms play a three stage game. In the first stage,

[7] Instructions are available upon request from the authors.
[8] Sessions in T0 lasted around 90 minutes.

firms contribute to the public good. In the second, they compete in prices and, in the third, consumers choose which firm to buy from a unit of the product. While firms decide the selling price each period, the level of investment is a strategy for companies in the medium term, so they decide on that level every only in periods 1, 7, 13, 19, 25, and 31. In T1 and T2, each firm knows the information concerning the transactions made in the previous period. In T3, firms have a complete history on prices, demand and firm profits for each period in the past. In T4, the aforementioned complete history incorporates the investment level chosen by each company.

Firm behavior

Figure 1 shows that, in the baseline Bertrand markets, firms have posted prices which have remained relatively close to the competitive price 100, while, at the same time, a significant amount of heterogeneity is observed, both in the absence (markets 1 and 2) and in the presence of contribution strategies (markets 3-18). In fact, in several markets, there have been systematic efforts to maintain higher than competitive prices, especially in the presence of an energy-saving strategy available to the firms. On the contrary, some markets have remained almost perfectly competitive, including cases of markets with an energy-saving strategy available to the firms, like for example market 13. However, clearing prices (those at which consumers actually buy the product) have presented far less heterogeneous patterns, remaining much closer to the competitive level of 100 monetary units. This is more clearly reflected on average market clearing prices aggregated by treatment, presented in figure 3. Generally speaking, we observe tight convergence of clearing prices to the competitive level in all treatments implemented.

When comparing prices obtained from the baseline treatment, T0 with those obtained in the other treatments (T1-T4), we find that both posted (M-W test, p= 0.0014) and clearing prices (M-W test, p= 0.0000) are significantly higher in the presence of CSR strategies, rather than in the absence of them. Therefore we can formally state the first result of our experiments:

RESULT 1: ***The adoption of energy-saving investments leads to higher posted and market clearing prices than the absence of such strategies.***

Next, we refer to figure 2. We observe the evolution of firms' energy-saving investments as the result of their "altruistic" behavior. Contributions start relatively low and they rise during the early periods of the session, while they decrease over the remaining periods of the session.

Figure 4 represents pricing and purchasing decisions made in the last period of the session, using a bi-dimensional price-energy-saving space. Overall, we see that persistent dispersion exists in both sellers' and consumers' strategies. Firms tend to invest positive amounts to the greening of their production, posting at the same time higher than competitive prices. Firms tend to set close to competitive prices, even when they have invested maximal amounts to energy saving processes. Consumers also seem to be fairly homogeneous in their behavior, choosing sellers who are investing more. Sellers seem to recognize their ability to sustain higher prices when becoming greener thus differentiating from other sellers and consumers tend to increasingly enjoy firms' altruism at lower and lower prices.

This pattern is now presented in a more formal way. First, we analyze firm i's pricing decision (logarithm of p_i) in period t as a function of other firms' (j) logarithm of average price in the previous period, $t-1$, as well as own and rival average contributions (C_i, C_j, respectively) through the estimation of the following model:

(1) (1)

$$lp_{it} = \alpha + \delta \cdot t + \beta_0 \cdot lp_{it-1} + \beta_1 \cdot lp_{jt-1} + \sum_{k=1}^{4} \gamma_k \cdot C_{it} \cdot Treat_k + \sum_{k=1}^{4} \mu_k \cdot C_{jt} \cdot Treat_k + u_{it}$$

where $Treat_k$, $k \in \{1,2,3,4\}$, is a treatment specific dummy. The estimates are presented in Table 2.

The results of this estimation indicate the existence of several intuitively expected patterns. Specifically, a firm reacts by raising its price as a response to its rival's higher prices in the previous period. The firm sets a higher price the higher is its contribution to the public fund and the lower is its rival's contributions. Thus, a firm's price is higher, if it perceives its situation as advantageous in the "altruism" market, either through a higher own or a lower rival contribution. Furthermore, the firm is more likely to have a higher price, if the firm or its rivals had set a high price in the previous period. Finally, as expected, the only case in which rival contributions are insignificant in a firm's pricing decision is T3, in which there is no historic information on rival contributions.

RESULT 2: ***Firms adopting higher energy-saving investments tend to set higher prices, whereas they set lower prices when their rivals adopt higher energy-saving investments. Prices behave like in standard differentiated oligopoly models, exhibiting strategic complementarities.***

Thus, adopting an energy-saving investment is like investing in higher product quality. It raises a firm's own price and decreases the rivals' prices, whereas prices exhibit the standard strategic complementarity pattern.

The most interesting pattern obtained on firm behavior is reflected on figure 3. While the baseline treatment has yielded the perfectly competitive outcome, driving firms' profits down to zero, markets with energy saving available to the firms have been clearly unprofitable. We have also formally compared profits in T0 to profits in treatments T1-T4 and found that, in the latter, firms have earned significantly lower profits (M-W test, p=0.0000). We formally state next this finding:

RESULT 3: ***When firms adopt energy-saving investments, their gains from relaxing price competition do not compensate their increased costs.***

Consumer behavior

We report the results on consumer behavior relying on regression techniques and taking advantage of the panel data structure of our sample. Our basic specification is as follows:

(2) $D_{it} = X_{it}\beta + \eta_i + e_{it}$ (1)

The demand variable D_{it} is an ordered categorical variable taking the value from 1 to 9, therefore we employ a Random Effects Ordered Probit model where i is the individual, t is the periods of observations, η_i are the individual effects, ε_{it} is the error term. X_{it} includes the following variables[9] : the firm's own price, the average of other's prices in the same period, the firm's own contribution, the other firms' average contribution, the subsidy when certificate from 1 to 4 is chosen by the firm (in model 1) or alternative the saving costs (in model 2).

We recognize the possibility that individual random effects, η_i, are likely to be correlated with some, if not all the explanatory variables. Suppose that the correlation takes place only through the long run components of the X_{it} variables and that these can be captured via the average, $\overline{X}_{it}$, of these variables over time[10]. Table 3, reports the results obtained from the estimation of the demand model. We compare two alternative motivations for consumer's attraction to pro-social firms. Model 1, presents the estimation results of the demand model after controlling for the effect of the consumer self-interested recognition of the firm's contribution to the public and private welfare. Model 2 shows the estimation results of the demand model which incorporate the firms' cost entailed in each pro-social action.

Result 4: ***Consumers react to energy-saving investments as if these were quality improvements in a firm's product. Prices have the expected effect on own and rival demand.***

Comparing model 1 and 2, it is found that the main reason of consumers' willingness to support socially responsible firms, is that the activity itself has a direct utility-increasing effect, rather than the alternative of the consumer's willingness to compensate the firm's costs incurred during the pro-social activity.

Result 5: ***Consumers prefer energy-saving manufacturers for the effect of energy saving on the environment, rather than as a way of compensating them for the extra costs incurred.***

Finally, as stated earlier, the action of policy makers towards socially responsible firms and its impact on consumer and, finally, firms' strategies is important be studied. The working hypothesis here is that institutional support towards energy saving may affect consumers' responses towards socially responsible firms and, eventually, the socially responsible strategies of the latter. The possibility of a "first-order" negative effect of extrinsic incentives on intrinsic ones has been studied under the term "crowding out". According to Bruno Frey's (1997) famous book "Not Just for the Money", such a subsidy may first, "crowd out" intrinsic genuinely altruistic

[9] The variables included in the model are defined in the Appendix, Table 4, whereas Table 5 reports the sample means.

[10] This specification is based on Mundlak (1978) methodology by specifying the correlation between the individual random effects and the time-varying observables as a linear function of those observables.

motivations in firms' socially responsible action. This would correspond to the well-known first-order crowding out effect. In our first model, we uncover this undesirable crowding-out effect of public subsidies to pro-social firms especially in lower levels of social contribution.

Result 6: ***Subsidies to energy-saving producers may have a crowding-out effect, reducing the consumer's intrinsic willingness to support a firm's corporate social responsibility.***

Conclusions

Our findings confirm that energy-saving investments have similar effects to those of vertical product differentiation. Firms adopting higher energy-saving investments behave as if they were selling a superior product, allowing them set higher prices. However, they end up competing too much among them, lowering their prices close to competitive levels. Thus, they do not recover their energy-saving costs and incur losses. This, turns their ex ante profit-driven strategy into an ex post purely altruistic contribution to the public good.

Consequently, consumers deal with energy-saving firms' products as if they were the result of costly quality improvements. Regarding consumer behaviour, we are the first to show that consumers exhibit a higher willingness to pay for energy-saving firms' products due to the positive externality this has on the environment, rather than as a way of compensating them for the extra costs they incur. We are also the first to show that public subsidies to energy-saving firms may have an undesirable crowding-out effect, as they reduce the consumer's intrinsic willingness to support energy-saving manufacturers.

Both results have critical implications for economic policy in product markets with energy-intensive production processes, as they suggest that consumers may not appreciate firms' investment as a cost to the seller but as a benefit to the society as a whole. Finally, subsidies could overlap in an undesired way with intrinsic motivations, failing to achieve the pretended efficiency-inducing outcomes.

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Appendix I: Tables and Figures

Table 1: Main Characteristics of Treatments in the Market Experiment

Treatment	Energy-saving Investment	Information	Contribution Costs	Sessions	Markets	Nº of Subjects
T0	NO	PH	--	1	1-2	36
T1	YES	NH	Low	2	3-6	72
T2	YES	NH	High	2	7-10	72
T3	YES	PH	High	2	11-14	72
T4	YES	CH	High	2	15-18	72
				TOTAL	18	324

CH: Complete History (selling prices and investment levels). NH: No History. PH: Selling Prices History only.

Table 2: Estimation of equation (1)

Variable	Coefficient	Std. Error	p>|t|
cons.	.0789	.0136	.000
T	.0007	.0003	.027
$\mathbf{lp_{it-1}}$	.3856	.0471	.000
$\mathbf{lp_{jt-1}}$	.0656	.0352	.065
$\mathbf{C_{it}Treat_1}$	.0071	.0024	.003
$\mathbf{C_{it}Treat_2}$	.0147	.0071	.041
$\mathbf{C_{it}Treat_3}$	.0146	.0071	.042
$\mathbf{C_{it}Treat_4}$	.0106	.0042	.013
$\mathbf{C_{jt}Treat_1}$	-.0089	.0046	.056
$\mathbf{C_{jt}Treat_2}$	-.0193	.0087	.028
$\mathbf{C_{jt}Treat_3}$	-.0029	.0051	.578
$\mathbf{C_{jt}Treat_4}$	-.0118	.0062	.058
R^2 = 0.3692		**F(11,143) = 31.37**	**Prob > F=0.000**

Table 3: Demand model, equation (2): ordered probit with individual random effects

	Model (1)		Model (2)	
	Estimate	t-value	Estimate	t-value
Firm price	-0.045	24.95***	-0.044	24.62***
Average price	0.024	8.83***	0.024	8.70***
Firm contribution	0.003	3.35***	0.008	28.11***
Average contribution	-0.010	16.44***	-0.010	16.26***
Subsidy when certificate 1	0.126	0.28	-	-
Subsidy when certificate 2	0.012	0.08	-	-
Subsidy when certificate 3	-0.079	1.89*	-	-
Subsidy when certificate 4	0.031	2.17**	-	-
Saving costs when certificate 1	-	-	-2.127	0.71
Saving costs when certificate 2	-	-	0.583	0.47
Saving costs when certificate 3	-	-	0.247	0.10
Saving costs when certificate 4	-	-	-0.053	0.04
Periods	-0.010	5.32***	-0.012	6.34***
Log likelihood	-5827.02		-5826.84	
N of individuals	5,305		5,305	

****, **, *** indicate significant improvement at 10, 5, 1 percent levels respectively***

Table 4: Variable List

Amount of the selling product	Amount of the selling product measured on a 9 point scale of 0=not to sell to 9=sold out
Firm price	the firm's own selling price
Average price	the mean of others' firms selling prices per period
Firm contribution	the firm's own energy-saving investment
Average contribution	the mean of other firms' average energy-saving investment per period
Subsidy when energy-saving certificate is 1 to 4	This variable has 5 possible levels, numbered 0 through 4, so that level 0 means no contribution, and level 4 involves maximum contribution to the public good.
Saving costs when certificate is 1 to 4	This variable has 5 possible levels, numbered 0 through 4, so that level 0 means no saving costs, and level 4 involves maximum saving costs.
Periods	Periods/rounds of the experiment (1 -37 rounds)

Table 5: Sample descriptive statistics

Selling product from 0 to 9, mean (SD)	1(1.8)
Firm price in ExCUs (Experimental Currency Units), mean(SD)	113 (19.6)
Average price of firms in ExCUs, mean(SD)	114 (8.6)
Firm contribution in ExCUs, mean(SD)	88 (80.5)
Average contribution of firms in ExCUs, mean (SD)	88(42.4)
Subsidy when certificate 1 in ExCUs, mean (SD)	9.24(8.82)
Subsidy when certificate 2 in ExCUs, mean(SD)	26.2(24.5)
Subsidy when certificate 3 in ExCUs, mean(SD)	90.2 (80.6)
Subsidy when certificate 4 in ExCUs, mean(SD)	198.5(175.6)
Saving costs when certificate 1 in ExCUs, mean (SD)	7.98 (3.36)
Saving costs when certificate 2 in ExCUs, mean (SD)	19.7(8.12)
Saving costs when certificate 3 in ExCUs, mean (SD)	28.3 (13.02)
Saving costs when certificate 4 in ExCUs, mean (SD)	34.9 (16.8)
Valid Observations	5,305

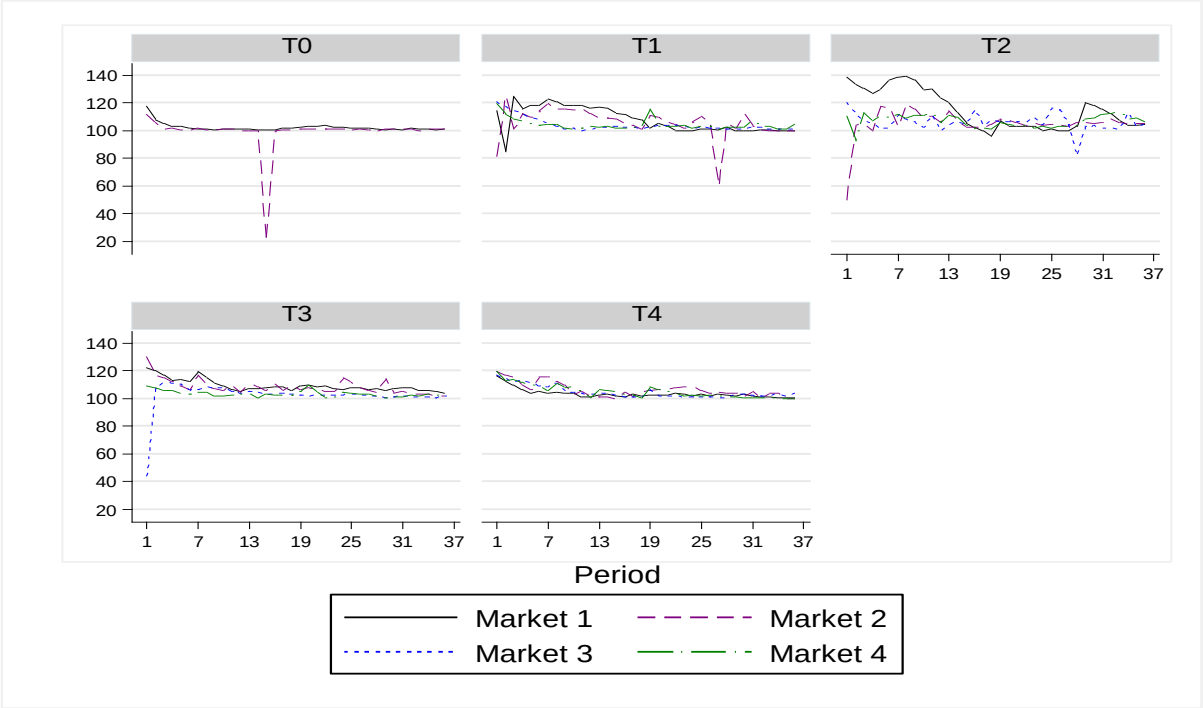

Figure 1: Evolution of average clearing prices over time: Treatment aggregates

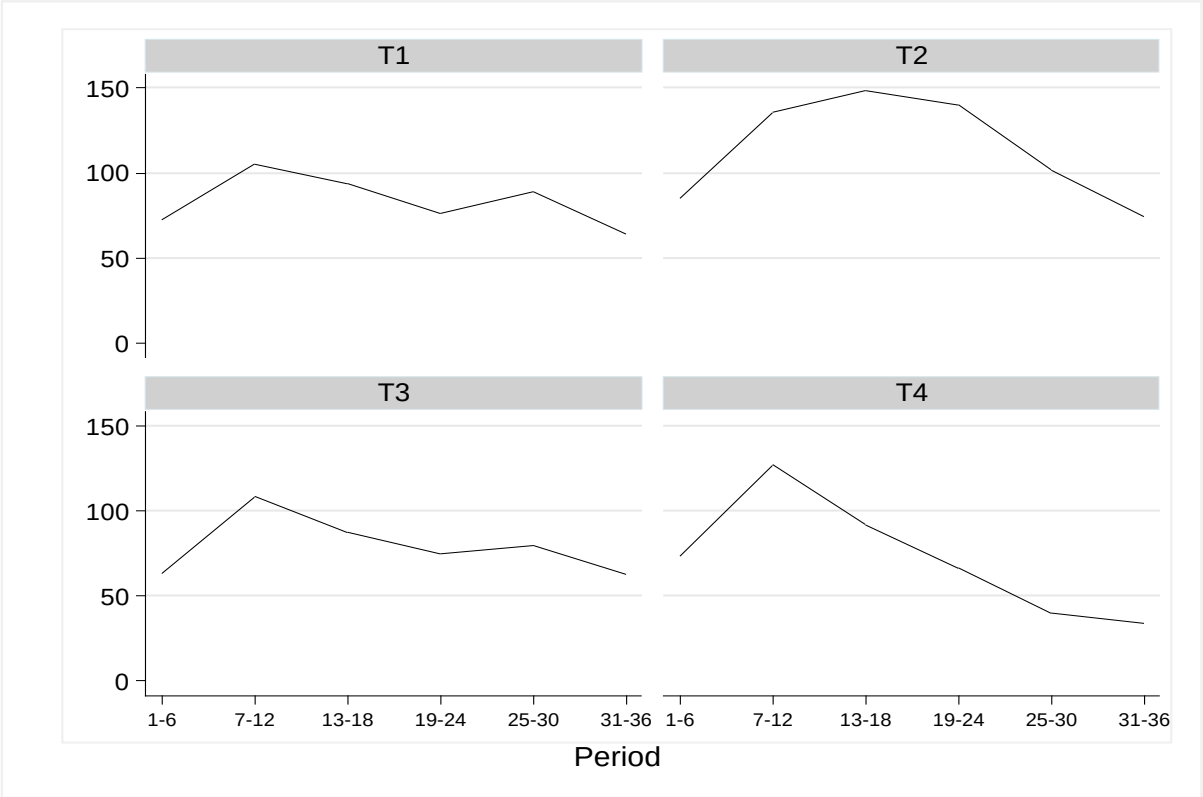

Figure 2: Evolution of green investments over time: Treatment aggregates

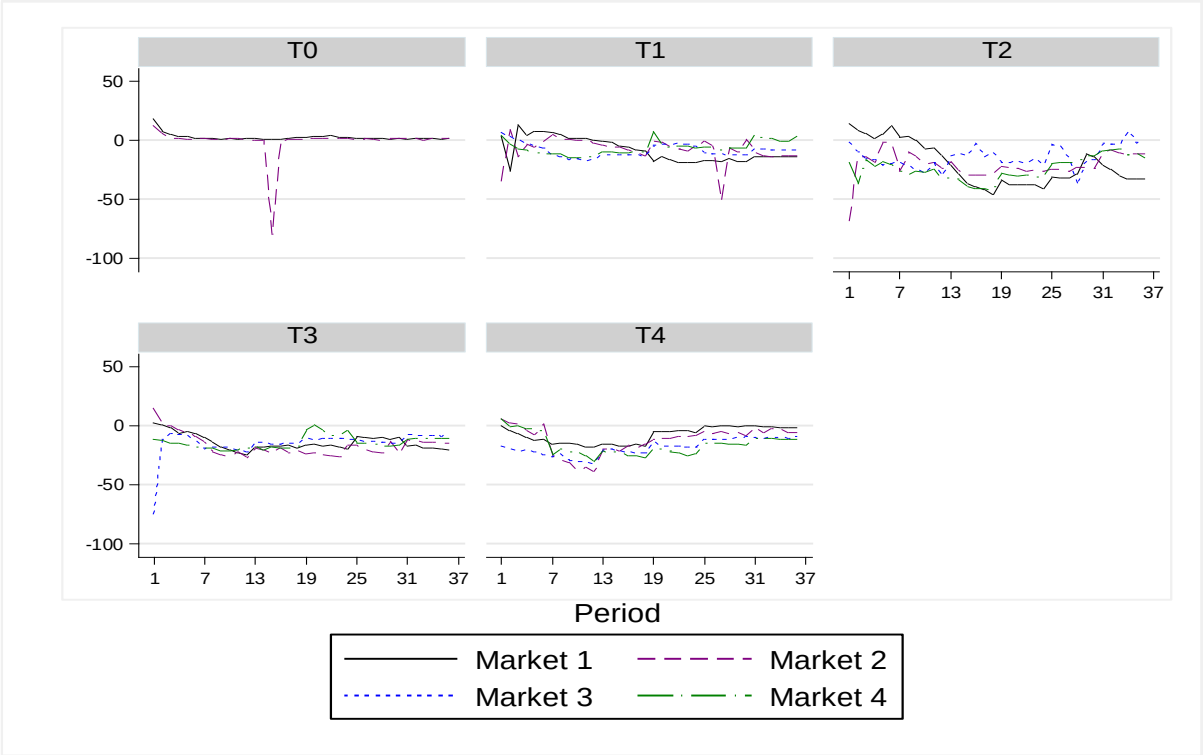

Figure 3: Evolution of average profit over time: Treatment aggregates

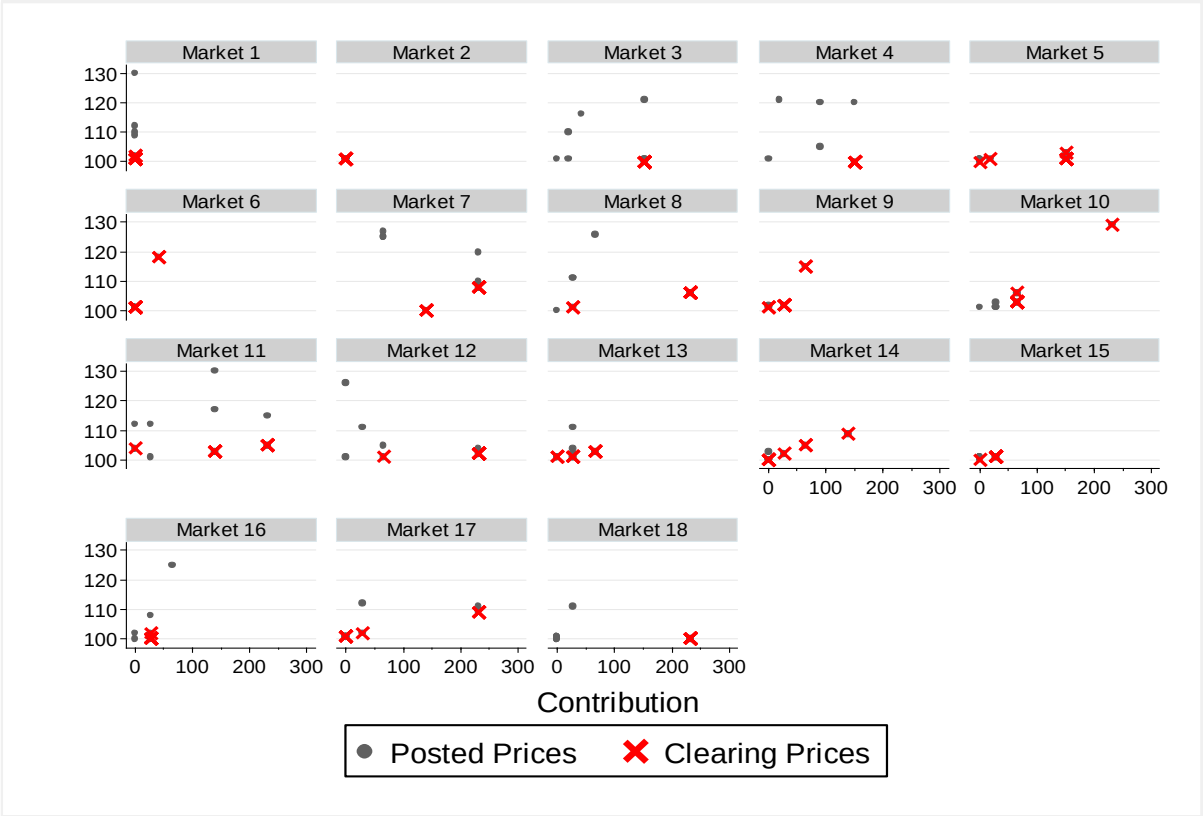

Figure 4: Period 36 posted prices (dots) and purchasing decisions (marked with "x") per market