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THE POLITICAL ECONOMY OF CERTIFICATES FOR LAND USE IN GERMANY – EXPERIMENTAL EVIDENCE

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The political economy of certificates for land use in Germany – experimental evidence

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Abstract: Certificate trading schemes have been discussed as a cost-efficient means of reducing land use in Germany by capping and reallocating permissions to conduct building projects. However, in contrast to the established cap & trade systems for emissions, reputation-seeking politicians would be in charge of buying and trading certificates – an aspect not considered to date. We thus present a laboratory experiment that captures politician's incentives connected to electoral cycles in a cap & trade scheme for land use, whereby tradable certificates are auctioned and grandfathered in equal shares. We find the cap & trade system to be efficient at large, yet there are several politically relevant distortions that are aggravated by self-serving incentives. Prices show high volatility, initially by far exceed fair values and are substantially biased by the endowment effect. Further, the timing and location of land use projects and the heterogeneity in income across municipalities are sensitive to the specifics of the system and politicians' interests. We thus identify potential problems to a cap & trade system for land use that could substantially reduce both its assumed superior efficiency and its political feasibility.

Keywords: economic experiment, land use, municipal actors, political business cycle, tradable certificates

JEL Classification: C910, Q580

I. Introduction

Increasing land use and degradation due to economic activity has been recognized by industrialized nations as a core obstacle to the preservation of natural resources and biodiversity. Consequently, economic and environmental policy-makers are striving for effective means to preserve biodiversity and ecologically valuable land while sustaining economic growth (Fischer et al., 2013; Weber, 2006). To achieve these goals in Germany, in 2002 the federal government committed to taking measures to reduce the growth of settlement and traffic infrastructure from the 81ha per day in 2008-2011 (Federal Statistical Office, 2013) to 30ha by 2020 (Federal Government, 2002). This political commitment was confirmed by the latest German coalition treaty of 2013[1] and has revived the scientific discussions on regulatory measures to reduce land use.

While the traditional approach to reducing land use demands stricter regulatory planning control over all administrative levels or increased taxation (Bovet et al., 2011), environmental economists have been calling for more efficient policy instruments (Hansjuergens and Schroeter-Schlaack, 2008). A strand of literature emerged considering the introduction of tradable certificates systems as a presumably superior instrument for reducing land use.[2] This superiority is assumed to stem from market forces achieving a nation-wide reallocation of the limited number of certificates to the most valuable land use projects. The market system is thus expected to allocate certificates efficiently among political entities, in the German case municipalities (Henger and Bizer, 2010). Conversely, a centrally administered allocation of land use permissions is expected to fail in minimizing welfare losses following a cap on land use (Henger, 2010).

Several arguments are presented in support tradable certificates for land use that mirror the arguments for CO_2 cap & trade systems. Primarily, the cap & trade system is expected to allow for the realization of the most valuable projects at minimal transaction costs (Hansjuergens and Schroeter-Schlaack, 2008). Secondly, the superior precision of the

[1] Coalition treaty between the conservatives (CDU/CSU) and socialists (SPD), see Coalition Treaty (2013), p.83.

[2] The discussion in Germany has been driven by numerous studies issued by governmental agencies following the federal government's 2002 commitment. Among the recent studies are Walz et al. (2005) for the Federal Ministry for the Environment, the Council of experts on environmental questions (2002), Heiland et al. (2006), Perner and Thoene (2007), Bizer et al. (2012) for the Federal Agency for the Environmental Protection, as well as Kaule and Siedentrop (2010). Evolving simultaneously, the scientific discourse has put forth a large number of publications from the perspective of institutional and environmental economics concerning its practical and theoretical questions, which can be accessed through the recent dissertations by Schroeter-Schlaak (2013) and Henger (2010).

mechanism implementing a fix quantity and variable prices is pointed out, which is unattainable through a centrally administered regulation of prices. Thirdly, a cap & trade system inherently provides incentives for decision-makers to use land more efficiently, thus stimulating innovative inner-city development (Schmalholz, 2005) rather than continuing to rely on the use of undeveloped outskirt areas (Wegelin, 2006). Fourthly, the participation in the trading scheme is likely to increase municipal awareness of the ecological problems of land use (Henger, 2010).

To empirically assess these mostly theory based claims, two framed field experiments have been presented to provide empirical evidence, both featuring municipal officials interacting in a realistic system of allocation and trading of certificates (Ostertag et al., 2010; Henger, 2011; Henger 2013). They find the trading system to work fairly efficient overall. However, both experimental designs implement a payoff function that assumes municipal politicians to unambiguously strive for the maximal outcome for their community by optimally weighing costs of certificates and the return of land use projects. While assuming such an optimization behavior in the case of strictly profit-maximizing companies buying CO_2 certificates may be appropriate[3], we argue that in actual municipalities, the politicians' and the collective interest frequently diverge. Our argument is motivated by the established evidence in public choice emphasizing that politicians tend to consider their individual payoff rather than maximizing the welfare for their constituents (Black, 1948; Downs, 1957). This regularly translates to starting "political business cycles" (Nordhaus, 1975; Buchanan and Wagner, 1977) through increasing public spending before elections. In turn, short-sighted spending policies due to the individualistic time preference contradict macroeconomic stability and long-term fiscal prudence (e.g. Buchanan and Tullock, 1962). Following these seminal contributions, a large number of empirical studies have confirmed this characteristic pattern of public spending prior to elections (for a recent survey, see Eslava, 2010) with several studies suggesting that

[3] While empirical studies on land use certificates remain limited, a large body of empirical literature has evolved dealing with various aspects of CO_2 emission certificates, particularly regarding the European emissions trading system in 2005, to which Convery (2009) provides an introduction. Furthermore, numerous experimental studies have investigated various aspects of certificate allocation trading schemes, including the efficiency of different allocation mechanisms (Grimm and Ilieva, 2013); the effect of market power of participants (Cason et al., 2003); price discovery in emissions certificate auctions (Burtraw et al., 2010); collusion and speculation in emission certificate markets (Mougeot et al., 2011) or different pricing strategies following an initial allocation of certificates (Wrake et al., 2010). While these studies enable a substantiated prediction of the behavior by profit-maximizing entities in a certificate-trading situation, they offer no outlook on potential distortions caused by reputation-seeking political actors.

politicians on the municipal level act similarly.[4] Accordingly, politicians in a cap & trade system for land use could start political business cycles by purchasing certificates to conduct specific projects prior to elections to increase their chance of reelection while potentially concealing that the costs for certificates are higher than the expected return of the land use projects. Different from a traditional regulatory cap on land use, politicians in a cap & trade system might be susceptible to short term individual gains translating into long term collective losses. This systematic distortion might reduce the theoretically assumed superiority of a cap & trade system, and thus needs to be taken into account when assessing its efficiency and political feasibility.

To investigate the distortive influence of self-serving politicians, laboratory experiments provide a methodology that allows us to run a counterfactual comparison of different institutional settings, which remains inaccessible when using field data.[5] While experiments might have a lower external validity, they enable us to highlight the effects of systematically different incentives and individually biased reactions, both of which are accessible only in counterfactual ceteris paribus analyses. As our experimental design comprehends the main features of a cap & trade scheme in land use, we are confident that our results can provide novel insight on potential distortions and hold external validity. Accordingly, we present an experimental design that implements self-serving motives for politicians trying to maximize their electoral success by authorizing and conducting specific land use projects, which potentially reduce the respective municipality's and overall welfare. Our experiment implements a cap & trade system that is structured according to the current state of discussion within the German administration. Six players each simulate a municipality and generate income by realizing projects over the course of the game. Project realizations are restricted by the total number of certificates available, whereby in the first stage of each period half of the

[4] Prime examples of such studies concerning overall municipal expenditures prior to elections include Goeminne and Smolders (2014) for Flemish municipalities, Alesina and Paradisi (2014) for Italy, Bastida et al. (2013) for Spain, Sakurai and Menezes-Filho (2011) for Brazil, as well as Veiga and Veiga (2007a) and Coelho et al. (2006) for Portugal and Foucault et al. (2008) for France. More specifically, Klien (2014) points to a similar result for local water tariffs in Austria, while Guillamon et al. (2013) show the effect or municipal police expenditures in Spain. Vicente et al. (2013) show a strong relationship between transparency in municipal governments and the level of pre-electoral spending. Veiga and Veiga (2007b) point out that the likelihood of reelection is highest for incumbents when spending on highly visible items is increased, particularly on building projects.

[5] For example Sutter (2003) and Tyszler (2008) have provided initial evidence suggesting that the relationship between opportunistic behavior by political actors and election dates is robust in a laboratory setting.

certificates are grandfathered and the other half is sold in a uniform price auction with sealed bids. In the subsequent second stage, certificates can be traded in a double auction market. In the third and last stage subjects may execute their projects provided that they have collected enough certificates. These features apply to our benchmark treatment, whereby the reputation element is added in a second and third treatment, which both feature electoral cycles and a substantial bonus payment representing politician's benefit of an increased reelection probability. In the second treatment the bonus is achieved by realizing a prestigious project. In the third treatment, subjects can signal activity and competency and thus achieve the bonus by completing a player-specific number of projects prior to the election period; however, there are not enough certificates available to allow all subjects to obtain the bonus. We are interested in whether politicians seeking to increase their likelihood of reelection, i.e. striving for the bonus, may lead to a substantial decrease in the efficiency and stability of a cap & trade system for land use. This would have stark political implications for the feasibility of this mechanism to reduce land use.

The remainder of this paper is organized as follows. In section 2, we explain the experimental design; Section 3 provides a theoretical framework. Section 4 presents our results and section 5 concludes.

II. Experimental Design

We outline our experiment in five steps. First, we describe the general course of the game, before secondly explaining player and projects specifics. Third, we present the payoff regime and, fourthly, we describe our treatment conditions and provide information on the experimental procedure. A theoretical framework deriving the individual and collective payoff-maximizing behavior is detailed in section 5.

Course of the game

We implement a 15-period three-stage game that closely simulates the issuing and trading of certificates for land use as outlined in studies for the German Federal Environmental Agency and implemented in previous field experiments (Ostertag et al., 2010; Henger, 2011). Although framed neutrally, subjects represent municipalities obliged to accumulate certificates to realize land use projects. Three stages in each period capture the accumulation, trading and consumption of certificates.

In the first stage, subjects accumulate certificates to realize land use projects later on. 50 % of certificates are issued through a uniform price auction with sealed bids, where bidders enter a quantity and price. The bids are then ranked and the price for the least unit that is auctioned determines the unit price that all bidders have to pay for their respective quantities. The

remaining 50% of certificates are grandfathered, i.e. they are issued to subjects for free. Overall, 12 certificates are grandfathered and an additional 12 certificates auctioned in each period.

The second stage enables subjects to trade certificates in a double auction market for two minutes. There are no limits on prices or quantities and no transaction costs. Accordingly, subjects can generate income by selling certificates or they can buy additional certificates from other players.

The third stage involves players using their certificates on land use projects that yield income conditional upon the respective project values. Each player can only realize one project per period. Unused certificates can be accumulated over periods but expire after the last period without compensation.

Player and project specifics

We employ a partner matching protocol as subjects are randomly assigned to societies of six at the beginning of the game. Within all societies, each of the six subjects is assigned a specific player type to capture different sizes of administrative units. Subjects are endowed with a player type-specific pool of 30 projects.

There are two types of projects, denominated as "Type A" or "Type B". The former require eight certificates for realization, simulating projects with a high land use outside of urban areas, which the cap & trade system would aim at reducing. Type B projects do not require certificates, simulating inner-city development, which – despite being more costly than development in the outskirts - is considered as an ecologically preferable alternative. Note that we assume all Type A projects to use up the same quantity of land as they require the same number of certificates. While this represents a strong simplification, it serves at keeping the game comprehensible to participants without violating the basic characteristics of a cap & trade system. Type A projects pay at most 100 experimental currency units (ECU), decreasing in five steps of 20 to zero ECU, while Type B projects always pay 10 ECU.

Player types representing larger municipalities are assigned more valuable projects, which captures the extended possibilities associated with a greater size of the municipalities. Furthermore, player types are grandfathered a different number of certificates, simulating the apportionment of certificates according to the population of administrative units. Players are not informed about other player types' number of grandfathered certificates or their available projects; they merely know that all of them have Type A projects worth 0 to 100 ECU and Type B projects paying 10 ECU.

Table 1 provides an overview of player types, as well as their assigned number of certificates and available projects.

project	**Number**	1	2	3	4	5	6	7			
	Value	100	80	60	40	20	0	10			
	type	A	A	A	A	A	A	B			
	certificates	8	8	8	8	8	8	0			
player										**certificates period (total)**	
	#projects for type								**total**	#grandfathered	#auctioned
	1	10	8	6	4	2	0	15	**45**	4(60)	-
	2	8	10	6	4	2	0	15	**45**	3(45)	-
	3	6	8	10	4	2	0	15	**45**	2(30)	-
	4	4	6	8	10	2	0	15	**45**	1(15)	-
	5	2	4	6	8	10	0	15	**45**	1(15)	-
	6	0	2	4	6	8	10	15	**45**	1(15)	-
	total	**30**	**38**	**40**	**36**	**26**	**10**	**90**	**270**	**12(180)**	**12(180)**

Table 1. Overview of players, projects and certificates

Payoff structure

A subject's payoff of the game comprises three parts: (1) the initial endowment, (2) the net payments for certificates and (3) the revenues generated by the realization of projects. All payoffs, prices and values of projects are denoted in ECU, whereby 100 ECU convert to 1€ at the end of the game.

The initial endowment of 700 ECU enables players to participate in the auction and trading stage. It decreases as certificates are purchased in the auctions or the trading stages and it conversely increases when certificates are sold to other players. Subjects' current budgets constrain potential buying offers or biddings in auctions, so there is no borrowing from the experimenter. The revenues from realized projects are paid at the end of the game to simulate the long-term character of land use projects and the delay of potential returns for municipalities. Additionally, players receive a show-up fee of 4€ unrelated to the game itself.

Treatment conditions

A benchmark treatment (*BASELINE*) incorporating all specifications as described above is run to assess the efficiency of a cap & trade system for land use in general, as well as serving as a benchmark for the treatments outlined below.

We are interested in the effects of introducing self-serving motives for municipal decision-makers. In line with previous studies in public choice, we assume that political actors' aim for reelection is a central influence in their individual utility maximization (Black, 1948; Downs,

1957). Given that politicians often try to influence reelections through the visible realization of specific projects (Veiga and Veiga, 2007), we hypothesize that the politically motivated pursuit of higher reputation will influence the efficiency of a cap & trade system for land use. In this case, it might be profitable for politicians to realize particular projects at a specific point in time, thus condoning long-term disadvantages for their community due to political business cycles. As the costs for land use certificates might be disguised from the electorate, bearing excessive costs that cannot be balanced by gains from project realizations might be optimal for politicians, given that these project realizations increase the probability of reelection. By contrast, municipalities' overall welfare depends on the relation of actual gains from realized projects and the net payments for certificates.

By introducing two treatment conditions, we aim to analyze the effects of such scenarios on the overall efficiency, prices and the distribution of income in a cap & trade system for land use.

(I) Realization of a prestigious project prior to an election (PRESTIGE)

Our first treatment condition implements a rather weak incentive for starting political business cycles. We assume that politicians can increase the probability of reelection by carrying out a prestigious project right before the election date that adds to her reputation. In our design, this transfers to a bonus payment of 300 ECU if a subject manages to realize one of her most valuable projects specifically in period 7.[6] While we explicitly chose non-extreme values for the bonus, it remains sufficiently high to divide municipalities and politicians' welfare to a relevant extent. Besides the bonus payment, all other parameters of the general setting apply. The manipulation in *PRESTIGE* can be seen as rather mild as all players are able to realize the bonus payment simultaneously and the overall efficiency should not be affected. For considerations of altered optimal behavior for players in both treatments and the respective implications, we refer to section 3.

(II) Showing competency and high activity before and election (ACTIVITY)

In our second treatment, we implement a more competitive structure of obtaining the bonus payment of 300 ECU. Again, the game up to period 7 simulates the pre-election phase. Subjects are now required to display a high level of activity to achieve the bonus, again representing the increased probability of reelection through higher reputation. This level of activity is defined by a certain number of projects to be realized. The respective number of projects required is determined conditional upon a municipality's size, i.e. on player types.

[6] For reasons of simplification, we only consider the case of simultaneous elections, which is also the appropriate setting when looking at German municipalities within a federal state.

Players 1 to 6 require 6/5/4/3/3/3 realized projects for the bonus and thus necessarily need to buy additional certificates. It should be noted that it is not possible for all players within a society to earn the bonus at the same time in this treatment, due to the restricted total number of certificates available. Therefore, it can be expected that changes in prices and overall efficiency are stronger in *ACTIVITY* than in *PRESTIGE*, which is again explained in further detail in section 3.

Procedure

Treatment	**bonus activity**	**bonus prestige**	**No. of participants**	**No. of societies**
Baseline	no	no	48	8
Prestige	no	yes	48	8
Activity	yes	no	48	8
total			**144**	**24**

Table 2. Summary of treatments and participants

Table 2 provides an overview of our treatments, variations and the respective numbers of participants. The experiments took place in 11 sessions within one week in October 2014. They were run with z-Tree (Fischbacher, 2007) in the Laboratory for Behavioral Economics at the University of Goettingen; the participants were recruited with ORSEE (Greiner 2004). They were only allowed to participate in one session and the understanding of the game was guaranteed by asking mandatory control questions before the experiment started. The sessions in all treatments lasted around 80 minutes. There were 48/48/48 participants in *BASELINE/ACTIVITY/PRESTIGE*. On average, each participant earned 15.65€. Participants were students from various fields (49% economic sciences as the largest group), were 24.4 years old on average and 50% were female.[7]

III. A theoretical framework

Without a cap on land use, players will activate their 15 most valuable projects of Type A (see Table 1). In this scenario, a total of 90 land use projects would be realized. We assume the state (federal government) to aim at reducing land use by 50% to foster inner-city development using a cap & trade system. Consequently, the regulatory cap only allows for three projects per period, a total of 45 Type A projects and 45 Type B projects over the course of the game. As we assume all Type A projects to lead to the same land use and uniformly

[7] The original instructions for the game were in German. They are available from the authors upon request; a translation is provided in Appendix A.

require eight certificates, this determines the total number of certificates issued per period to be (3 x 8) 24 certificates.

We rely on the willingness to pay to calculate the equilibrium prices for certificates. A player deciding to realize a Type A project bears opportunity costs of 10 ECU, i.e. the fixed value of Type B projects. The realization of the most valuable Type A project pays 100 ECU and requires eight certificates. The willingness to pay for one certificate then amounts to (100-10)/8=11.25 ECU. Overall, there are only 30 projects with a value of 100 ECU, which players do not know. Therefore, players act rationally if they are willing to pay 11.25 ECU per certificate as long as Type A projects worth 100 ECU are available. Subsequently, prices should drop to (80-10)/8=8.75 ECU. A rational player sells certificates if prices exceed the fair price and buys if they are lower. Players have all the information to derive these fair prices for certificates.

Consequently, the prices observed in *BASELINE* should not exceed these fair values. It cannot be stated unambiguously which projects worth 80 ECU will be realized, given that several players have the same willingness to pay. To illustrate a potential outcome, we assume that the certificates will be allocated according to players in descending order. For payments in the auction and the market, we assume that players pay the full 11.25 ECU for certificates used for Type A projects and 8.75 ECU for Type B projects and grandfathered certificates are distributed evenly between 100 ECU and 80 ECU projects.[8] Table 3 details the resulting project realizations and welfare effects. Please note that "net transfer" simultaneously measures the income of the state as auctioneer, since all certificates bought were initially sold by the state in the auction.

[8] For example, player 1 realizes ten 100 ECU projects and five 80 ECU projects and is grandfathered 60 certificates. We then assume that she uses two thirds of these grandfathered certificates for 100 ECU projects and one third for 80 ECU projects. Accordingly, the 60 certificates she has to buy additionally raise costs of 40 certificates at 11.25 ECU and 20 certificates at 8.75 ECU.

project	number	1	2	7
	value	100	80	10
	type	A	A	B
	certificates	8	8	0

player					certificates total			value		
	#projects for type				total	#used	#bought(free)	gross	net transfer	net
	1	10	5	0	**15**	120	60(60)	1400	625	775
	2	8	5	2	**15**	104	59(45)	1220	607	613
	3	6	5	4	**15**	88	58(30)	1040	587	453
	4	4	0	11	**15**	32	17(15)	510	191	319
	5	2	0	13	**15**	16	1(15)	330	11	319
	6	0	0	15	**15**	0	-15(15)	150	-157	307
	total	**30**	**15**	**45**	**90**	**360**	**180(180)**	**4650**	**1864**	**2786**
	value	**3000**	**1200**	**450**						
	certificates	**240**	**120**	**0**						

Table 3. Potential project realizations in BASELINE and PRESTIGE

Note: All numbers are rounded to integers. "free" refers to certificates grandfathered.

It can be seen that there should be 45 project realizations of Type A (30 worth 100 ECU and 15 worth 80 ECU) and 45 realizations of Type B, which represents the most efficient solution to achieve the regulatory objective of halving land use. Players' income subsequently depends on the projects available and certificates grandfathered. The net transfer describes the maximum income of the state given perfect price discrimination fully transforming consumer (player) surplus to revenues for the auctioneer.

Note that payments in the auction can be seen as a mere matter of transferring wealth to the state; payments in the market stage redistribute wealth among municipalities. In this system, inefficiencies can only occur due to unused certificates or inferior project realizations.

Rationality in PRESTIGE

In *PRESTIGE*, players need to accumulate eight certificates in period 7 to earn an additional 300 ECU. Players 4 to 6 are only grandfathered seven certificates until period 7 but can buy one additional certificate at 11.25 ECU or with a marginal surplus. Assuming payoff maximizing behavior, the overall effect on prices should be negligible, overall efficiency should remain constant and all players should obtain the bonus by uniformly realizing the most valuable project at the same point in time (right before the election date).

However, we are interested in whether this slight manipulation of incentives for actual players causes politically relevant distortions in a cap & trade system, such as increased price volatility or substantial income redistributions.

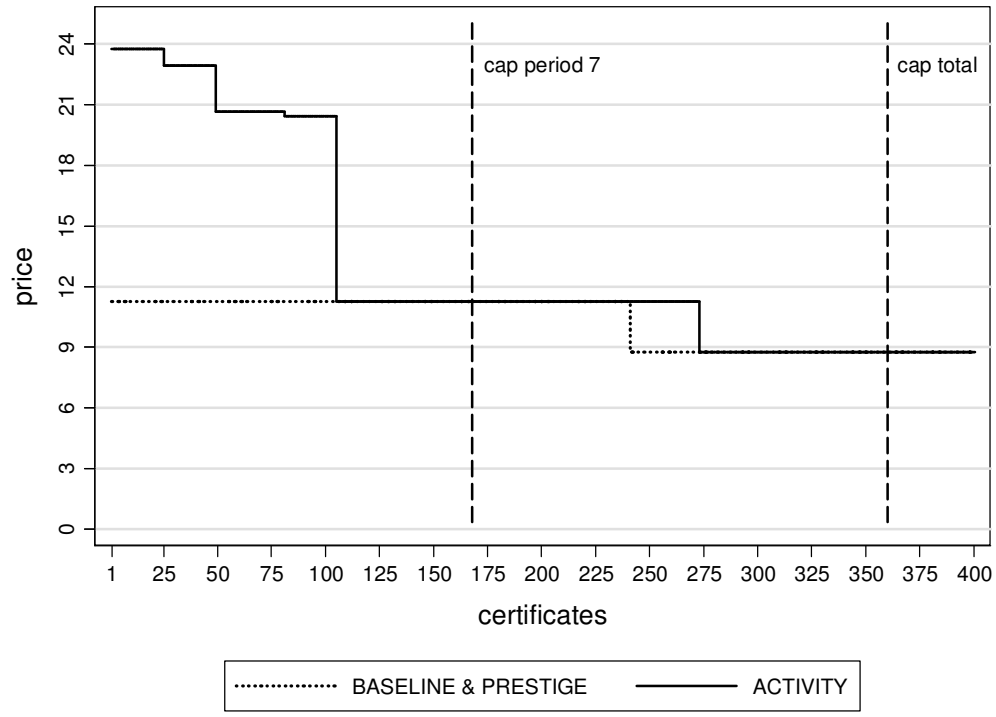
Rationality in ACTIVITY

While no significant reaction should be observed in *PRESTIGE* assuming rational agents, *ACTIVITY* introduces a much more effective shift of incentives. As mentioned above, not all players can simultaneously realize the number of Type A projects required to obtain the bonus payment since not enough certificates are issued.[9] Besides, the dynamics of the game, e.g. the one project per period restriction, have to be considered as a potentially restrictive criterion.

The willingness to pay for certificates in the *ACTIVITY* condition is different for each player due to the bonus payment requirement, whereby the smaller municipalities tend to be willing to pay more per certificate.[10] Primarily the players with a higher willingness to pay will accumulate the required number of certificates and thus obtain the bonus.

Figure 1 shows the aggregate demand and the respective equilibrium prices over all treatments.

Figure 1. Aggregate demand function for certificates by treatment



[9] Overall, 24 projects need to be realized until period 7, while the restriction to 24 certificates per period also restricts the maximal number of projects to [(24/8)*7=] 21.

[10] Mean willingness to pay represents the average payoff a player can obtain with a certificate and depends on the available projects and the number of certificates needed to obtain the bonus. E.g. for player 1, we calculate the mean willingness to pay as:

[(# required Type A*(net value Type A) + bonus) / required certificates]=[(6*(100-10)+300)/48] =17.5 ECU.

In *ACTIVITY,* players foregoing the bonus should be compensated by benefitting from higher certificate prices. In Period 5, once 104 certificates are accumulated by the players achieving the bonus payment (players 3 to 6), prices should drop to fair values derived merely by the remaining projects. Table 4 summarizes project realizations that lead to the bonus payment derived from aggregate demand.

project	**number**	1	2	3
	value	100	80	60
	type	A	A	A
	certificates	8	8	8

player						**certificates required**		**reservation price**	**period of achievement**	
	#projects for type				**required**	#total	#buy(free)	per certificate	certificates	projects
	1	0	0	0	0	48	20(28)	17.5	-	-
	2	0	0	0	0	40	19(21)	18.75	-	-
	3	4	0	0	**4**	32	18(14)	20.65	4	7
	4	3	0	0	**3**	24	17(7)	23.75	1	3
	5	2	1	0	**3**	24	17(7)	22.92	2	4
	6	0	2	1	**3**	24	17(7)	20.42	5	7
	total	**9**	**3**	**1**	**24**	**192**	**84(84)**			

Table 4. Potential project realizations in *ACTIVITY* relevant for the bonus payment

Note: "period of achievement" denotes the period in which a player accumulates enough certificates and the respective period of the last project realization required to obtain the bonus payment. "free" refers to certificates grandfathered.

We do not expect substantial changes in overall efficiency of the system, as players striving for the bonus should mainly realize projects that would have been realized anyways. Only player 6 should realize one project worth 60 ECU lowering the total value of realized projects by 20 ECU. Note that there would still be enough certificates to achieve the bonus for either player 1 or 2, but this is precluded by the "one project per period rule". The distribution of realized projects over players should be different in comparison to *BASELINE* as the municipalities that are grandfathered the most certificates have the lowest willingness to pay for certificates within this framework. Again, for players' income, it does not matter who is going to realize the 80 ECU projects, as we assume perfect price discrimination by the state.

In sum, the *ACTIVITY* manipulation increases expected prices for certificates and leads to a redistribution of realized projects. Recall that subjects receiving the bonus represent politicians who have achieved a higher probability of reelection due to higher reputation through signaling competency and activity. However, the bonus does not add to the respective

municipality's income, which only depends on the total value generated by realized projects and the net payments for certificates. As prices for certificates in the pre-election period increase, we expect a redistribution of wealth toward the state at the expense of municipalities' income, while the respective politician could be overcompensated by the bonus payment.[11]

All these considerations assume players to maximize payoffs and expect others to do so as well. Thus, all calculations described rely on the perfect ex-ante evaluation of the game by all players, which is naturally a doubtful assumption. We abstained from describing potential speculation motives, arbitrage and path dependencies. While our theoretical considerations cannot cover these outcomes in detail, they serve as a benchmark to show systematic deviations from optimal behavior and overall efficiency guaranteed by perfect foresight.

IV. Results

First, we analyze our results with respect to the efficiency of the cap & trade system in general and across treatments. Second, the dynamics of prices in auctions and markets are presented in detail. Third, we consider distributional effects between the state and municipalities and the differences between municipalities.

Welfare and Efficiency

For our analysis, we assume that the income of the state as auctioneer and the municipalities equally contribute to aggregate welfare. Recall that the state generates income exclusively by auctioning land use certificates. Municipalities pay the auction prices, which reduces their budget, and they rely on realizing projects to generate income using the certificates. Since there are no transaction costs, the only way in which this system can produce inefficiencies is through the realization of projects with lower value while projects with a higher value are still available. However, even in this case, the society's welfare deteriorates only slightly as the different project values do not deviate substantially.

Therefore, we can assess the efficiency of the system by comparing the total value from realized projects to the theoretical optimum or between treatments. Figure 2 provides these comparisons.

[11] The auctioneer can expect to sell 12 certificates at 23.75 ECU and 22.92 ECU. 20 certificates are sold to player 3; 12 at 20.65 ECU in period 4 and eight at a unit price of 20.42 ECU in period 4. Player 6 buys four certificates in period 4 at 20.42 ECU and eight at 11.25 ECU in period 5. Given the residual Type A projects, 76 certificates are further sold at 11.25 ECU and 48 at 8.75 ECU from period 11 to 15. This gives a total income of 2418.8 ECU, which is about 30% higher than in *BASELINE*.

Obviously, the cap & trade system works fairly efficiently, as there are only few deviations from the optimal allocation of certificates. Only in ACTIVITY, the average number of realized projects worth 80 ECU tends to be lower, while there are more realizations of 60 ECU projects. To look into these results in more detail, Figure 3 captures the heterogeneity among societies, as we rank societies by their net value created.

Figure 2. Realized projects by treatments

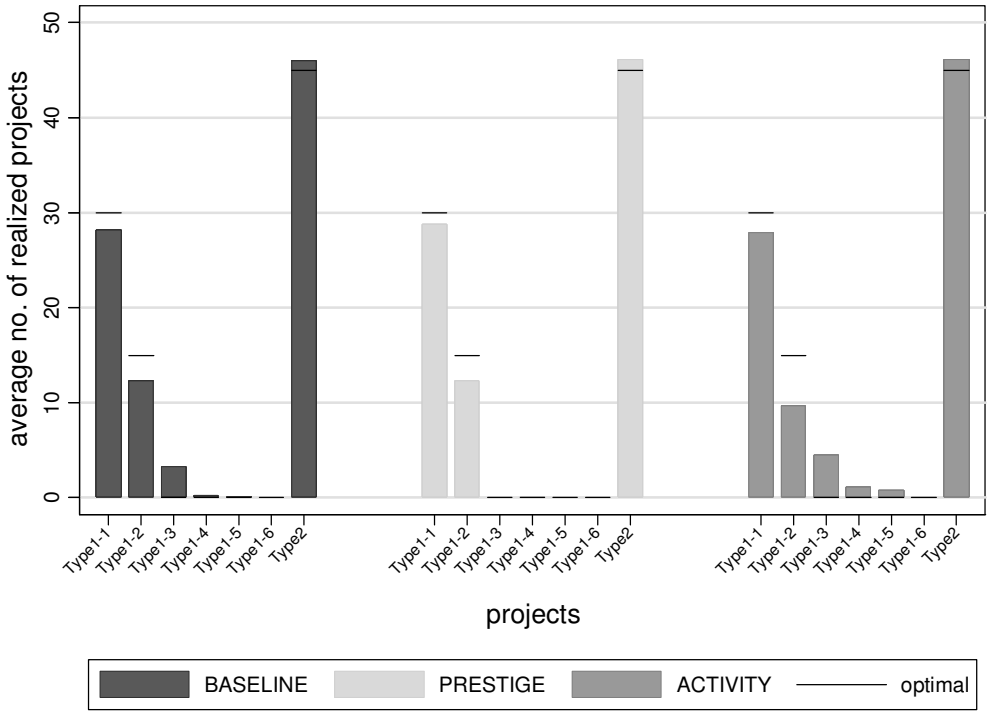
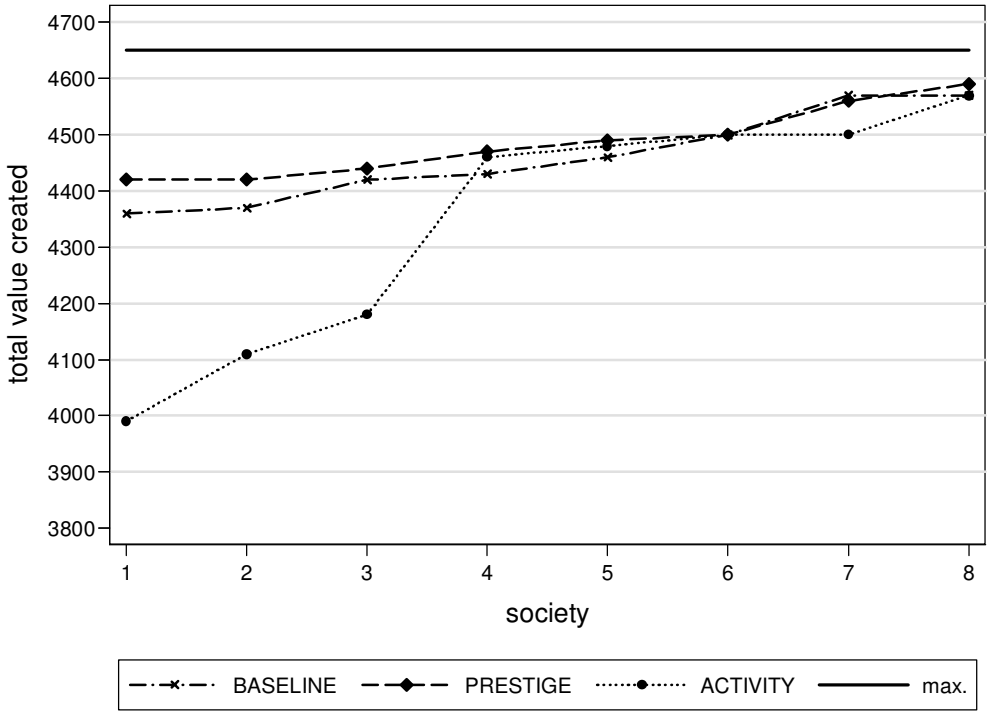


Figure 3. Realized projects by treatments



There are only minor differences between *PRESTIGE* and *BASELINE* with respect to the total value created (Wilcoxon-Rank-Sum test on the society level: z=-0.686, p=.4929). In *ACTIVITY,* three societies perform substantially worse, although, on average, there is no significant difference in comparison to *BASELINE* (Wilcoxon-Rank-Sum test on the society level: z=0.476, p=.6343). In *ACTIVITY*, the difference between the weakest and the best performance on the society level amounts to 580 ECU or about 15%, while for *BASELINE* the difference is only 210 ECU or about 5%. However, on average societies in *BASELINE/PRESTIGE/ACTIVITY* realize 96%/96.5%/93.5% of the maximum possible value.

Result 1: *The cap & trade system efficiently reduces land use. Introducing incentives for political business cycles does not substantially reduce the system's efficiency. However, in the case of strong incentives, the heterogeneity across societies tends to be higher.*

Dynamics of prices

Besides the efficiency, the dynamics of prices is of great interest when evaluating the feasibility of tradable certificates. Municipalities are quite sensitive to high price volatility since they need to make long-term plans regarding their budget and project realizations. A high volatility substantially impedes the planning and execution of profitable projects. In particular, small municipalities - which have to save certificates for several periods - may refuse to undertake such risky investments, which might result in a welfare loss as valuable projects are not realized.

Figure 4 shows the unit prices in the auction stages by treatments over periods, while Figure 5 illustrates prices in the market stage.

Figure 4. Dynamics of auction prices

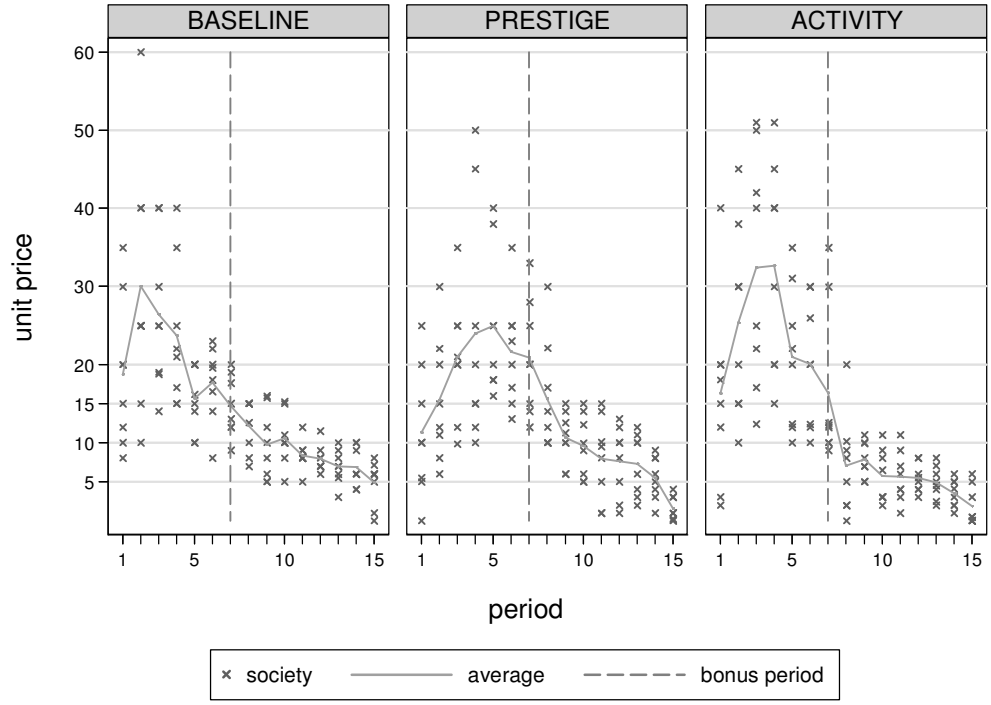
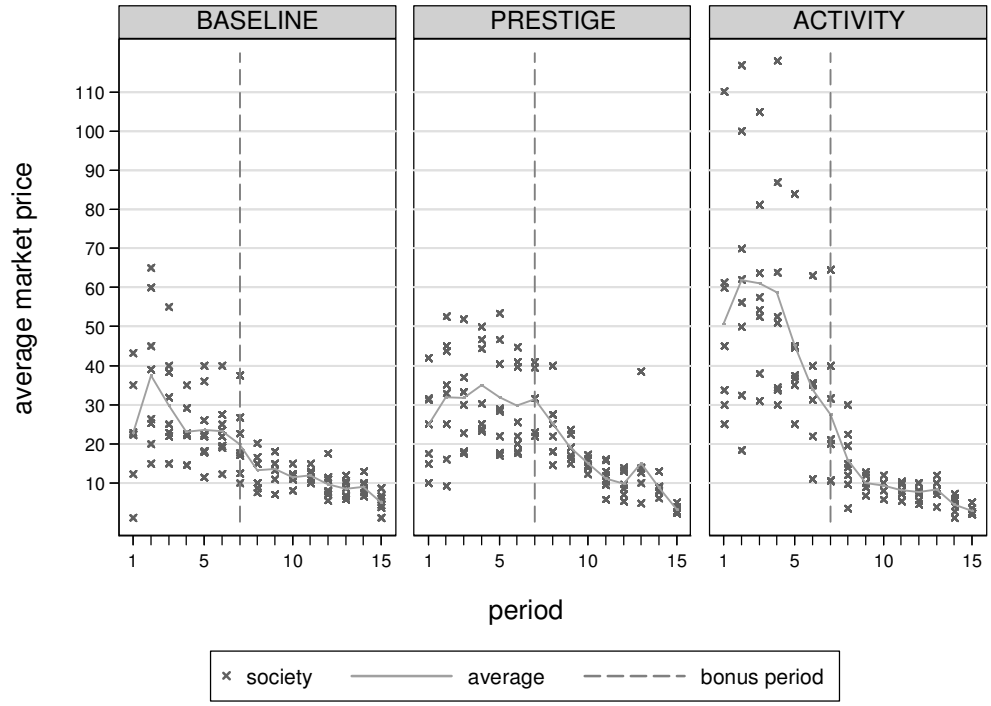


Figure 5. Dynamics of market prices



It can be seen that average prices start off fairly high for all treatments and regularly exceed the fair levels derived in section 3. Moreover, prices tend to decrease after the first couple of periods and are usually lower than the fair prices in the end of the game. This particular pattern might be due to learning effects as prices become closer to fair prices when subjects get used to the system. For all societies, the average price is strictly higher for the first half of the game when compared to the second half.[12]

Result 2: *Prices tend to substantially exceed fair values right after the introduction of the cap & trade system, before gradually deteriorating.*

The difference between the first and second half of the game is considered in detail in Table 5, which offers a compact overview of prices and reports test statistics.

		BASELINE	*PRESTIGE*	*ACTIVITY*
auction	period<=7	**20.99**	**19.9**	**23.43**
		(2.23)	(6.68)	(6.50)
	period >7	**8.43**	**8.20**	**5.24***
		(2.12)	(2.78)	(2.39)
market	period<=7	**27.28**	**30.45**	**50.61*****
		(7.14)	(9.38)	(21.59)
	period >7	**9.70**	**13.14****	**8.95**
		(1.88)	(3.93)	(2.67)

Table 5. Average prices and standard deviation over societies by treatment

Note: *, ** and *** indicate p-values smaller than 0.1, 0.05 and 0.01 respectively, which refer to tests against *BASELINE* applying a Wilcoxon-Rank-Sum test. Standard deviation in parentheses. All calculations are on the society level.

The gap between first and second half averages is greatest for *ACTIVITY*, which is the basic expectation following our experimental design. This pattern is even more evident and highly significant when considering market prices. The differences between *PRESTIGE* and *BASELINE* are rather small and the weak shift towards self-serving incentives has no strong influence on prices. Evidently, our treatment condition primarily influences market prices, while it hardly affects unit auction prices.

[12] Applying a Wilcoxon-Signed-Rank test for matched-pairs on the society level gives significant differences in average prices for all treatments (p<.0117).

Result 3: *Introducing strong motives for self-serving decisions inflates prices in the pre-election period, while prices substantially decrease after the elections. This effect is much stronger for market prices than for unit auction prices.*

In general, market prices exceed unit auction prices, which is especially evident in the first half of the game.[13] This gap is not in line with the hypothesis of rational agents and enables speculative earnings for subjects buying in the auction and selling in the market stage. Given this opportunity, the gap should be evened out over the course of the game. However, the difference remains strong as in *BASELINE/PRESTIGE/ACTIVITY* average prices in the market exceed unit auction prices by 15%/60%/70% in the second half of the game, which again shows that our treatment conditions primarily affect market rather than auction prices. This finding might be explained by the endowment effect (Kahneman et al., 1991), as subjects on average continue to demand higher prices for their certificates in the market place than they were willing to pay in the auction.

Result 4: *Certificate prices are substantially lower in auctions than in the markets. This systematically biased behavior can be interpreted as an endowment effect.*

Besides the development of average prices, we are interested in price volatility, which tends to increase across societies in the bonus treatments, as indicated by the lower standard deviations for *BASELINE* (see Table 5). However, the volatility within societies has to be considered and can be measured over periods (unit auction prices) or even within periods for the market stage. For unit auction prices, relying on the simple measurement of the average standard deviation, we find that in *ACTIVITY,* volatility tends to be higher in the first half of the game, i.e. in the pre-election phase. The same holds when considering market prices, while there seems to be no effect after bonus payments have been determined.[14]

Result 5: *Price volatility in the pre-election period is increased by strong incentives for political business cycles.*

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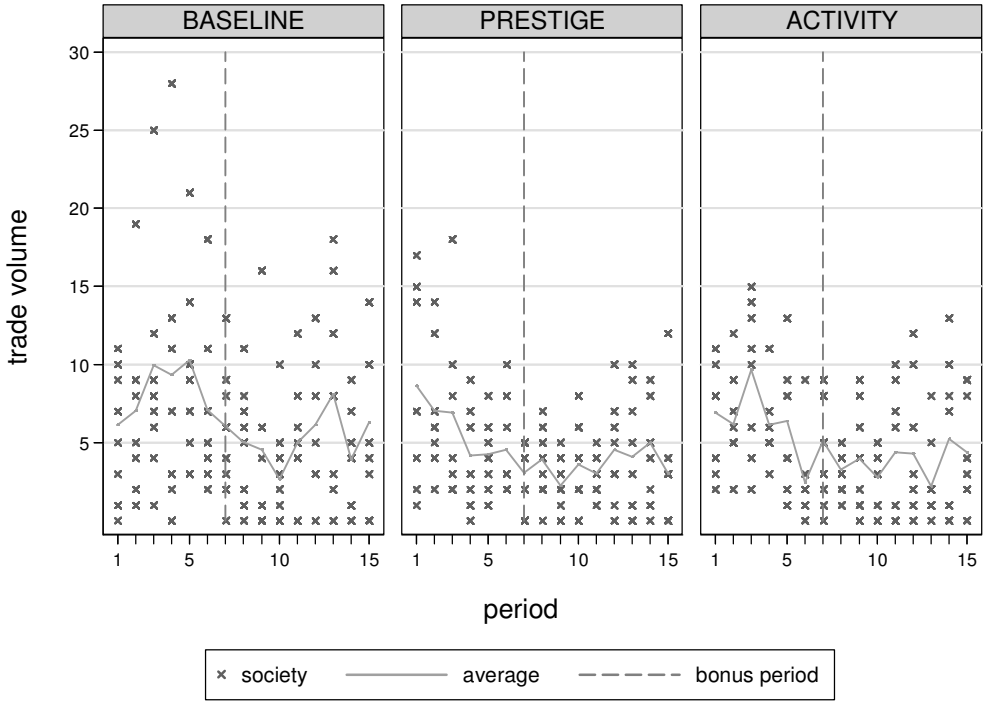
[13] For the first half of the game, applying a Wilcoxon-Signed-Rank test for matched-pairs on the society level gives z=-2.240, p=.0251 for *BASELINE*; z=-2.51, p=.0117 for *PRESTIGE* and *ACTIVITY*. For the second half, we obtain z=-1.540, p=.1235 for *BASELINE*; again z=-2.51, p=.0117 for *PRESTIGE* and *ACTIVITY*.

[14] The average standard deviation is calculated by summing the variances of auction prices of all societies within a treatment divided by the number of observation and subsequently taking the square root. For *BASELINE/ PRESTIGE/ ACTIVITY,* we get 10.68/8.25/12.0 for the first half of the game and 3.08/5.28/2.93 for the second half. Considering the average range of auction prices or the coefficient of variation gives the same tendency and ranking over treatments. We apply the same procedure for market prices, only adding the stage of standard deviations within periods, obtaining 9.15/8.77/13.03 for the first half and 2.21/7.20/1.84 for the second half.

These price differences might further affect trading volumes of certificates in the market stage; this indicator is presented in Figure 6 over periods by treatments.

Figure 6. Dynamics of market volume



For all treatments, the trading volumes tend to decrease over time.[15] We do not find significant differences in the trading volumes between *BASELINE* and *ACTIVITY* (Wilcoxon-Rank-Sum test on the society level: z=1.419, p=.1559), while in *PRESTIGE* volumes seem to be somewhat lower (z=1.682, p=.0927).

Result 6: *Trading volumes decrease over time and are not affected by self-serving incentives.*

In section 3, we derived the willingness to pay for each player and predicted that the two largest municipalities should not be able to realize the bonus payment despite their relatively high number of grandfathered certificates. However, since trading volumes do not increase due to self-serving incentives, this is a first indication that willingness to pay might not be the best predictor for the beneficiaries of the bonus payment; rather, the mere number of certificates grandfathered predominantly determines the final outcomes due to the endowment effect. To analyze this finding in detail, we consider the treatment effects on the distribution of income and project realizations between municipality players within a society.

Distributional Effects

[15] Wilcoxon-Signed-Rank test for matched-pairs on the society level gives z=1.823, p=.0684 for *BASELINE*; z=1.96, p=.0499 for *PRESTIGE* and z=2.38, p=.01173 for *ACTIVITY*.

The distribution of income at the state or municipality level is not relevant for an evaluation of the efficiency of a cap & trade system. However, the aspect of income distribution can be considered an important part of the political feasibility.

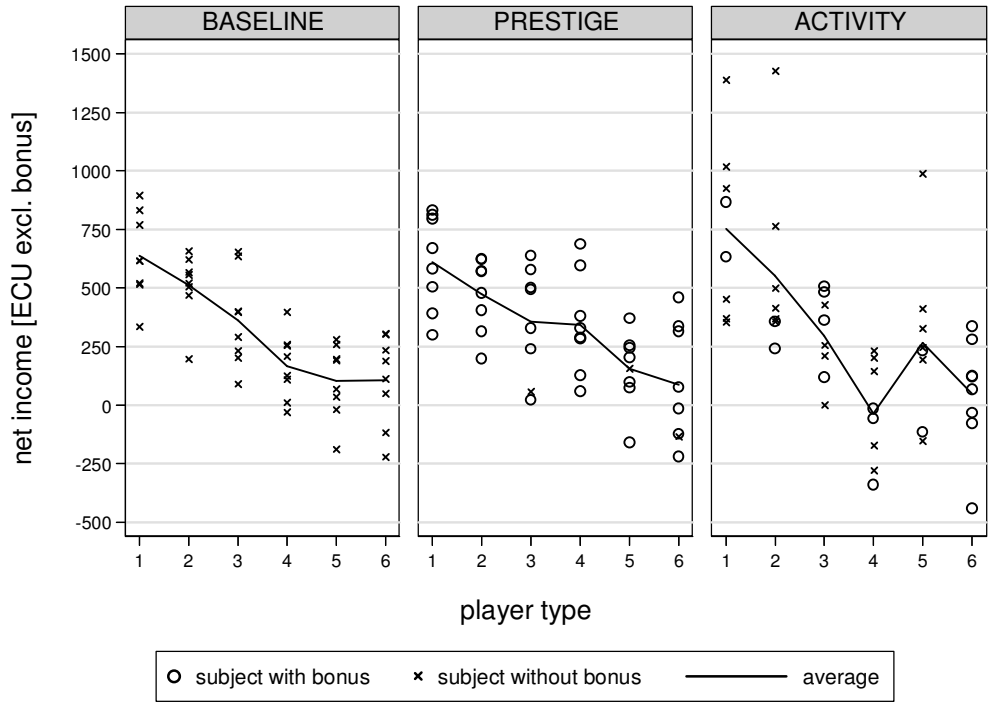
When considering the income distribution between municipalities and the state, recall that differences can only occur due to price differences in auctions, given that payments in the market stage are merely redistributing wealth among municipalities. As shown in Table 5, unit auction prices are equal across treatments. Accordingly, the distribution of income also shows no significant differences, although we expected the state's income to increase by 30% in *ACTIVITY* due to the bonus triggered higher willingness to pay. We find that in *BASELINE/PRESTIGE/ACTIVITY,* municipalities' total income (excluding bonus payment) amounts to 1887/2027/1878 ECU and state's income to 2572/2459/2470 ECU. For both municipalities' and state's income, a WRS test between respective treatment societies and in *BASELINE* gives no significant differences with all $p>.34$.

Result 7: *The distribution of income between the state and the municipalities does not depend on the existence of political business cycles as unit auction prices prove stable.*

Again, unlike market prices, the auction prices do not react to treatment conditions. These prices determine the distribution of wealth across municipalities. Further, in *ACTIVITY* and *PRESTIGE,* the role of the bonus payment is crucial. Politicians might try to signal activity or competency by realizing additional or prestigious projects, which might lead to losses for the respective municipalities if total expenditures for certificates exceed income yielded by this investment, while decision-makers are overcompensated by the bonus payment.

We analyze municipality players' income conditional upon size, as presented in Figure 7. Player type 1 represents the largest municipality, Player type 6 the smallest one.

Figure 7. Distribution of wealth



Since municipalities' income crucially depends on the number of grandfathered certificates and projects available, the expected pattern of wealth distribution, i.e. income decreasing along the size of the municipality, is evident for all treatments. Moreover, as expected, in *PRESTIGE* almost all players achieve the bonus payment (94%), while on average only 44% manage to do so in *ACTIVITY*. Considering treatment effects, we find no substantial differences between *BASELINE* and *PRESTIGE*. However, in *ACTIVITY*, the heterogeneity of income levels conditional on player type increases. There are more extreme values in *ACTIVITY*.

Result 8: *Municipalities' income crucially depend on certificates grandfathered and projects available. The heterogeneity of income increases with stronger incentives for political business cycles.*

Moreover, Figure 7 illustrates that the smallest municipalities (Player type 6) in *ACTIVITY* tend to realize more projects when compared to *BASELINE*, which is indicated by subjects obtaining the bonus payment. In *PRESTIGE*, almost all subjects receive the bonus, which then implies that a higher number of projects are specifically realized in period 7 compared to

BASELINE. Consequently, not only project values and allocated certificates determine the timing of project realizations but also incentives for political business cycles.[16]

Result 9: *Political business cycles influence the timing and location of land use projects realizations, i.e. the distribution over time and between small and large municipalities.*

V. Conclusion

This paper presents an experimental study to further the understanding of a cap & trade scheme as an instrument to reduce land use. Our experimental setting builds on the state of federal planning in Germany. We extend the existing literature by considering the effect of politicians seeking to enhance their reputation. Accordingly, optimal behavior from a municipality's perspective is no longer equivalent to its politician's individual maximization problem.

We find that the cap & trade system proves fairly effective in fostering the efficient reallocation of land use certificates towards the most valuable projects. However, there are major distortions aggravated in the presence of self-serving incentives. Overshooting prices in the initial periods have some municipalities bear overly high costs. High volatility in auction and market prices makes investments risky in particular for small municipalities that rely on saving certificates over many periods. Further, a strong endowment effect occurs when certificates are traded, i.e. players' willingness-to-accept in the market is systematically higher than willingness-to-pay in the auction. The heterogeneity in income and actual land use across municipalities are sensitive to the specifics of the system, as well as politicians' self-interest. Once prestigious projects play a major role in building up reputation for reelection, certificates are hoarded and land use projects are strategically postponed, which is likely to contradict real-world municipalities' interests. These distortions altogether are very likely to hinder the efficient reallocation of certificates, in particular when differences in project values and sizes of municipalities become more pronounced.

In sum, while the cap & trade system works fairly efficient, we have identified several distortions to the system. Highly volatile, biased prices, strategic hoarding, redistributional effects in income as well as the timing and location of project realizations may substantially question the political feasibility of a market-based regulatory approach. These need to be considered in particular when politicians are expected to pursue self-serving interests. Thus,

[16] Note that these results are in line with our prediction derived in the theoretical framework which shows that the smallest municipalities have the highest willingness to pay under ACTIVITY. Please find a comprehensive graphical illustration of cumulative realized projects by player type over periods in Appendix B.

despite the system's theoretical superiority in efficiently allocating land use, the distortions identified in our experimental setting might well make a traditional cap on land use the preferable regulatory choice.

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Appendix A: Instructions for the three treatments. Differences in treatments are indicated in braces; T2 refers to *PRESTIGE*, T3 refers to *ACTIVITY*.

OVERVIEW OF THE GAME

You can earn money in this game by realizing projects and trade with certificates. At the beginning, you will be randomly assigned to a group of 6 players, which will remain constant during the 15 periods of the game. All prices and values in the game will be paid in ECU with up to two positions after the decimal point. 100 ECU convert to 1€ for your payoff.

Projects

Overall, each player has 30 projects of **Type A** and 15 projects of **Type B**. Both types of projects have different values, which are shown in this table:

Type of project	Project Value (in ECU)
A	0 to 100
B	10

In each period, only one project can be realized. Before the game starts, the values of all Type A projects will be shown to you. All players are assigned different Type A projects.

Certificates

For the realization of Type A projects, you need 8 certificates each, Type B projects do not require certificates. Certificates are assigned to you at the beginning of each period and auctioned. Additionally, certificates can be traded among the players. In the game, you receive an endowment of 700 ECU, which you can use to buy certificates at the auction and from the other players. You can also sell certificates, thus increasing your payoff.

{T2&3: *Bonus payment*}

{T2: Additionally, you have the opportunity to receive a bonus payment of 300 ECU. Therefore, you will need to realize one of your most valuable projects (Type A with the highest value) in period 7. If you already realized your most valuable projects before period 7 or if you realize a less valuable project in period 7, you will not receive the bonus.}

{T3: Additionally, you have the opportunity to receive a bonus payment of 300 ECU. Therefore, you will need to realize a specific number of projects until the end of period 7. The necessary number of realized projects will be shown to you on your screen at the beginning of

the game.}

Your payoff

The payoffs that you receive in the course of the game, as well as the sum of all realized projects, add up to your final payoff. Furthermore, a basic payoff of 400 ECU will be added.

COURSE OF THE GAME

Each of the 15 periods follows an identical course, which comprises three phases.

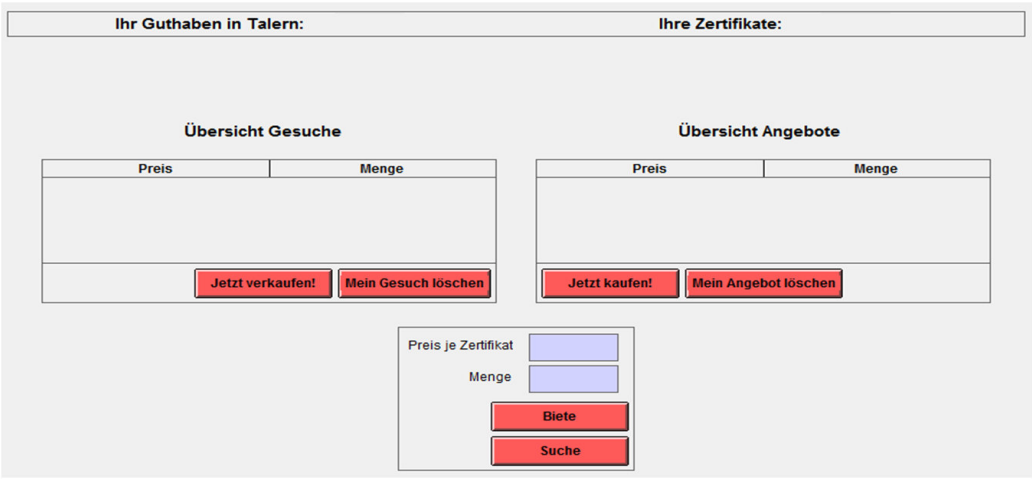
Phase 1: Issuance and auctioning of certificates

At the beginning of each period, 12 certificates are issued. The number of certificates that a player receives is determined randomly at the beginning of the game and does not change during the game.

Additionally, 12 certificates are auctioned after the issuance. Depending on your current funds, you can bid for a number of certificates of your choice at a unitary price. The 12 highest bids will receive the certificates at the price of the lowest successful bid.

Phase 2: Trading of certificates

Following the issuance and auctioning, this phase lets you trade with the other five players, i.e. buy and sell certificates. You can offer a trade yourself and accept offers from other players. To clarify this, please see the respective screen of the trading phase below:



Offering a trade

In the lower box, you can enter a price (in ECU) and the respective amount of certificates that you would like to buy.

- **By clicking "searching"**, all players are shown your buying desire in the left box. Once another player agrees to your offer, you will receive the respective number of certificates. The total value (price x quantity) of the trade will be withdrawn from your funds.
- **By clicking "offering"**, all players are shown your sell offer in the box on the right. Once another player accepts your offer, you sell the respective number of certificates. The total value (price x quantity) of the trade will be added to your funds.

Accepting another player's offer

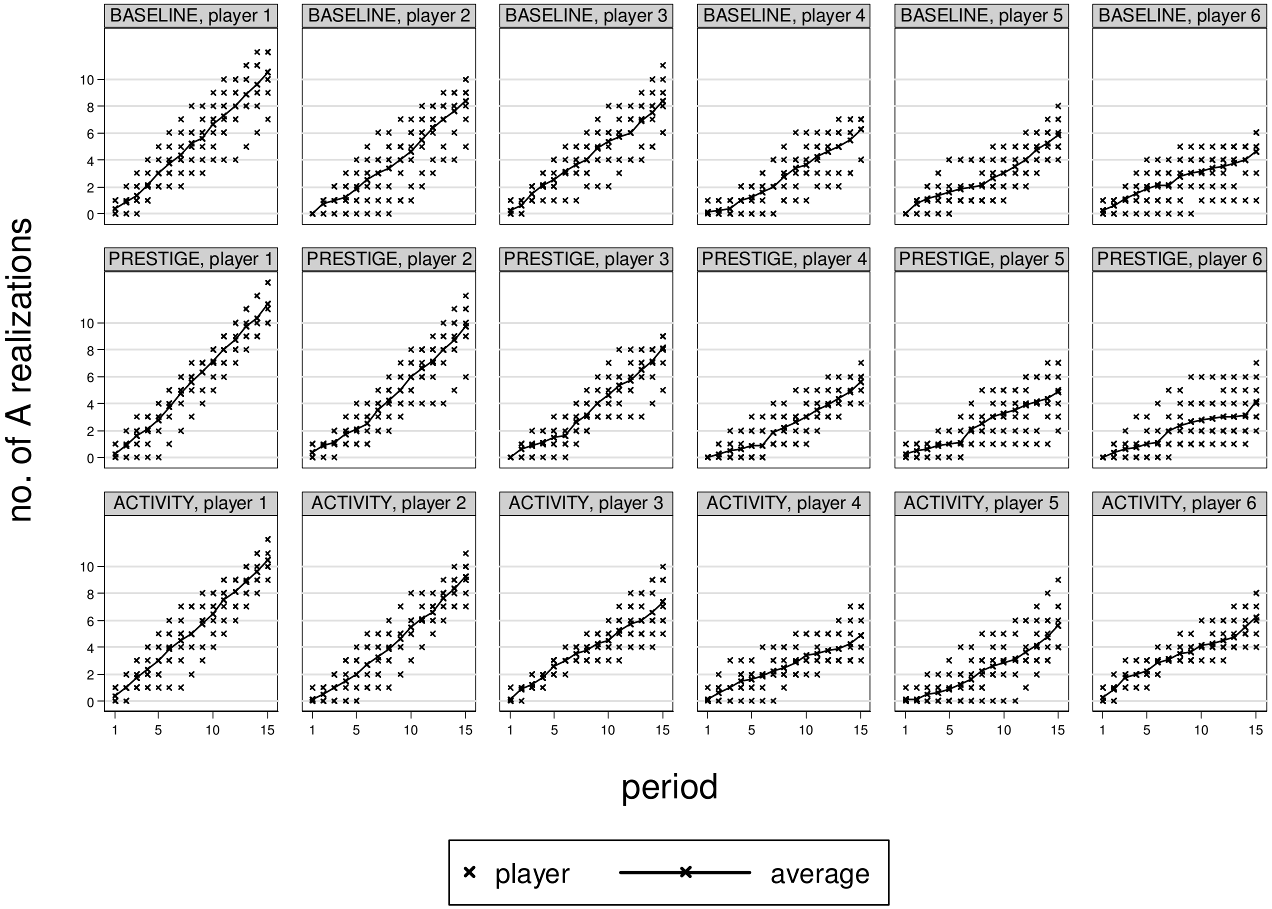
In the boxes on the right and left side, you can see all current buy and sell offers for certificates. If you choose an offer and click on "sell now!" or "buy now!", you will make the trade with the respective player.

You are allowed to trade as often as you please. You can also make multiple sell and buy offers at the same time. The trading phase ends automatically once **2 minutes** have passed.

Phase 3: Realizing projects

In the third phase of the game, you can realize one of your projects. You will receive the respective payoffs (project value in ECU) at the end of the game. After the third phase, the next period begins. Certificates that are not used in one period can be saved for subsequent periods. However, note that you will not receive a payoff for certificates that remain unused at the end of period 15!

Appendix B: Cumulative realized projects by player type over periods



BASELINE, player 1
BASELINE, player 2
BASELINE, player 3
BASELINE, player 4
BASELINE, player 5
BASELINE, player 6
PRESTIGE, player 1
PRESTIGE, player 2
PRESTIGE, player 3
PRESTIGE, player 4
PRESTIGE, player 5
PRESTIGE, player 6
ACTIVITY, player 1
ACTIVITY, player 2
ACTIVITY, player 3
ACTIVITY, player 4
ACTIVITY, player 5
ACTIVITY, player 6
no. of A realizations
period
player
average