



## UvA-DARE (Digital Academic Repository)

### Democracy and Regulation: The Effects of Electoral Competition on Infrastructure Investments

Schram, A.; Ule, A.

**Publication date**

2014

**Document Version**

Submitted manuscript

[Link to publication](#)

**Citation for published version (APA):**

Schram, A., & Ule, A. (2014). *Democracy and Regulation: The Effects of Electoral Competition on Infrastructure Investments*. University of Amsterdam.

**General rights**

It is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), other than for strictly personal, individual use, unless the work is under an open content license (like Creative Commons).

**Disclaimer/Complaints regulations**

If you believe that digital publication of certain material infringes any of your rights or (privacy) interests, please let the Library know, stating your reasons. In case of a legitimate complaint, the Library will make the material inaccessible and/or remove it from the website. Please Ask the Library: <https://uba.uva.nl/en/contact>, or a letter to: Library of the University of Amsterdam, Secretariat, Singel 425, 1012 WP Amsterdam, The Netherlands. You will be contacted as soon as possible.

# Democracy and Regulation: The Effects of Electoral Competition on Infrastructure Investments

Arthur Schram\*  
Aljaž Ule\*\*

March 10, 2014

## Abstract:

This paper investigates infrastructure investment in markets where regulation is subject to varying degrees of manipulation by elected politicians. Based on a game between a service provider, consumers with voting rights and elected decision makers we construct a model of price regulation in a market with increasing demand and long-term returns on investment. Investment is irreversible and profitable only with a sufficiently high price, thus a fear of future electoral pressure on prices may lead to inefficient delay. We investigate the price and investment dynamics through an experiment with human subjects. The experimental results show that, in contrast to the prediction, the agency problems are only a minor source of inefficiency. When decision-makers interests' align with those of the consumers, the possibility to create independent regulation does increase efficiency, because it induces both optimal pricing and timely investment, shielded from future price manipulation. Surprisingly however, independent regulation is not efficient when decision makers align with service providers because it facilitates collusion and may serve to cement prices inefficiently high.

Key Words: Infrastructural investment; regulation; holdup, electoral competition  
JEL Codes: L5, L43,D92, C9

## Address:

CREED and Tinbergen Institute  
Amsterdam School of Economics  
Roetersstraat 11  
1018 WB Amsterdam  
The Netherlands

\*[Schram@uva.nl](mailto:Schram@uva.nl).

\*\*[A.Ule@uva.nl](mailto:A.Ule@uva.nl)

## Acknowledgments

The research in this paper was funded by CPB in Den Haag. We are grateful to Rob Aalbers, Victoria Shestolova and Gijsbert Zwart of the CPB for useful suggestions at various stages of the research project. We are also indebted to Sander Onderstal for comments on an earlier draft of this paper.

## 1. Introduction

In the worldwide wave of privatization of state-owned natural monopolies that characterizes the past three decades, unbundling of infrastructure and operations has been a consistent policy (Kessides 2004, Klein and Gray 1997). This implies a vertical separation of ownership of elements where competition is possible from those where natural monopoly is believed to exist. This way of privatizing natural monopolies has been widely used for utilities like electricity and natural gas, where the provision of an infrastructure is separated from the generation and distribution of the utility. This allows for competition in distribution that is not hindered by the natural monopoly characteristics of the infrastructure.<sup>1</sup> Whereas regulation in the competitive environments of the operations can be minimized, the natural monopoly of the infrastructure typically remains regulated.

The separation of infrastructure from distribution comes at a potential cost, however. Technological progress and other developments in the markets from which the infrastructure has been separated may require substantial investments into the infrastructure itself. It is unclear whether the separation of operations provides proper incentives to invest, especially in a regulated environment (Cremer et al. 2006). There is namely an inherent holdup problem with the long-term infrastructure investment in a market which is subject to regulation. The regulator may not be able to guarantee that its policy will not be reviewed in concession to an uninformed electorate. In response, the infrastructure operators may be inefficiently cautious in their investment decisions.

Consider, for example, a competitive market for the generation and distribution of electric power that has been vertically separated from the supply of the infrastructure (cables, etc.) by a (regulated) network operator. Both the demand and the supply side of the competitive market are subject to rapid development. On the one hand, the demand for electricity is expected to rise rapidly in the foreseeable future (e.g., due to the further development of heat pumps and electric cars; cf. Campillo et al. 2012; van Vliet et al. 2011, respectively). On the other hand, new technology has enabled decentralized generation of electricity via, e.g., micro-CHP<sup>2</sup>, solar panels, or rooftop wind mills. As a consequence of these developments on

---

<sup>1</sup> Another prime example is the privatization of railways, where responsibility for the railway infrastructure is typically allocated to a different company than those who transport passengers and freight (Cox et al, 2001). For a discussion of the effects of electoral competition in this context, see Ponti and Erba (2002).

<sup>2</sup> Micro-CHP involves a combined generation of heat and power. It allows, for example, a household that uses natural gas for heating to generate electricity as a by-product. If it generates more than it uses, it can supply electricity to the network.

both sides of the market, the demand for the service provided by the infrastructure may challenge capacity constraints that can be relaxed only if the network operator invests in its expansion.<sup>3</sup> Infrastructural investments are risky, however, not only because the future developments of demand and supply –which depend on the rate of technological change– are uncertain. Investments also have to be recouped from regulated tariffs. Investment lifetimes are very long (over 20 years), and the regulation may change during the long payback period after the investment, causing uncertainty over remuneration for the network owners.

This paper focuses on the latter effects of uncertain regulation. We investigate how the lack of commitment power from a regulator, arising from her vulnerability to public or political pressure, may influence network investment and the resulting market performance. Such pressure is prominent in democratic environments, where regulation is governed by elected representatives who have a desire to be reelected. Typically, these representatives can force a regulator to adjust the regulatory scheme, which will affect the profits of the monopolist responsible for the infrastructure (henceforth referred to as the ‘infrastructure operator’).<sup>4</sup> The latter, recognizing this possibility, may react by lowering or postponing her investment, thereby increasing the probability of constrained capacity, congestion, and low efficiency.

For an empirical exploration of the conditions that may lead to such an agency problem in a complex interaction between infrastructure investors, regulators and an uninformed electorate we design a laboratory experiment around a stylized model of this interaction. The laboratory allows us to implement variations in types of regulation with a high degree of control. For the environment studied here, such control provides major advantages that can complement evidence from observational field studies.<sup>5</sup> For example, laboratory control allows us to take away the uncertainty related to the future development of infrastructural utilization and isolate the uncertainty related to the variation in future prices caused by changes in regulation. It also allows us to systematically vary the extent to which the

---

<sup>3</sup> To illustrate the cases we are interested in, we use here the example of investment in electricity transmission capacity. Other infrastructural investments may also be required. E.g., an increased demand for electricity due to heat pumps and cars may require investments in so-called ‘smart grids’. Our framework intends to cover different types of infrastructural investments.

<sup>4</sup> This may explain why there is such a large variety of regulatory policies across countries. See footnote 1 in Henze et al. (2012) for examples of the various regulatory schemes in Europe.

<sup>5</sup> Falk and Heckman (2009) provide a recent methodological discussion of the advantages and disadvantages of laboratory experiments. Aside from the control discussed in the main text, one important advantage is the possibility of replication of results.

regulator's interests are aligned with those of the infrastructure operator. Such control thus allows us to study the effects of variations in the regulatory framework and in the regulator's preferences under conditions that are strongly *ceteris paribus*. More generally, this kind of control has made laboratory experiments a popular method for studying issues related to various markets (e.g., Brunner *et al.* 2010), including electric power markets (Rassenti et al. 2002; Staropoli and Jullien 2006; Brandts and Schram 2008; Brandts et al. 2013). Normann and Ricciuti (2009) provide an overview of the contributions of studies using laboratory experiments to economic policy making. One of the broad areas they discuss is the regulation of markets.

The experimental design is based on a highly stylized model of a market with increasing demand over time and long-term returns on investment. In the model, the infrastructure operator must decide about investing in an environment where current and future prices in the market are determined by a regulator. The regulator's future decisions are subject to possible political manipulation. For this purpose, we construct a six-player multi-period game between one infrastructure operator, two political decision makers competing for office, and three consumers. The consumers hold voting rights and in each period elect a decision maker who may then influence the regulated (per unit) price for use of the infrastructure. The scope of the decision-maker's influence is typically limited by regulation. As discussed below, we will distinguish between four different benchmark regulatory frameworks that to various degrees constrain the decision maker's possibility to change the regulated price. We also systematically vary the extent to which the decision makers' interests are aligned with those of the infrastructure operator.

Before an election the infrastructure operator chooses whether to increase its capacity against an investment cost. Investment is irreversible and profitable only with a sufficiently high price for service provision. The infrastructure operator therefore faces (political) uncertainty about future prices –and, hence, about the profitability of investments. In the subgame perfect equilibrium of this game, the investment decision depends mainly on the regulatory framework. Crucially, our model creates conditions where the electoral competition creates a potential holdup problem. The infrastructure operator will only invest (in equilibrium) if the framework allows the elected decision maker to fully commit to a sufficiently high price in all future periods.

After showing that our model indeed induces an agency problem where the holdup is a consequence of electoral pressure, we explore the potential inefficiencies with our laboratory experiment. The experimental results provide only limited support for the comparative static predictions from the formal equilibrium analysis. In particular, when the elected decision-maker's interests follow those of the infrastructure operator, we observe efficient investment. Such interests lead to inefficiently high prices, however, in particular when the regulatory framework is rigid, that is, when the political decision maker sets up price regulation and then grants it independence beyond future elections. Such commitment allows the politician to avoid the downward pressure that electoral competition could put on future prices. On the other hand, when the decision maker's interests are not aligned with those of the infrastructure operator, the prices remain low. In this case, efficient investment is *only* observed with rigid regulation. In other regulatory frameworks, there is too little investment, which is a consequence of electoral competition that pushes (regulated) prices down to levels that are beneficial to consumers in the short run, but detrimental in the long run.

To the best of our knowledge, we are the first to study the impact of electoral competition on regulation policies and their consequences for infrastructural investment. It is important to consider the interaction between (i) firms (like infrastructure operators); (ii) politicians and the regulators they appoint; and (iii) consumers with voting rights. Consumers consume the product produced by the firms and select politicians that determine the (efficiency) of outcomes in the markets concerned, where their interests may be conflict. While the general analysis allows for feedback effects between the various interests, the existing studies only consider partial effects. Most of the literature have focused on the relationship between regulation and investment (e.g., Cambini and Rondi 2010; Égert, 2009; Nagel and Rammerstorfer 2008; Vogelsang 2010; for a more complete overview see Normann and Ricciuti 2009). Some other studies have focused more on the political determinants of regulatory policies, sometimes including the influence of voters (see Noll 1989 for a survey). We, however, study the interaction of all three groups of actors (i)-(iii) and how this affects the efficiency in regulated markets.

The remainder of this paper is as follows. The following section introduces the stylized model that we use to create the type of agency problem we are interested in and includes the equilibrium analysis. This is followed by our experimental design and procedures in section 3.

Section 4 gives our results and section 5 offers a conclusion. Technical details are given in the appendix that also contains experimental instructions.

## 2. Theoretical Model

We structure our analysis and our experiment around a game-theoretic model of investment in an industry where the political decision makers –concerned about reelection– choose price regulation. Rather than providing a formal description of an existing polity, we consider a stylized model aiming at a clear identification of the possible effects of electoral competition on the investments. Our notation is inspired by the example of electricity transmission regulation, involving an owner of a transmission network, electricity consumers with voting rights, and elected decision makers with varying freedom to regulate transmission charges. In this example electricity production and trade and production are assumed competitive and do not affect the conclusions below. We first describe and analyze a general model and then present and discuss the treatments used in the experiment. In the next section we describe and analyze the model with the specific parameters used in our experimental treatments.

The economy consist of the following agents:

- One infrastructure operator (IO). IO decides whether to invest in infrastructure. We assume that it always maximizes its profit through pricing, which is subject to regulation.
- A set of available decision-makers (DM). One decision maker is elected into office, denoted by  $DM^E$ , and may decide on the regulation of (electricity) infrastructure usage price. The non-elected decision-makers make no decisions.
- A set of  $n$  consumers/voters (CV). Voters choose  $DM^E$  and consume electricity.

Investment relaxes capacity constraints imposed by the infrastructure. It also involves cost  $c$  for the investor, which can be recuperated through charges from the extra service it enables. For simplicity we assume that IO accommodates any quantity of service up to  $Q^{cst}$  with no investment, but can meet an unlimited demand for service if it does invest into its infrastructure.<sup>6</sup> The capacity constraint is binding only when consumer demand for IO's

---

<sup>6</sup> Electricity transmission networks face low marginal costs for normal capacity but steeply increased marginal costs when capacity reaches network constraints (Brandts et al. 2008). We model this by assuming that transmission is costless when capacity is not reached, but has an infinite cost when capacity is exceeded. Cost  $c$  can be seen as the rental cost of invested capital. We assume in the paper that it is incurred in every period after investment has been made.

service is sufficiently high. In this case consumers benefit from investment as it allows them higher consumption. Their preferences regarding price and investment may be in conflict, however: on one hand the consumers prefer prices that are low, on the other they prefer that IO invests into infrastructure, for which IO may require prices to stay high.

This conflict occurs already under simple linear demand. Let each consumer's demand for IO's service<sup>7</sup> be given by  $q(P) = b(P^{max} - P)$  for  $P \in [0, P^{max}]$  and let the market demand be  $Q(P) = nb(P^{max} - P)$ . We show in Appendix A that an unregulated profit maximizing IO invests and charges the monopoly price  $P^* = \frac{1}{2}P^{max}$  only when the demand sufficiently exceeds the capacity constraint,

$$\frac{nb}{2}P^{max} > Q^{cst}, \quad (1)$$

and when the investment cost is sufficiently small,

$$c < \frac{nb}{4}(P^{max})^2 - (P^{max} - \frac{1}{nb}Q^{cst})Q^{cst}. \quad (2)$$

Similarly, if regulation allows IO to charge at most price  $P^{reg} < P^*$  then IO charges price  $P = P^{reg}$  and invests when the demand sufficiently exceeds the capacity constraint,

$$nb(P^{max} - P^{reg}) > Q^{cst}, \quad (3)$$

and when the investment cost is sufficiently small,

$$c < nbP^{reg}(P^{max} - P^{reg}) - P^{reg}Q^{cst}. \quad (4)$$

From (4) it is clear that, given a fixed investment cost  $c$  and maximum price  $P^{reg} > 0$ , investment is profitable for IO only with sufficiently high  $n$ ,  $b$  or  $P^{max}$ , that is, when the aggregate demand is sufficiently high.

Consumers maximize their total surplus: after investment (with unconstrained infrastructure) given by  $\pi^V(P) = \frac{nb}{2}(P^{max} - P)^2$ ; and before investment (with constrained infrastructure) given by  $\pi^V(P) = \min\{\frac{nb}{2}(P^{max} - P)^2, Q^{cst}(1 - \frac{1}{2nb}Q^{cst})(P^{max} - P)\}$ . It is clear from this that consumers prefer low prices –which might prohibit investment– but at the same time prefer investment when their demand is sufficiently high.

---

<sup>7</sup> Vertical separation of infrastructure and operations implies that consumers do not directly demand infrastructural services. The assumed competitiveness of the market for operations permits a reduced form to model this demand, however.

The preferences of decision makers are not specified in this model. We consider three cases in this paper:<sup>8</sup>

[CA] Preferences of all DMs are aligned with those of consumers.

[IA] Preferences of all DMs are aligned with those of infrastructure owners.

[N] Preferences of all DMs are neutral, their only care is to be elected.

Throughout this paper we assume that the alignment of DMs' preferences is common knowledge.<sup>9</sup> Though this is a strong assumption, voters generally do have ideas about politicians' motives, which are revealed through past policies. Consumers, however, do not have complete information: they do not know IO's payoff structure. As a consequence, they do not know DMs payoffs in the IA case, either. In contrast, the IO and DMs are assumed to be better informed and know CVs' payoffs.

Finally, when regulation limits the set of possible prices below the monopoly price, the IO always chooses the maximal possible price  $P^{reg}$ . We therefore assume that regulation by  $DM^E$  consists of choosing price  $P^{reg} < P^*$  which the IO has to charge.

To obtain theoretical predictions we need to specify the sequence of decisions and determine subgame perfect equilibria (SPE). We begin with the analysis of the game when all decisions are taken just once. This stage game consists of the following consecutive steps:

1. IO decides whether to invest. Investment costs  $c$  and eliminates capacity constraints.
2. CVs vote to choose a DM that may regulate IO's price. The DM with a majority of votes becomes  $DM^E$ , where a random draw breaks ties in voting.
3.  $DM^E$  chooses price  $P^{reg}$ , adopted by IO.

The SPE of this stage game depend on the size of demand and on the DMs' preferences. IO never invests with low demand, while with high demand investment depends on the DMs' preferences. With [CA] preferences  $DM^E$  will set  $P^{reg} = 0$  and the IO will never invest. With [N] preferences the DMs are unpredictable, but the consumers vote for the DM who would set the lowest price, which may lead to the race to the bottom and the same outcome as

---

<sup>8</sup> An alternative case would be that DMs' interests are aligned with total surplus. We do not consider this case of a benevolent dictator in the current paper but see it as a possibility for future research. We will discuss efficient prices after presenting the experimental design.

<sup>9</sup> Note that the three cases are chosen so as to compare extreme situations. In reality, alignment with IO seems more likely than with CV (Enikolopov 2012), because (i) a natural choice for a politician's post career employment is in industry; (ii) an IO will typically have much more effective lobbying power than CV; (iii) an IO has a strong incentive to offer future benefits (e.g., employment) to the DM.

above.<sup>10</sup> With [IA] preferences the  $DM^E$  will set  $P^{reg} \geq P^*$  (that is, it will abstain from regulation); the IO will charge the monopoly price  $P^*$  and invest whenever conditions (1) and (2) above are satisfied.

We now shift our focus to the extended game where the stage game is played repeatedly. Our main aim is to investigate environments where investment is a long-term commitment relative to the electoral cycle with an uncertain regulatory dynamics. For this we consider an extended game where steps 1-3 above repeat  $T$  times, with the following exceptions:

- 1a. Investment is irreversible: the IO retains the power to decide only until it actually invests. More precisely, if the IO did not invest in any previous period then it faces the decision whether to invest in period  $t$ . However, if it did invest in an earlier period then IO does not make any decision; it incurs cost  $c$  and all agents benefit from the increased capacity in each of the remaining periods  $t, \dots, T$ .<sup>11</sup>
- 3a. Depending on the regulatory framework,  $DM^E$  may face restrictions or costs when choosing price  $P^{reg}$ . We consider four stylized regulatory frameworks that cover the benchmarks of interest:<sup>12</sup>

[UR] Unstable Regulation:  $DM^E$  can choose  $P^{reg}$  in every period without restrictions.

[CR] Costly Regulation:  $DM^E$  can change  $P^{reg}$  between periods only against a cost.

[SR] Stable Regulation: only the  $DM^E$  elected in period 1 can choose  $P^{reg}$  which then becomes fixed. In later periods this regulated price cannot be changed and the  $DM^E$ 's elected in periods 2, ...,  $T$  make no decisions.

[ER] Endogenous Regulation: initially the  $DM^E$  makes two decisions; it chooses  $P^{reg}$  and decides whether to fix the regulation for the remaining periods. If it does not fix

---

<sup>10</sup> Strictly speaking, there are multiple SPE because the elected DM is indifferent between regulation prices.

Any price can be achieved in an equilibrium where all DMs choose the same price if elected.

<sup>11</sup> Cost  $c$  is then the periodic rental cost of the invested capital, incurred in every period.

<sup>12</sup> Rather than a faithful reproduction of an existing regulation our regulatory conditions cover the various boundary benchmarks. This facilitates clear identification of the effect of regulatory variance. The regulation in real markets typically involves a combination of our four rules and rarely imposes a single price. The actual regulation of electricity transmission charges in the Netherlands determines how the maximum charge changes with the consumer price index (CPI). Evidence from transmission charges in the Netherlands show that network operators almost always charge the maximal possible price, however. We simplify this in our model by assuming a constant CPI and a single (maximal) regulated price. This leads to regulation with a constant regulated price. Moreover, we choose not to include the possibility of a 'regulatory holiday' (Gans and King 2003, 2004) where the IO would be exempt from  $P^{reg}$  for a pre-specified number of periods if she invests. One reason is that in a setting without competition like ours the holiday would involve monopoly pricing. The IO may then delay investment to optimize the period in which monopoly profits can be reaped. Evidence of such welfare-reducing behavior is found in a controlled laboratory environment by Henze et al. (2012).

this price then the DM elected in the next period faces the same situation. If, however, it decides to fix its chosen  $P^{reg}$ , it remains fixed forever and the  $DM^E$ 's elected in later periods make no decisions. In other words, the game starts with unstable regulation but an elected  $DM^E$  can choose to stabilize it in any period.

We assume that all agents maximize the sum of the payoffs earned across the periods. Moreover, inspired by the example of electricity transmission we assume that demand increases with periods. The first period that makes investment profitable for IO, when price sequence  $P, \dots, P$  is stable (fixed) across periods, is denoted by  $in(P)$ .

Interestingly, the SPE of this extended (repeated) game are less dependent on the DMs' preferences than the SPE of the simpler (one-shot) game. This is because  $DM^E$  cares about reelection, as non-elected DMs earn nothing. CVs can use this to credibly threaten  $DM^E$  that does not regulate  $P^{reg}$  in their favor. In particular, below we show how in all our treatments the CVs can enforce low prices in an SPE through the following combination of strategies:

CV: "Vote for DM1 in period 1. In period  $t$  vote for the same DM as in period  $t-1$  as long as she did everything in her power (choosing and perhaps fixing the price) to achieve the price that across the remaining periods is best for CVs and still profitable for DM. In the opposite case vote for the other DM."

DM: "Always choose the regulation requested by the CVs, with one possible exception: in the final period  $T$  choose the best price for yourself if change of regulation is cheap and possible."

IO: "Invest in period  $in(P)$  if and only if given above strategies,  $P^{reg} \geq P > 0$  is certain for all subsequent periods."

Assuming voter's behavior, this SPE is given by backwards induction.<sup>13</sup> Obviously, with [CA] and [N] preferences the DM elected in period 1 has no reason to deviate and will be reelected in all subsequent periods. Consider now [IA] preferences. The  $DM^E$  in the last period  $T$  will profit from being elected. Because of increasing demand she profits more from waiting with her preferred (monopoly) price until period  $T$  than to choose it in period  $T-1$  and lose the election in period  $T$ . If other DMs use the above strategy, a DM that loses an election never

---

<sup>13</sup> Strictly speaking, any outcome can emerge in an equilibrium of such a voting game, because three voters voting for the same candidate is always an equilibrium. Multiple equilibria are typical for voting games with obligatory voting. To avoid the folk-theorem type result for the SPE of the (repeated) game we posit the voters behavior. For a further discussion of this multiple voting equilibria problem, see Banks & Duggan (2006).

returns to office. By induction the above argument therefore extends to all periods. Finally, the assumed CVs' voting is rational given DM and IO strategies.

The exact calculation of SPE prices, regulation and investment depends on the details of the demand function dynamics. In the next section we describe the model parameters that we implemented in our experiments. We then determine the detailed equilibrium behavior as well as the efficiency benchmark for all our treatments.

### **3. Experimental Design and Procedures**

#### **General Setup**

The experimental design implements the model of section 2 with groups of six subjects, consisting of one infrastructure operator, two (political) decision makers and three consumers with voting rights. Groups and roles are fixed throughout the nine periods of the computerized experiment. A translation of the Dutch instructions is given in Appendix B. In these instructions, the IO is introduced as an “investor” and the political decision makers as “price determiners”. All subjects are told:

“ In every period, the investor delivers to each consumer a good. Exactly the same good is delivered to each consumer. Every consumer must buy the product. The price of the product is determined by one of the price determiners.”

Subsequently, they are told that the investor must decide on investing in the production process and that consumers elect by majority vote which of the two decision makers will be allowed to set the price in a period. In the experiment, the set of prices from which can be chosen consists of the integers  $\{0,1,2,3,4,5\}$ .

Each period then consists of six steps, which were taken sequentially:

Step I: If the investor has not previously invested in high capacity, she decides whether to do so. If she has previously invested, capacity remains high (no decision is needed).

Step II: The investor publicly announces a desired price for the good.

Step III: The price determiners simultaneously and publicly each announce a target price for the good.<sup>14</sup>

---

<sup>14</sup> Steps II and III are cheap talk and do not imply any kind of commitment. They are included for reason of external validity and do not affect the theoretical results presented in section 2.

Step IV: Each consumer votes for one of the two price determiners. The price determiner with two or more votes is elected.

Step V: The elected price determiner sets the price for the period.<sup>15</sup>

Step VI: Earnings are determined and each participant is informed about her own earnings in the period concerned.

Given the one-shot nature of the model, we choose to have each group of subject play this nine-period game only once. Note that this means that investors are inexperienced and could conceivably make errors that they would not make if they had an opportunity to learn across multiple repetitions of the game. In particular, because a decision to invest is irreversible, there may be a bias where inexperienced investors invest too early. Nevertheless, we believe that real-world investment decisions in infrastructure provide no opportunities to learn from experience and that we should maintain this characteristic in our design. Moreover, our experimental sessions already took long (see below) and further extension would stretch the duration beyond what is reasonable for our subject pool. Because our analysis will be based on treatment comparisons, this design choice will not affect our conclusions as long as the bias caused by inexperience is independent of treatments.<sup>16</sup>

## **Earnings**

Earnings in the experiment are denoted by “experimental Franks”. At the end of a session, these are exchanged for euros at a rate of €1 for 50 Franks. Decision makers are given a starting capital of 325 Franks to avoid negative aggregate earnings. The instructions inform all subjects that additional earnings depend on (i) whether or not the investor has invested; and (ii) the price chosen by the price determiner. All subjects are subsequently told that the following general rules hold:

- investing never harms the consumers’ earnings and often increases them;
- higher prices are usually better for the investor;

---

<sup>15</sup> As will be explained below (and was discussed above), in some treatments the price is fixed across periods. In these cases no choice is required in step V.

<sup>16</sup> One possible error is obvious in our setup. We cannot conceive of a rationalization for investing in period 1, before having observed any other choices. When discussing our results, we will show that this error is made independently of treatment and that our main conclusions are barely affected if we drop such observations from the analysis.

- lower prices are better for the consumer;
- the price determiner that is not elected in a period earns nothing;
- the elected price determiner earns [.....].

The earnings of the elected price determiner shown in the last bullet depend on her preferences which differ between treatments, as will be explained below.

On their computer monitor the subjects are shown the possible earnings in a period in a two dimensional table that discriminates between the six possible prices  $\{0,1,2,3,4,5\}$  and whether or not an investment has taken place. For each price-investment combination the investors and decision makers are shown the earnings of each type of participant whereas consumers see only their own earnings.<sup>17</sup> When subjects have finished reading the (computerized) instructions and before the experiment itself is started, they receive a table showing the payoffs of all nine periods.

The payoffs are based on the model from Section 2 above, with parameters  $P^{\max}=6+t$ ,  $b=2$ ,  $n=3$ ,  $Q^{\text{cst}}=15$  and  $c=20$ , where  $t \in \{1,2,\dots,9\}$  denotes the period. For simplicity we permit just discrete values for the price. These cover the most interesting cases. Figure 1 shows the resulting payoff tables of investors and consumers (payoffs of price determiners will be described below).

During the experiment the subjects also have access to a calculation aid' on their monitor, with which they can calculate the payoff consequences of all possible combinations of prices and investments in the remaining periods. Figure 2 provides an example of this aid.

## Treatments

We vary treatments along two dimensions in a way that runs parallel to our discussion of the theoretical model. First, we vary the earnings of the elected price determiner. In '*Investor Aligned*' [IA], this price determiner earns exactly the same amount as the investor in a period. In '*Consumer Aligned*' [CA] she earns the same as the consumer. Finally, in the treatment '*Non-aligned*' [N], the price determiner earns 75 Francs if elected. These treatments allow us

---

<sup>17</sup> As in the theoretical model, this asymmetry was chosen for external validity reasons. We doubt that most consumers know the details about the consequences of specific price-investment combinations, instead relying on general notions such as 'high prices are good for producers'. Producers and politicians are generally better informed.

**Figure 1: Payoff tables**

**Investor's earnings; no investment**

| $p^{reg}$ | 1  | 2  | 3   | 4   | 5   | 6   | 7   | 8   | 9   |
|-----------|----|----|-----|-----|-----|-----|-----|-----|-----|
| 0         | 0  | 0  | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| 1         | 30 | 30 | 30  | 30  | 30  | 30  | 30  | 30  | 30  |
| 2         | 60 | 60 | 60  | 60  | 60  | 60  | 60  | 60  | 60  |
| 3         | 72 | 90 | 90  | 90  | 90  | 90  | 90  | 90  | 90  |
| 4         | 72 | 96 | 120 | 120 | 120 | 120 | 120 | 120 | 120 |
| 5         | 60 | 90 | 120 | 150 | 150 | 150 | 150 | 150 | 150 |

**Investor's earnings; investment**

| $p^{reg}$ | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 0         | -20 | -20 | -20 | -20 | -20 | -20 | -20 | -20 | -20 |
| 1         | 16  | 22  | 28  | 34  | 40  | 46  | 52  | 58  | 64  |
| 2         | 40  | 52  | 64  | 76  | 88  | 100 | 112 | 124 | 136 |
| 3         | 52  | 70  | 88  | 106 | 124 | 142 | 160 | 178 | 196 |
| 4         | 52  | 76  | 100 | 124 | 148 | 172 | 196 | 220 | 244 |
| 5         | 40  | 70  | 100 | 130 | 160 | 190 | 220 | 250 | 280 |

**Consumer's earnings; no investment**

| $p^{reg}$ | 1  | 2  | 3  | 4  | 5  | 6  | 7   | 8   | 9   |
|-----------|----|----|----|----|----|----|-----|-----|-----|
| 0         | 45 | 55 | 65 | 75 | 85 | 95 | 105 | 115 | 125 |
| 1         | 35 | 45 | 55 | 65 | 75 | 85 | 95  | 105 | 115 |
| 2         | 25 | 35 | 45 | 55 | 65 | 75 | 85  | 95  | 105 |
| 3         | 16 | 25 | 35 | 45 | 55 | 65 | 75  | 85  | 95  |
| 4         | 9  | 16 | 25 | 35 | 45 | 55 | 65  | 75  | 85  |
| 5         | 4  | 9  | 16 | 25 | 35 | 45 | 55  | 65  | 75  |

**Consumer's earnings; investment**

| $p^{reg}$ | 1  | 2  | 3  | 4   | 5   | 6   | 7   | 8   | 9   |
|-----------|----|----|----|-----|-----|-----|-----|-----|-----|
| 0         | 49 | 64 | 81 | 100 | 121 | 144 | 169 | 196 | 225 |
| 1         | 36 | 49 | 64 | 81  | 100 | 121 | 144 | 169 | 196 |
| 2         | 25 | 36 | 49 | 64  | 81  | 100 | 121 | 144 | 169 |
| 3         | 16 | 25 | 36 | 49  | 64  | 81  | 100 | 121 | 144 |
| 4         | 9  | 16 | 25 | 36  | 49  | 64  | 81  | 100 | 121 |
| 5         | 4  | 9  | 16 | 25  | 36  | 49  | 64  | 81  | 100 |

Notes. Cells denote payoffs in Franks for each period (column) for each of the six possible prices (row). Investors and price determiners were shown all four tables; consumers only saw the lower two.

| ronde | prijs                 |                       |                       |                       |                       | invest                   |
|-------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|--------------------------|
|       | 0                     | 1                     | 2                     | 3                     | 4                     |                          |
| 1     | <input type="radio"/> | <input type="checkbox"/> |
| 2     | <input type="radio"/> | <input type="checkbox"/> |
| 3     | <input type="radio"/> | <input type="checkbox"/> |
| 4     | <input type="radio"/> | <input type="checkbox"/> |
| 5     | <input type="radio"/> | <input type="checkbox"/> |
| 6     | <input type="radio"/> | <input type="checkbox"/> |
| 7     | <input type="radio"/> | <input type="checkbox"/> |
| 8     | <input type="radio"/> | <input type="checkbox"/> |
| 9     | <input type="radio"/> | <input type="checkbox"/> |

**Consument:**   
**Investeerder:**

**Figure 2: Calculator**

*Notes.* Subjects choose a price for each remaining period and click a period for investment (if any). All later periods are then automatically also selected. Decisions for periods that have already passed can no longer be entered. If the investor has invested in a previous period, investment is automatically selected for all remaining periods. This example calculates and shows cumulative payoffs for consumers and investors. Consumers are only shown their own payoffs.

Translation: ‘ronde’ = period; ‘prijs’ = price; ‘consument’=consumer; ‘investeerder’=investor.

to investigate the effects of variations in the alignment of a political decision maker’s interests with those of the other actors.

The second treatment dimension varies the freedom that an elected price determiner  $DM^E$  has in determining the price. In ‘*Unstable Regulation*’ [UR], the  $DM^E$  is free to choose a price in any period. ‘*Stable Regulation*’ [SR] is the other extreme. Here, the price determiner that is elected in period 1 chooses a price that holds for all nine periods. In ‘*Endogeneous Regulation*’ [ER], fixing the price for future periods is optional. In any period, if the price has not yet been fixed in previous periods, the  $DM^E$  chooses a price, and additionally decides whether that price will hold only in the period concerned or for all remaining periods.<sup>18</sup> Finally, in ‘*Costly Regulation*’ [CR], the  $DM^E$  can choose any price. If this price is different

<sup>18</sup> Due to a software error, price determiners in some groups were asked to determine a price even after this had previously been fixed. This had no consequences for earnings and progress of the game however, and we will neglect the decisions made in these cases when analyzing the data.

than the price chosen in the previous period, the  $DM^E$  is charged 15 Franks (which is approximately 20% of  $DM^E$ 's period earnings). If the same price is chosen as in the previous period, there are no costs. The two treatment dimensions were varied in a between-subject design. Table 1 summarizes the treatment combinations and shows the number of observations for each combination.

**Table 1: Treatments**

|      | [CA] | [IA] | [N] |
|------|------|------|-----|
| [UR] | n=5  | n=5  | n=4 |
| [SR] | n=4  | n=4  | n=4 |
| [ER] | n=5  | n=5  | n=6 |
| [CR] | n=5  | n=4  | n=8 |

*Notes.* n denotes the number of groups in each treatment combination. [UR] Unstable Regulation; [SR] Stable Regulation; [ER] Endogeneous Regulation; [Costly Regulation]; [CA]=Consumer Aligned; [N]=Non-aligned; [IA]=Investor Aligned.

## Procedures

The experiments were run at the laboratory of the Center for Research in Experimental Economics and political Decision making (CREED) at the University of Amsterdam. Subjects were recruited from the CREED subject pool, which consists of approximately 2000 students, mainly UvA undergraduates from various disciplines. 354 subject participated and earned on average €27,42 (including a €7 show-up fee). Sessions lasted between 90 and 120 minutes.

Each session started with computerized instructions (Appendix B). When subjects had finished with these, a summary was handed out, as were the payoff tables. Subjects were given five minutes to study this material. Then every subject participated in a brief measurement of aversion to commitment before the main experiment started.<sup>19</sup> The experiment was programmed in Delphi. Before subjects were paid, they filled out a brief questionnaire soliciting background information.

## Theoretical Benchmarks

We base equilibrium predictions on the SPE analysis given in Section 2, adapted for our parameters and the discrete price set in our 9-period game. Using the arguments and

---

<sup>19</sup> The results of the commitment measurement proved uninformative for behavior in the main experiment and will not be discussed in this paper.

strategies from Section 2, Table 2 gives the SPE outcomes for all treatments. Below, we will present hypotheses based on the treatment differences implied by these predictions.

**Table 2: Equilibrium prices and investment**

|      | [CA] or [N]   | [IA]  |
|------|---|---|
| [UR] | $P^{\text{reg}}=\{0,\dots,0\}; in^r = \text{never}$             | $P^{\text{reg}}=\{0,\dots,0,5\}; in^r = 9$                      |
| [SR] | $P^{\text{reg}}=\{1,\dots,1\}; in^r = 4$                        | $P^{\text{reg}}=\{1,\dots,1\}; in^r = 4$                        |
| [ER] | $P^{\text{reg}}=\{0,0,1,\dots,1\}; \text{fix in r.3}; in^r = 4$ | $P^{\text{reg}}=\{0,0,1,\dots,1\}; \text{fix in r.3}; in^r = 4$ |
| [CR] | $P^{\text{reg}}=\{0,\dots,0\}; in^r = \text{never}$             | $P^{\text{reg}}=\{0,\dots,0,5\}; in^r = 9$                      |

*Notes.* Treatments are defined in the note to Table 1.  $P^{\text{reg}}$ =the regulated price.  $In^r = in(P^{\text{reg}})$ =the first period of investment given the price regulation.

The numbers in table 2 follow straightforwardly from the analysis in section 2. Take, for example the (ER,IA) cell. If IO invests before the price is fixed, the voters will elect the DM that fixes the price to 0. IO will therefore invest only after the price is fixed and if the fixed price is at least 1. Given the price is fixed to 1, IO invests in period 4. It is therefore optimal for the consumers that the price is fixed to 1 in round 3.

As a different benchmark than SPE, we consider efficiency. We measure efficiency with the total surplus from service production and consumption, calculated as the sum of IO's and all CVs' profits. Our efficiency benchmark determines the most efficient outcome obtainable under the restriction that no agent makes a loss in any single period (implying only that the price must be 1 or more after IO invests).<sup>20</sup> Table 3 shows the resulting outcomes.

**Table 3: Efficient prices and investment**

|      | No loss efficiency                         |
|------|--|
| [UR] | $P^{\text{reg}}=\{0,1,\dots,1\}; In^e = 2$ |
| [SR] | $P^{\text{reg}}=\{1,\dots,1\}; In^e = 2$   |
| [ER] | $P^{\text{reg}}=\{0,1,\dots,1\}; In^e = 2$ |
| [CR] | $P^{\text{reg}}=\{0,1,\dots,1\}; In^e = 2$ |

*Notes.* Treatments are defined in the note to Table 1.  $P^{\text{reg}}$ =the regulated price.  $In^e$ =the first period of investment.

None of the equilibrium outcomes is efficient. The unstable regulation of treatments UR and CR leads to the largest inefficiency, because the possibility of future low prices creates a holdup problem that discourages investments. Independent regulation of treatments SR and ER increases efficiency, however, with higher prices and just a slight delay in investment.

<sup>20</sup> This represents the text book case of average cost pricing.

For the sake of completeness, we consider the inequality involved in the various outcomes. Before investment, the most equal payoffs are obtained with price sequence  $\{2,2,3,3,3,3,4,4,4\}$ , but after investment the payoffs are most equal when  $P^{\text{reg}}=2$  in all periods. Comparing this to the results in Tables 2 and 3 implies shows that observed prices of 2 or higher may be an indication of subjects with inequity aversion.

### **Hypotheses**

We can use the equilibrium predictions of Table 2 to formulate several hypotheses and predict comparative statics in treatment comparisons.

- H1. Investment will happen earlier in treatments that permit fixing the regulated price (SR and ER) than in treatments where the price cannot be fixed (UR and CR).
- H2. Prices will be higher in treatments that permit fixing the regulated price (SR and ER) than in treatments where the price cannot be fixed (UR and CR).
- H3. Except in the final period, the DMs' preferences do not affect investment or prices. In the final period the prices will be higher when the DMs' interests are aligned with those of the investor [IA] and the prices cannot be fixed (treatments [UR] and [CR]).

In addition, recall from section 2 that the equilibrium involves CVs voting for the incumbent DM, if she previously chose the lowest price, conditional on her not making a loss (across all periods). Note that this means that from period 2 onward, CVs vote to reelect after price 0 in UR and CR. In SR they reelect if the price is fixed at 1 in period 1 and in ER they do so after an unfixed price 0 in periods 2 or 3 and after a fixed price 1 in period 4. This yields:

- H4: Voters are less likely to vote to reelect the incumbent after she previously chose a price of 2 or more than after a lower price. In UR and CR, voters are less likely to vote to reelect the incumbent after she previously chose a price of 1 than after a price of 0.

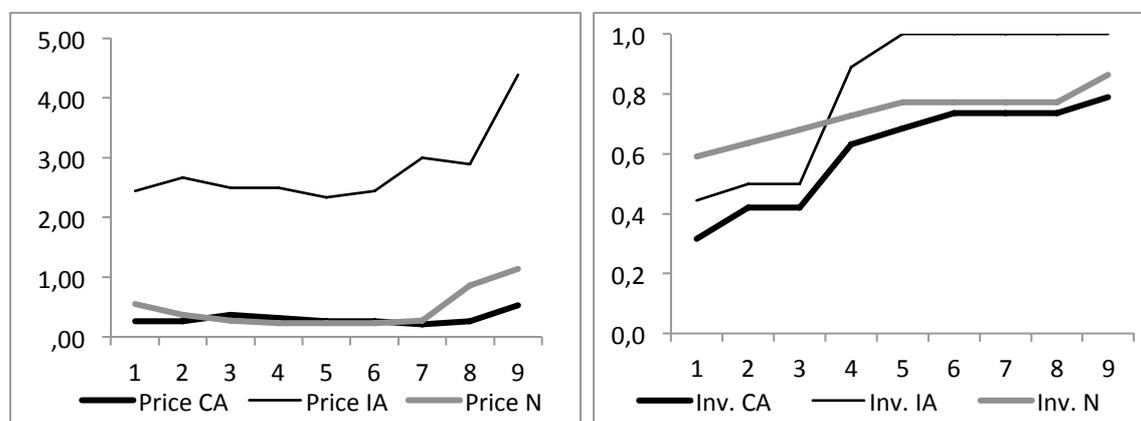
### **4. Experimental Results**

In analyzing the experimental data, we will consider the effects that treatment variation has on average prices, the period of investment, and aggregate welfare. We will first provide a general overview of the results and subsequently analyze the data in more detail. We will end by formally testing the hypotheses derived in the previous section. All p-values reported in this section are based on two-sided tests.

## Partial treatment effects

Figure 2 shows the development of prices (left panel) and investments (right panel) across the 9 periods, distinguishing between the three variations in alignment for the DMs' interests.

**Figure 2: Investments and Prices by Alignment**



*Notes.* The left panel shows the average price (vertical axis) per period (horizontal axis). The right panel shows the fraction of groups in which investment ('Inv.') has occurred (vertical axis) for each period (horizontal axis). Inv.=Investment; [CA]=Groups where the price determiners' interests are aligned with the consumers' interests; [IA]=Groups where the price determiners' interests are aligned with the Investor's interests; [N]=Groups where the price determiners have independent interests.

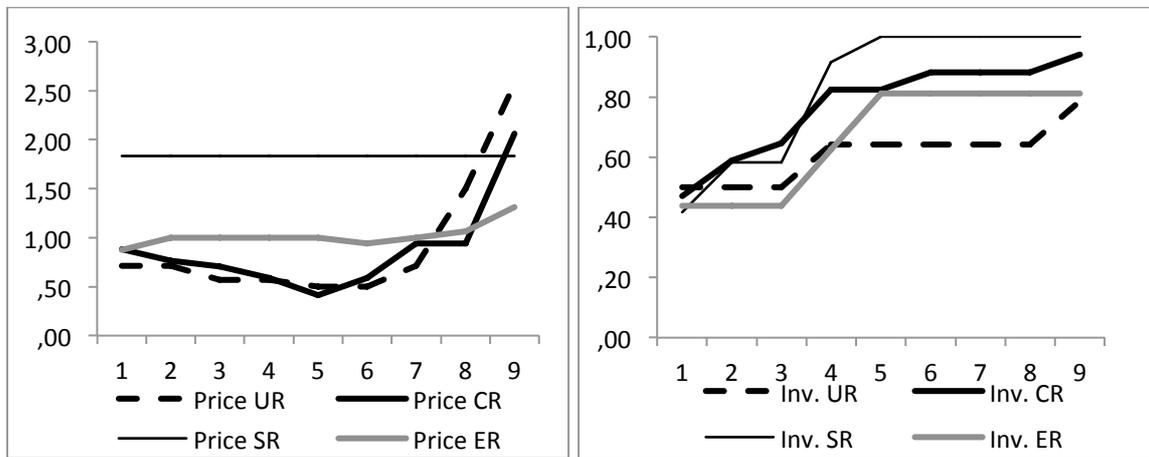
The figure shows that prices are much higher (from the beginning) when the price determiners and the investor share common interests. Apparently, electoral competition for office is insufficient to bring prices down to the levels observed in the other two treatments. When price determiners have interests that are aligned with those of the consumers, prices start off low and remain so across the nine periods. Interestingly, a very similar pattern is observed when their interests are independent. Here, electoral competition does keep prices in line with the consumers' wishes (and the SPE).

These price dynamics are only partly reflected in the investors' decisions. When they know that the DMs share their interests, in [IA], almost 50% invest already in period 1 and all have invested by period 5. Recall that investing in periods 1-3 is never efficient (because with the efficient price the demand can be met with the constrained capacity). Investment in period 4 is optimal for the investor if prices are expected to stay at 1 or above. The jump in the fraction of investment from 50% in period 3 to 89% in period 4 seems to indicate that investors expect such prices in treatments [IA]. In treatments [CA], investors invest at relatively low rates early on (starting at 32%), but the rate gradually increases to 79%.

Interestingly, there is a strong increase in investments between periods 3 and 6 (from 42% to 74%) that does not seem to be justified by changes in prices. Apparently, our investor subjects insufficiently take into account the fact that price determiners have no reason to increase prices once investments have taken place.<sup>21</sup> Finally, the treatment with independent price determiners [N] shows that 59% of the investors invest already in period 1. If they do so expecting high prices, they are disappointed as mostly the prices remain close to 0. As a consequence, the subsequent increase in investment is limited.

Figure 3 shows the dynamics of the same two variables, now distinguishing across the second treatment variation, i.e., types of regulation.

**Figure 3: Investments and Prices by Regulation**



*Notes.* The left panel shows the average price (vertical axis) per period (horizontal axis). The right panel shows the fraction of groups in which investment ('Inv.') has occurred (vertical axis) for each period (horizontal axis). Inv.=Investment; [UR]=Unstable Regulation (prices freely chosen each period); [CR]: Costly Regulation (prices changed at a cost); [SR]: Stable Regulation (prices fixed in period 1); [ER]: Endogenous Regulation (price determiner chooses whether or not to fix the price).

At first sight, differences across regulation types are smaller than across alignments.<sup>22</sup> The treatment that stands out is [SR], where prices are chosen and fixed, in period 1. This yields the highest prices and the maximum investment rate from period 5 onward. Furthermore, prices in UR and CR show only small differences. This means that the costs related to changing the price from one period to the next (0 in UR and 20% of earnings in CR) have little effect on the price. Nevertheless, IOs seem to invest slightly earlier when it is costly to

<sup>21</sup> Perhaps experienced real-world investors will be less prone to such unjustified optimism about future prices. As mentioned above, we therefore prefer to look at cross-treatment differences. In this respect it is to be expected that investments are lowest in the CA treatments.

<sup>22</sup> Below, we provide statistical tests of differences across treatments.

change regulation. Finally, average prices are quite stable when the price determiner can choose to fix them (ER). This yields investments that almost double from 44% to 81% between periods 3 and 5. Below, we investigate in more detail how our subjects choose to fix the price.

Finally, note an end effect in some treatments, seen in figures 2 and 3 in the last periods. For this reason, we will present some results based on the first six periods only, excluding the end-game effects. Of course, the number of electoral periods outside of the laboratory is typically unlimited.

### Combined treatment effects

Next, we consider combinations of the two treatment variations. Table 4 presents an overview of some key statistics.

**Table 4: General Overview of the Results**

|       | CA                                       | IA                                       | N  | Total                                    |
|-------|--|--|--|--|
| UR    | P9=0.09<br>P6=0.07<br>I6=3.60<br>E9=0.84 | P9=2.11<br>P6=1.50<br>I6=1.20<br>E9=0.95 | P9=0.50<br>P6=0.13<br>I6=3.00<br>E9=0.87 | P9=0.93<br>P6=0.60<br>I6=2.58<br>E9=0.89 |
| CR    | P9=0.31<br>P6=0.30<br>I6=1.80<br>E9=0.99 | P9=2.64<br>P6=2.13<br>I6=1.50<br>E9=0.93 | P9=0.35<br>P6=0.15<br>I6=1.86<br>E9=0.93 | P9=0.93<br>P6=0.66<br>I6=1.74<br>E9=0.95 |
| SR    | P9=0.50<br>P6=0.50<br>I6=2.52<br>E9=1.00 | P9=4.25<br>P6=4.25<br>I6=1.26<br>E9=0.86 | P9=0.75<br>P6=0.75<br>I6=0.78<br>E9=1.00 | P9=1.83<br>P6=1.83<br>I6=1.50<br>E9=0.95 |
| ER    | P9=0.36<br>P6=0.33<br>I6=3.18<br>E9=0.88 | P9=2.44<br>P6=2.33<br>I6=2.58<br>E9=0.95 | P9=0.39<br>P6=0.36<br>I6=1.68<br>E9=0.95 | P9=1.32<br>P6=0.97<br>I6=2.46<br>E9=0.93 |
| Total | P9=0.30<br>P6=0.29<br>I6=2.76<br>E9=0.92 | P9=2.80<br>P6=2.48<br>I6=1.68<br>E9=0.93 | P9=0.46<br>P6=0.31<br>I6=1.80<br>E9=0.94 | P9=1.22<br>P6=0.97<br>I6=2.10<br>E9=0.93 |

*Notes.* P9=average price across all 9 periods; P6=average price periods 1-6; I6=average number of periods without investment, periods 1-6; E9= average efficiency across all 9 periods (defined as the realized surplus divided by the surplus in the efficient case of Table 3). [UR]=Unstable Regulation (prices freely chosen each period); [CR]: Costly Regulation (prices changed at a cost); [SR]: Stable Regulation (prices fixed in period 1); [ER]: Endogenous Regulation (price determiner chooses whether or not to fix the price). ; [CA]= the price determiners' interests are aligned with the consumers' interests; [IA]= the price determiners' interests are aligned with the Investor's interests; [N]= the price determiners have independent interests.

First, consider average prices. Note that the end effect observed in Figures 2 and 3 does not seem to have qualitative consequences for the comparisons across treatments (treatment effects for P6 are very similar to those for P9). Nevertheless, to avoid possible confounds with such an end effect we base our statistical analyses on the first six periods, by investigating cross-treatment differences in the variable P6.<sup>23</sup> These (average) prices differ significantly across the three DM alignment categories (Kruskal Wallis –henceforth, KW–;  $n=59$ ;  $p<0.01$ )<sup>24</sup>. Considering each of the regulation treatments separately shows that alignment has a significant effect on prices in each.<sup>25</sup> Hence, DMs’ alignment affects prices, irrespective of the regulatory environment. Price differences across the regulation treatments are not significant (KW;  $n=59$ ;  $p=0.19$ ). There are differences across alignments, however. Whereas regulation does not matter (statistically) when DMs are aligned with consumers (KW;  $n=19$ ;  $p=0.79$ ), nor with independent DMs (KW;  $n=22$ ;  $p=0.19$ ), IA-aligned DMs do respond differently to distinct forms of regulation (KW;  $n=18$ ;  $p<0.01$ ). Specifically, DMs who share interests with the investor choose much higher prices (on average 4.25) when they must fix the price in the first period (SR). The average price decreases as changes in regulation become easier (2.33 in ER; 2.13 in CR; and 1.50 in UR). Note that this effect cannot straightforwardly be attributed to differences in electoral competition. In all regulation treatments, a DM needs to be elected to make money. Hence, a DM that chooses a high price in period 1 of UR may be subject to punishment (by way of not being elected) by the consumers in subsequent periods (we discuss observed voter behavior below). This result does show that when political decision makers have interests that are aligned with those of the provider of an infrastructure, inflexible price regulation may have consequences opposite to those that were intended by the regulation in the first place (i.e., it yields high instead of low prices).

Next, consider the investment decision, i.e., the average number of periods (out of six) in which no investment is observed (I6). Here, the differences across alignment conditions are statistically insignificant (KW;  $n=59$ ;  $p=0.26$ ), as are differences across alignment for each regulation treatment separately.<sup>26</sup> Similarly, we observe that distinct frameworks do not affect investment, neither for all preference alignments in aggregate (KW;  $n=59$ ;  $p=0.79$ ) nor for

---

<sup>23</sup> Note that this provides a conservative approach. Differences are larger for P9.

<sup>24</sup> In our statistical testing, we use the (statistically) independent group as the unit of observation.

<sup>25</sup> UR: KW;  $n=14$ ;  $p<0.01$ ; CR: KW;  $n=17$ ;  $p<0.01$ ; SR: KW;  $n=12$ ;  $p=0.02$ ; ER: Mann Whitney (MW);  $n=16$ ;  $p<0.01$ .

<sup>26</sup> UR: KW;  $n=14$ ;  $p=0.44$ ; CR: KW;  $n=17$ ;  $p=0.98$ ; SR: KW;  $n=12$ ;  $p=0.22$ ; ER: MW;  $n=16$ ;  $p=0.58$ .

any specific alignment.<sup>27</sup> We will show below, however, that the lack of significance stems from inefficient (irrational) first-period investments.

We next investigate treatment differences in efficiency. We do so with data from all nine periods, because surplus consequences of early-period decisions are most severe in the final three periods. We again start with the effects of DMs' alignment. Across all types of regulation, alignment matters, in a statistical sense (KW;  $n=59$ ;  $p=0.02$ ). In general, efficiency is slightly lower when DMs share interests with the consumers.<sup>28</sup> For UR (KW;  $n=14$ ;  $p=0.94$ ), CR (KW;  $n=17$ ;  $p=0.28$ ) and ER (MW;  $n=16$ ;  $p=0.51$ ) there are no significantly different effects of alignment, however. In SR, efficiency is much *lower* when DMs share interests with the IOs, because they set inefficiently high prices. This effect is significant (KW;  $n=12$ ;  $p=0.02$ ). Turning to the efficiency effects of variations in the type of regulation, in aggregate there are no statistically significant effects (KW;  $n=59$ ;  $p=0.47$ ). Differences are also insignificant for consumer-aligned DMs (KW;  $n=19$ ;  $p=0.51$ ) and non-aligned DMs (KW;  $n=22$ ;  $p=0.45$ ). When considering only investor-aligned DMs, the difference in efficiency for distinct types of regulation is highly significant, however (KW;  $n=18$ ;  $p<0.01$ ). Again this may be attributed to the case of IA-aligned DMs in SR, where the inflexible nature of the price regulation yields high prices.

All in all, the outcome in terms of prices and efficiency depend on both treatment dimensions. The treatment that appears to be most detrimental for consumer prices and efficiency is where decision makers' interests align with investor and regulation forces them to decide on a fixed price in the first period, thus taking away any chance that future electoral competition will put a downward pressure on prices.<sup>29</sup> In contrast, when DMs interests align with those of the consumers, the type of regulation has little effect on the prices chosen by the decision maker: these are typically low. As a consequence, investment then tends to be postponed, but not abandoned. This gives rise to outcomes with negative yields for the investors.

### **A subsample conditioning on period 1 behavior**

One noticeable result in our data is the large number of investors that invest in the first period (45.8% of the IOs do so; cf. figures 2 and 3). Recall that this implies making an irreversible

---

<sup>27</sup>CA: KW,  $N=19$ ;  $p=0.72$ ); IA: (KW;  $N=18$ ;  $p=0.54$ ); N: (KW;  $N=22$ ;  $p=0.74$ ).

<sup>28</sup>Note from Table 4 that differences are small, however, i.e., between 0.92 for CA and 0.94 for N.

<sup>29</sup>Note that the efficiency in the (UR, CA) cell is even lower, but the difference is not significant in the row-wise and column-wise comparisons.

decision before having observed any behavior (or any cheap talk) from the other participants. The decision to invest in period 1 is statistically independent of the type of regulation (KW;  $n=59$ ;  $p=0.98$ ) and alignment (KW;  $n=59$ ;  $p=0.22$ ). Because investment in period 1 is never profitable (IO's earnings are higher if she does not invest in period 1), we consider the possibility that these are caused by inexperienced investors making errors.<sup>30</sup> Hence, we tested for treatment effects in investment decisions by IOs, conditional on them not having invested in period 1.

First, consider the effect of alignment. The average value of  $I_6$  (number of periods without investment) is 4.08, 3.00, and 4.44, for CA, IA and N, respectively (recall that for prices – guaranteed to be – equal to 1, a money maximizing IO will invest in period 4, i.e.,  $I_6=3$ ). Hence, conditional on not investing in period 1, the first period in which IOs invest is on average sooner when the DMs' preferences are aligned with their own. The difference across the three alignment treatments are statistically insignificant (KW;  $n=32$ ;  $p=0.17$ ), but the difference between IA and non-IA is weakly significant (Mann-Whitney –henceforth, MW–;  $n=32$ ;  $p=0.08$ ).

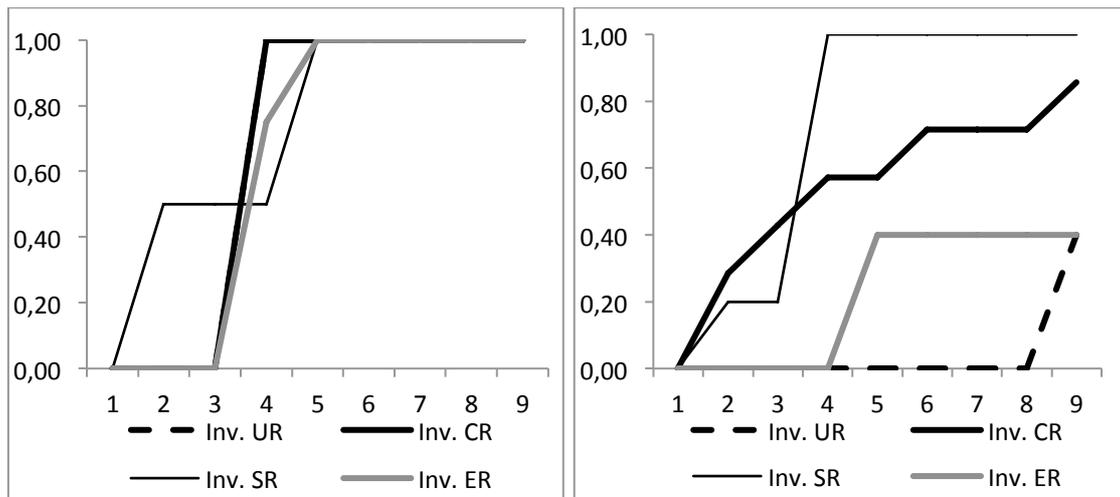
As for differences across regulation treatments in this subsample, the number of periods without investment is on average 5.16, 3.36, 2.58, 4.43, for UR, CR, SR, and ER, respectively. This shows that IOs who do not invest in the first period of the unstable regulation treatment, understand the diverging effects of regulation on prices and on average postpone investments until after the 5<sup>th</sup> period (of the 6 periods under investigation). The differences across regulation treatments are statistically significant (KW;  $n=32$ ;  $p=0.03$ ).

To illustrate investment behavior by this subgroup, figure 4 shows average investment per period for each type of regulation. It does so separately for the cases where the DMs' interests are aligned with IA's and the cases where it is not (CA and N). Note that for IA (left panel) the different types of regulation yield only minor differences in investment patterns, whereas investments strongly depend on regulation for alignments CA and N. The differences for IA are statistically insignificant (KW;  $n=10$ ;  $p=0.93$ ), those for the combination of CA and N are strongly significant (KW;  $n=22$ ;  $p<0.01$ ). As long as IOs and DMs share interests, investment will take place near the optimal period. When their interests

---

<sup>30</sup> Alternatively, IOs may invest in the (mistaken) expectation that this will be reciprocated by DMs choosing high prices. This too, may be considered as a kind of error.

**Figure 4: Investments versus Regulation; if not Invested in Period 1**



*Notes.* The figure shows the fraction of groups in which investment has occurred (vertical axis) for each period (horizontal axis), for those IOs who have not invested in period 1. The left panel (n=10) shows investments for IA (DMs' preferences are aligned with IOs); the right panel (n=22) combines investments for CA (DMs' preferences aligned with CVs') and N (independent preferences for DMs). In the left panel, the line for UR is not visible because it coincides with CR. Inv.=Investment; [UR]=Unstable Regulation (prices freely chosen each period); [CR]: Costly Regulation (prices changed at a cost); [SR]: Stable Regulation (prices fixed in period 1); [ER]: Endogenous Regulation (price determiner chooses whether or not to fix the price).

differ such optimal investment is only observed when prices can be fixed across future elections (as in SR). Full investments are also observed (but often too late) when price changing is costly. In ER investment is not complete because electoral competition induces many DMs to fix the price to 0, making investment unprofitable.

### Voting Behavior

When deciding on which DM to vote for, a consumer can use either the DM's previous price choice, her announced price in the current period or both. To analyze this decision, we will distinguish between first and later period votes. For the latter, we will investigate the extent to which voters weigh currently promised prices versus previously chosen prices by the DMs.

Table 5 first shows the results of a probit model explaining the probability that a consumer will vote for DM2 as opposed to DM1.<sup>31</sup> The results show that prior investment and period number have no effect on the decision on which DM to support. This is as expected, because neither of these variables *per se* is informative about either DM. How the DMs' proposals are

<sup>31</sup> Random effects are introduced at the group level in order to correct for interdependencies across the three consumers in a group.

**Table 5: Consumers' Voting**

|                           | All Treatments  |                  |
|---------------------------|-----------------|------------------|
|                           | Period 1        | Period 2-9       |
| period                    | ---             | -0.003 (0.01)    |
| Invested                  | 0.090 (0.08)    | -0.016 (0.05)    |
| $\Delta$ proposal DM1-DM2 | 0.290 (0.05)*** | 0.136 (0.03)***  |
| $\Delta$ proposal DM1-IO  | 0.053 (0.03)    | -0.015 (0.01)    |
| LastPequal                | ---             | -0.034 (0.05)    |
| LastP2higher              | ---             | -0.229 (0.06)*** |
| LastP2lower               | ---             | 0.263 (0.07)***  |
| n                         | 177             | 1416             |

*Notes.* The table presents the results of a probit model with robust standard errors clustered at the group level. The binary dependent variable is 1(0) if the voter voted for DM2 (DM1). It gives the estimated marginal effects of variations in the dependent variables. Standard deviations are in parentheses. 'Period' denotes the period number; 'Invested' = 1(0) if there was investment in period  $s \leq t$ ; ' $\Delta$ proposal DM1-DM2' is the difference in proposed price between DM1 and DM2; ' $\Delta$ proposal DM1-IO' is the difference between DM1's proposal and IO's proposal; 'LastPequal' = 1(0) if both DMs have determined a price in a previous period and the most recent prices chosen are (un)equal; 'LastP2higher' = 1(0) if both DMs have determined a price in a previous period and the most recent prices chosen by DM2 is (not) higher; 'LastP2lower' = 1(0) if both DMs have determined a price in a previous period and the most recent prices chosen by DM2 is (not) lower. For the latter three variables, prices of 2 or higher are considered to be equal.

\* (\*\*/\*\*\* ) denotes statistical significance at the 10% (5%/1%)-level.

relative to the price suggested by the investor has no significant effect either; the investor's proposed price appears to be considered irrelevant. DMs' proposals matter in all periods, however. In period 1, when no other information is available to the consumer to distinguish between the two DMs, a unit increase in the difference in proposed price by DM1 and DM2 increases the probability of a vote for DM2 by 29%-points.<sup>32</sup> The effect of differences in promised prices reduces to 14%-points in later periods, where consumers have information about what the DMs had actually chosen after having been elected in a previous period.<sup>33</sup> Differences in actual choices matter: having previously chosen a higher price than DM1 decreases DM2's chances of election by 23%-points, whereas a previous lower price than DM1 increases it by 26%-points. Note that this effect is similar in size to that of differences in proposals in period 1, when consumers do not yet have information about actually chosen prices. Note also that these effects are symmetric and larger than the estimated effect of the

<sup>32</sup> These marginal effects are determined at the mean values of the independent variables. They are not constant. Hence, this estimated value should not be taken to imply that large differences in proposed prices would yield percentage point differences of more than 100%.

<sup>33</sup> The benchmark for the three dummy variables related to actual previous choices is the situation where one of the DMs has not yet been elected in an earlier period.

DMs' proposals in the current period. Finally, as expected, previous price choices by the DMs have no effect on the consumers' choices if they were equal.

All in all, the CVs in our experiment tend to vote 'rationally'. They care only about the DMs' prices and substitute information about actual price choices for cheap talk proposals when the former is available. Nevertheless, proposals do still have an effect, even when the consumers know what the DMs actually did in earlier periods.

Next, we consider whether CVs take into account the DMs interest in the prices. Table 6 shows the probit results for each alignment separately.

**Table 6: Consumers' Voting per Alignment**

|                           | Period 1        |                  |                 |
|---------------------------|-----------------|------------------|-----------------|
|                           | CA              | IA               | N               |
| Invested                  | 0.204 (0.16)    | 0.169 (0.13)     | -0.050 (0.16)   |
| $\Delta$ proposal DM1-DM2 | 0.296 (0.07)*** | 0.230 (0.07)***  | 0.426 (0.11)*** |
| $\Delta$ proposal DM-IO   | -0.024 (0.05)   | 0.030 (0.11)     | 0.093 (0.08)    |
| N                         | 57              | 54               | 66              |
| Periods 2-9               |                 |                  |                 |
| Period                    | 0.001 (0.01)    | 0.012 (0.02)     | -0.017 (0.01)   |
| Invested                  | -0.0324 (0.06)  | 0.038 (0.08)     | -0.065 (0.08)   |
| $\Delta$ proposal DM1-DM2 | 0.263 (0.06)*** | 0.057 (0.04)     | 0.215 (0.09)*** |
| $\Delta$ proposal DM1-IO  | -0.028 (0.02)   | 0.018 (0.02)     | -0.013 (0.01)   |
| LastPequal                | -0.010 (0.07)   | -0.033 (0.10)    | -0.066 (0.06)   |
| LastP2higher              | -0.188 (0.13)   | -0.245 (0.09)*** | -0.135 (0.10)   |
| LastP2lower               | 0.094 (0.07)    | 0.118 (0.10)     | 0.325 (0.08)*** |
| n                         | 456             | 432              | 528             |

*Notes.* The regression model and independent variables are described in the note to Table 5. CA=Consumer-aligned DMs; IA=Investor-aligned DMs; N=Neutral DMs.

\* (\*\*/\*\*\*) denotes statistical significance at the 10% (5%/1%)-level.

Consider first the votes in period 1. As in the aggregate case, only the difference in proposed prices by the two DMs significantly affects the vote, with the lower price proposal yielding more votes. The marginal effects differ strongly, however. For IA, this effect is three-quarters of what it is for CA and just over half of what it is for N. Apparently, the consumers realize that the DMs in IA have an incentive to set high prices, and therefore trust the proposals less than in the other treatments, even though these proposals are all they have to base their decisions on in period 1. For each alignment, the marginal effects of these differences in proposals decrease in later periods, when the DMs build a price setting reputation. For IA, differences in proposed prices no longer significantly affect the probability of being elected.

Instead, voters rely more on the DMs' actual previous choices. This does not hold for CA and N, where promises have a strong effect, even when evidence of past behavior is available. Note, however, that statistical power for the effects of actual relative previous choices is low for some of the significance tests. This is because DMs often agree on what price to choose. As a consequence, for CA we have only eight observations where the most recent price chosen by DM1 is larger than that chosen by DM2 (i.e.,  $LastP2_{lower} = 1$ ). Similarly, in N we have only six observations where  $LastP2_{higher}=1$ ). Taking this into account, we can draw only tentative conclusions from the tests that do have sufficient power.

All in all, the disaggregated analysis of Table 6 confirms that consumers tend to vote rationally in our experiments. They take into account that DMs interests are likely to affect the prices to be chosen and adjust the weight they attach to promises and previous prices accordingly.

### **Testing the Hypotheses**

We finalize the presentation of the results by formally testing the hypotheses presented in Section 3. We will repeat each hypothesis and present analysis by statistical tests.

H1. *Investment will happen earlier in treatments that permit fixing the regulated price (SR and ER) than in treatments where the price cannot be fixed (UR and CR).*

Formally, we test whether we can reject the null of no difference in investment period in favor of H1. On average, investment occurs after 2.34 periods in SR/ER and 2.70 periods in UR/CR. To test the hypothesis, we need to correct for the fact that the decision to invest only needs to be made if investment has not previously taken place. We therefore ran a probit regression with robust standard errors (clustered at the investor level) explaining any decision to invest when there was no previous investment (i.e., disregarding all periods after investment). The explanatory variables include a dummy for the first period (which yields a positive and highly significant coefficient; this reflects the fact that many IOs invest immediately, irrespective of the treatment). The other explanatory variables are the period number; a dummy representing the SR and ER treatments; and an interaction of period with this dummy. None of these explanatory variables yields a statistically significant result. The reason becomes clear from table 4 and figure 4: investments take place early in SR, but not in ER. We therefore ran a similar probit regression, replacing the SR-and-ER dummy by one

that distinguishes only the SR treatment. Now the interaction between period and SR is significantly positive at the 1% level (a marginal effect of 0.17,  $p < 0.01$ ), indicating that as rounds progress in SR, it becomes more likely that IO will invest. In contrast the effect of round is much smaller and insignificant for the other treatments (a marginal effect of 0.01,  $p = 0.58$ ). Hence, investment is estimated to occur significantly earlier in SR than in the other regulation treatments.<sup>34</sup>

H2. *Prices will be higher in treatments that permit fixing the regulated price (SR and ER) than in treatments where the price cannot be fixed (UR and CR).*

With an average of 1.37, prices are indeed higher in ER and SR than in UR and CR, where on average they are 0.90. Testing against the null of no difference, the observed difference is not significant using a nonparametric test (MW;  $n = 59$ ;  $p = 0.34$ ). Again, this may be related to behavior in ER that is different than predicted. As noted in the discussion following table 4, average prices depend strongly on the regulation treatment when interests of IOs and DMs are aligned. Considering only IA, we find that prices are much higher in SR (4.25) than in the other treatments (2.38). This difference is highly significant (MW;  $n = 18$ ;  $p < 0.01$ ).

H3. *Except in the final period, the DMs' preferences do not affect investment or prices. In the final period the prices will be higher when the DMs' interests are aligned with those of the investor [IA] and the prices cannot be fixed (treatments [UR] and [CR]).*

The discussions on Table 4 provide evidence against the first part of this hypothesis. They show that the DMs' preferences do matter. In particular, alignment with the IO yields higher prices and earlier investment (especially for the subgroup that does not invest in period 1). Though the DMs are rewarded by consumers for suggesting and choosing lower prices, this turns out to be insufficient to create an electoral competition that lowers prices to the levels observed in the other treatments. In period 9, average prices in the treatments [IA+UR] and [IA+CR] are always equal to 5. The average price in other treatments is 1.38. The difference is statistically significant (MW;  $n = 59$ ;  $p < 0.01$ ). This provides support for the second part of the hypothesis.

---

<sup>34</sup> The estimated marginal effect for the SR dummy is  $-0.19$ , n.s.). Hence, from period 2 onward, IOs in SR are estimated to be more likely to invest ( $-0.19 + 2 * 0.17 = 0.32 > 2 * 0.01$ ).

H4: *Voters are less likely to vote to reelect the incumbent after she previously chose a price of 2 or more than after a lower price. In UR and CR, voters are less likely to vote to reelect the incumbent after she previously chose a price of 1 than after a price of 0.*

The analysis provided above shows that voters respond to price differences between the two DMs and thus show evidence of rational voter behavior. Neither of these two specific hypothesis finds support, however. Using probit analysis (with the robust standard errors at the group level) to explain voting for the incumbent, a dummy variable denoting prices of 2 or higher yields statistically insignificant coefficients in various specifications. Similarly, for UR and CR a dummy variable for prices 1 (instead of 0) also yields only insignificant coefficients). Our earlier analysis of voter behavior reveals that voters may be slightly more rational than is assumed in this hypothesis. They not only consider the incumbent's most recent choices, but also the most recent choices of the other DM, when she had last been in office.

## **5. Conclusions**

Large infrastructure is often owned by private investors with the right to charge usage fees. In industries such as power or gas delivery the transmission networks represent natural monopolies where price regulation is necessary for efficiency. Periodic upgrades to the transmission infrastructure may, however, require significant irreversible investment with long-term return spanning several decades. Investors thus face uncertainty in their return in many dimensions: from highly unpredictable shifts in future demand to shifts in technology. In this paper we investigate a particular type of uncertainty, arising from unpredictable changes in price regulation when regulators are subject to electoral competition.

A model of investment in markets where regulation is subject to varying degrees of political manipulation confirms that independent regulation may be needed for efficient investment decisions. If voters cannot affect prices through their elected decision-makers then, in theory, investment will be relatively timely. On the other hand, if regulation cannot be separated from electoral dynamics, then investment may never occur, as investors expect that electoral competition will drive prices unsustainably low.

We complement our formal analysis with the empirical evidence from a laboratory experiment with human subjects. The predictions are only partially confirmed by the data. On average the infrastructure owners indeed delay investment if regulation is separated from

electoral dynamics, but the aggregate effect on resulting prices is marginal. We observe a much stronger effect of decision makers' private preferences. When decision makers' interests align with those of investors the prices remain far above the efficient levels, in particular when independent regulation eliminates the effects of electoral competition. Such high prices decrease general efficiency even with the early investment they induce. Here, the failure of electoral pressure to reduce high prices appears to be the main detriment of efficiency.

Our results thus highlight the limits of the intuition that an independent regulatory is beneficial for the consumers. This intuition only holds when regulation policy is designed with the interests of the consumers in mind. However, if the political interests align with infrastructure operators, a flexible regulatory may be more efficient.

## References

- Banks, J., & Duggan, J. (2006): "A General Bargaining Model of Legislative Policy-making", *Quarterly Journal of Political Science*, 1, 49-85.
- Brandts, J., P. Pezanis-Christou and A. Schram (2008): "Competition with Forward Contracts: A Laboratory Analysis Motivated by Electricity Market Design", *The Economic Journal*, 118, 192-214
- Brandts, J., S. Reynolds and A. Schram (2012): "Pivotal Suppliers and Market Power in Experimental Supply Function Competition", *The Economic Journal* (in press).
- Brunner, Ch., J.K. Goeree, Ch. A. Holt, and J. O. Ledyard (2010): "An Experimental Test of Flexible Combinatorial Spectrum Auction Formats", *American Economic Journal: Microeconomics* 2010, 2:1, 39-57.
- Campillo, J., F. Wallin, and E. Dahlquist (2012): "Electricity Demand Impact from Increased use of Ground Sourced Heat Pumps", paper presented at the 3<sup>rd</sup> IEEE Innovative Smart Grid Technologies Europe, Berlin.
- Cox, J., T. Offerman, M. Olson and A. Schram, "Competition for vs on the Rails, a Laboratory Experiment", *International Economic Review* 43, 2002, 709-735.
- Cambini, C. and L. Rondi (2012): "Incentive Regulation and Investment: Evidence from European Energy Utilities", *Journal of Regulatory Economics* 38:1-26.
- Cremer, H. J. Crémer, and P. de Donder (2006): "Legal vs. Ownership Unbundling in Network Industries," CEPR Discussion paper 5767.
- Égert, B. (2009) : "Infrastructure investment in network industries ; the role of incentive regulation and regulatory independence,": CESifo working paper, No. 2642.
- Enikolopov, R. (2012): "Politicians, Bureaucrats and Targeted Redistribution", working paper, available at SSRN: <http://dx.doi.org/10.2139/ssrn.945274>.
- Henze, B., Ch. Noussair, and B. Willems (2012): "Regulation of Network Infrastructure Investments: An Experimental Evaluation," *Journal of Regulatory Economics* 42:1-38.
- Kessides (2004): "Reforming Infrastructure: Privatization, Regulation, and Competition", World Bank report.
- Falk, A. and J. Heckman(2009), "Lab Experiments Are a major Source of Knowledge in the Social Sciences," *Science* 326:535-538.

- Gans J. and S. King (2003): “Access Holidays for Network Infrastructure Investment,” *Agenda* 10, 163-178.
- Gans J. and S. King (2003): “Access Holidays and the Timing of Infrastructure Investment,” *Economic Record* 80:89-100.
- Klein, M. and Ph. Gray (1997), “Competition in Network Industries – Where and How to Introduce it,” *Public Policy for the Private Sector Note* 104, World Bank.
- Nagel, T. and M. Rammerstorfer (2008): “Price Cap Regulation and Investment Behavior – How Real Options Can Explain Underinvestment,” *Journal of Energy Markets* 1: 23-45.
- Normann, H.-T. and Ricciuti, R. (2009): “Laboratory Experiments for Economic Policy Making,” *Journal of Economic Surveys* 23: 407–432
- Ponti, M. and S. Erba (2002), “Railway Liberalization from a “Public Choice” Perspective,” *Quarterly Journal of Transport Law, Economics and Engineering* VII (20-21): 38-46.
- Rassenti, S., V. Smith and B. Wilson (2002): “Using experiments to Inform the Privatization/Deregulation Movement in Electricity”, *The Cato Journal*, 22, 3, winter 2002.
- Staropoli C. and C. Jullien (2006): “Using Laboratory Experiments to Design Efficient Market Institutions: The Case of Wholesale Electricity Markets,” *Annals of Public and Cooperative Economics*, 77, 4, 555-577.
- Vliet, O. van, A. Brouwer, T. Kuramochi, M. van den Broek, and A. Faaij (2011): “Energy Use, Cost and CO<sub>2</sub> Emissions of Electric Cars,” *Journal of Power Sources* 196/4: 2298-2310.
- Vogelsang, I. (2010): “Incentive regulation, investments and technological change,” CESifo working paper, no. 2964.

## Appendix A

This appendix contains the analysis for the model described in section 2. We first determine the optimal pricing for each agent when the demand is fixed and game played just once, both with and without investment. We then determine the optimal investment behavior, again from the perspective of the different agents. We denote the payoffs that the IO and a CV maximize respectively by  $\pi^I$  and  $\pi^V$ .

We measure efficiency with the sum of the IO's all CVs' profits  $\pi^I + n\pi^V$ , that is, with the total surplus from service consumption. Given linear demand and zero marginal costs of IO's service, this is maximized when  $P = 0$ . Investment is then socially efficient when the benefits from additional service consumption it enables exceed its costs. Let  $P^{cst}$  be the price where demand equals capacity constraint  $Q(P^{cst}) = Q^{cst}$ ;  $P^{cst} = P^{max} - Q^{cst}/nb$ . Investment is therefore efficient when  $(Q(0) - Q^{cst})P^{cst}/2 > c$ . Rewriting this yields the following relation between demand parameters and investment efficiency:

$$P^{max}(nbP^{max} - Q^{cst}) > 2c$$

### 1. Pricing with investment

The IO can provide any quantity of service (electricity) but incurs cost  $c$ . If it chooses a price  $P \in [0, P^{max}]$  and delivers quantity  $Q(P) = nb(P^{max} - P)$ , it obtains profit  $\pi^I(P) = PQ(P) - c = nbP(P^{max} - P) - c$ . This yields a surplus  $\pi^V(P) = b(P^{max} - P)^2/2$  to any CV.

- The IO maximizes its profit with the monopoly price  $P^* = P^{max}/2$ , found through  $Q^* = nbP^{max}/2$  and  $P^* = P^{max} - Q^*/nb$ . This yields it the monopoly profit  $\pi^{I*} = P^*Q^* = nb(P^{max})^2/4 - c$ . It also yields a surplus  $\pi^{V*} = b(P^{max})^2/8$  to each CV.
- The regulated IO will choose price  $P = \min\{P^*, P^{reg}\}$  and earn  $\pi^I = PQ(P) - c$ , yielding  $\pi^V = b(P^{max} - P^{reg})^2/2$  to a CV. The CV, however, maximizes its surplus when  $P^{reg} = 0$ , with  $\pi^{Vo} = b(P^{max})^2/2$ . This yields a loss  $\pi^{Io} = -c$  to the IO.
- The IO has zero profit when  $PQ(P) = c$ , that is, when  $P = (P^{max} - \sqrt{(P^{max})^2 - 4c/nb})/2$ . We can determine other solutions for the IO, e.g. if it pays a tax or if its profit has an upper bound or if its profit per unit has an upper bound etc.

The interests of the three parties may be in conflict. If the  $DM^E$  wants to appease the voters it might choose to regulate a low price that yields the IO a loss. The monopoly price increases only with  $P^{max}$ .

### 2. Pricing without investment

In absence of investment the IO provides at most  $Q^{cst}$  units of service (electricity). If it chooses a price  $P \in [0, P^{max}]$  and delivers quantity  $Q(P) = \min\{nb(P^{max} - P), Q^{cst}\}$  it obtains profit  $\pi^I(P) = \min\{nbP(P^{max} - P), PQ^{cst}\}$ .

- If  $P < P^{\max} - Q^{\text{cst}}/nb$  the demand exceeds the max possible supply  $Q^{\text{cst}}$ . In this case it would have been better for the CVs (but not necessarily for IO or the efficiency) if IO invests.
- An unregulated IO chooses  $P^*$  when this leads to a demand below capacity constraint. The capacity constraint is an issue only when  $Q^{\text{cst}} < Q^*$ . In this case IO would set the price  $P = P^{\max} - Q^{\text{cst}}/nb$ , above the monopoly price  $P^*$  it would set had it invested. The IO's profit is then  $\pi^I(P) = Q^{\text{cst}}(P^{\max} - Q^{\text{cst}}/nb)$  and the CVs' profit is  $\pi^V(P) = (Q^{\text{cst}})^2/2nb$ . In general, therefore, IO will set  $P = \max\{P^*, P^{\max} - Q^{\text{cst}}/nb\}$ .
- If regulated the IO will choose the price  $P = \min\{P^{\text{reg}}, \max\{P^*, P^{\max} - Q^{\text{cst}}/nb\}\}$ . Again, the CV maximizes its surplus when  $P^{\text{reg}} = 0$ .

### 3. When is investment rational or efficient?

The unregulated IO invests when the demand is sufficiently high (exceeding the capacity constraint even with monopoly price  $P^*$ ). However, if IO is regulated, it might not invest even with sufficiently high demand, if the price is regulated so low that it becomes unprofitable for the monopolist to incur cost  $c$ .

For an unregulated IO the investment is profitable whenever the capacity constraint is binding and the monopoly profit after investment exceeds the monopoly profit without it. This is when  $Q^{\text{cst}} < nbP^{\max}/2$  and  $nb(P^{\max})^2/4 - c > Q^{\text{cst}}(P^{\max} - Q^{\text{cst}}/nb)$ , which implies (2).

When will a regulated monopolist invest? Say that the IO is regulated to charge price at most  $P^{\text{reg}} \in (0, P^*)$  irrespective of its investment. This is then exactly the price it will charge according to the rule above. Is there a  $P^{\max}$  for which it invests? Let the capacity constraint be an issue:  $nb(P^{\max} - P) > Q^{\text{cst}}$ .

- without investment the IO earns  $\pi^I = \min\{nbP^{\text{reg}}(P^{\max} - P^{\text{reg}}), P^{\text{reg}}Q^{\text{cst}}\}$ .

- with investment the IO earns  $\pi^I = nbP^{\text{reg}}(P^{\max} - P^{\text{reg}}) - c$

The investment is profitable for a regulated IO only when the demand sufficiently exceeds capacity:  $P^{\text{reg}}Q^{\text{cst}} < nbP^{\text{reg}}(P^{\max} - P^{\text{reg}}) - c$ , which implies (4).

Given regulation, investment is efficient only when demand exceeds capacity, as otherwise the investment cost is lost. Let this be the case. Investment yields the CVs' the added surplus from extra satisfied demand of  $(Q^{\text{reg}} - Q^{\text{cst}})(P^{\text{cst}} - P^{\text{reg}})/2 = [nb(P^{\max} - P^{\text{reg}}) - Q^{\text{cst}}]^2/2nb$ . The IO earns  $nbP^{\text{reg}}(P^{\max} - P^{\text{reg}}) - c - P^{\text{reg}}Q^{\text{cst}}$ . Together, investment with regulation is efficient when demand exceeds capacity (3) and  $c < [nb(P^{\max} - P^{\text{reg}}) - Q^{\text{cst}}]^2/2nb + nbP^{\text{reg}}(P^{\max} - P^{\text{reg}}) - P^{\text{reg}}Q^{\text{cst}}$ , that is, when

$$c < nb[(P^{\max} - Q^{\text{cst}}/nb)^2 - (P^{\text{reg}})^2]/2. \quad (5)$$

#### 4. When is regulation efficient?

As the IO fails to internalize the CVs' excess surplus from investment, it may invest too late (in the sense that it requires demand to exceed capacity for more than would be efficient).

This may be especially problematic when price is low. In particular, the IO will never invest if it expects the efficient price  $P^{\text{reg}} = 0$ . Which price regulation is therefore efficient, given demand and IO's rational response?

- The regulated IO will invest when (3) and (4). Equation (4) can be set as

$$nb(P^{\text{reg}})^2 + (Q^{\text{cst}} - nbP^{\text{max}})P^{\text{reg}} + c \leq 0 \quad (6)$$

which is solvable for  $P^{\text{reg}}$  only when  $nbP^{\text{max}} > Q^{\text{cst}}$ , that is, when demand (given by  $b$  and  $P^{\text{max}}$ ) is sufficiently high to possibly exceed capacity. In this case it is efficient to choose the lowest possible  $P^{\text{reg}}$  that still satisfies (6), determined by solving the quadratic equation

$$P_r = \frac{1}{2nb} \left( nbP^{\text{max}} - Q^{\text{cst}} - \sqrt{(nbP^{\text{max}} - Q^{\text{cst}})^2 - 4nbc} \right) \quad (7)$$

- For low demand (when  $nbP^{\text{max}} < Q^{\text{cst}}$  or  $(nbP^{\text{max}} - Q^{\text{cst}})^2 < 4nbc$ ), no  $P^{\text{reg}}$  will induce IO to invest and therefore setting  $P^{\text{reg}} = 0$  is efficient. For any higher demand choosing  $P^{\text{reg}}$  according to (7) is efficient.

## Appendix B: Experimental Instructions

What follows is a translation of the (Dutch) instructions for the treatment with investor-aligned decision makers (IA) and endogenous regulation (ER). Instructions for other treatments are very similar and available upon request. Instructions were provided as html pages, which are separated by horizontal lines, below. Subject could read through the instructions at their own pace.

---

p. 1/8

### Welcome

We have reached part 2 of the experiment. Again, the instructions are simple. If you follow them carefully, you may make a lot of money. Your earnings from this part will also be paid out in euros at the end of the experiment. This will be done confidentially, one participant at a time.

Earnings in this part of the experiment are denoted in '**experimental franks**'. At the end of the experiment, the franks will be converted into euros. The exchange rate used for this purpose is **1 euro for 50 franks**.

These instructions consist of 8 pages like this. During the instructions, you can always move forward and back by using the mouse to click the 'next page' or 'previous page' button. In some cases, a page may not fit on your screen. If this is the case, you can use the scroll bar and your mouse to scroll through the page.

[next page](#)

---

p. 2/8

### Rounds, Groups and Types

This part of the experiment consists of **9 rounds**.

For this part you are allocated to **groups of 6 participants**. The group composition remains constant, so you will remain in one group with the same other participants throughout. The composition of the groups is anonymous. You do not know with whom you are in a group. Similarly, others do not know whether you are with them.

In every group there are three different **types of participants**. More precisely, each group consists of **one investor, two price-determiners and three consumers**.

At the beginning of the first round you will get to see which type you are. You will remain **the same type throughout all 9 rounds**.

In each round the investor delivers a product to each of the consumers. Exactly **the same product** is delivered to every consumer. Every consumer **must** buy the product. The price of the product is determined by one of the price determiners.

[previous page](#) [next page](#)

---

p. 3/8

## Round

In general terms, each round proceeds as follows.

The investor first decides whether or not to invest in the production process. An investment cannot be undone. **If the investor invests in a round, then this decision holds in all subsequent rounds.**

Then, the consumers choose a price determiner.

The chosen price determiner then chooses the price for the round. He or she also decides whether this price holds only for the current round, or also for all subsequent rounds.

Below, we will better explain each of these steps. First, we will explain how the **prices and investment lead to earnings** for the different types of participants.

[previous page](#) [next page](#)

---

p. 4/8

## Earnings

The **price determiners will begin** with a **starting capital of 325 francs**.

Additional earnings of the various types depend on

- whether or not investment has taken place;
- the determined price.

In general terms, the following holds:

- Investment is **never disadvantageous to the consumer** and often profitable.
- **Higher prices** are good for the **investor**.
- **Lower prices** are good for the **consumer**.
- The price determiner which **is not chosen** in a round earns **nothing**.
- The price determiner that is **chosen** in a round will earn the same as the **investor** earns in that round.

The earnings in a round can be summarized more precisely in a table. Such tables will appear on your screen in each round. This is what they look like.

| NIET<br>geïnvesteed |                |                   | WEL<br>geïnvesteed |                |                   |
|---------------------|----------------|-------------------|--------------------|----------------|-------------------|
| prijs               | Consu-<br>ment | Inves-<br>teerder | prijs              | Consu-<br>ment | Inves-<br>teerder |
| 0                   | 10,00          | 0,00              | 0                  | 12,00          | -10,00            |
| 1                   | 8,00           | 10,00             | 1                  | 10,00          | 2,00              |
| 2                   | 4,50           | 12,00             | 2                  | 5,00           | 8,00              |
| 3                   | 2,00           | 13,00             | 3                  | 3,00           | 8,00              |
| 4                   | 0,50           | 14,00             | 4                  | 1,00           | 9,00              |
| 5                   | 0,00           | 15,00             | 5                  | 0,50           | 10,00             |

(translation: “Niet geïnvesteed”=no investment; “Wel geïnvesteed”= investment; “prijs”=price; “consument”=consumer; “investeerder”=investor)

These earnings are meant as an example. The numbers in the experiment will be different. Therefore you can deduce nothing about the experiment itself from this example. Remember that the losing price determiner earns nothing in a round and the winning price determiner earns the same as the investor.

This example shows, for example, at price 2 that consumers earn 4.5 francs without investment and 5 francs with investment. At price 2 the investor and the winning price determiner earn 12 with investment and 8 without investment.

**Please note:** the **tables change** from one round to the next. We will hand out the tables for all rounds before the experiment starts.

**Please note:** the **consumer** will **only see the own earnings** and therefore does not know what the earnings of the investor are in various circumstances. Price determiners know the earnings of both the investor and consumers.

[previous page](#) [next page](#)

## Calculation Tool

We can imagine that it is not easy to keep track of all possible earnings at different prices and investment decisions. For this reason we offer a **calculation tool** in the experiment. This will appear on the lower right part of your screen. It looks like this.

| ronde | prijs                 |                       |                       |                       |                       | invest                   |
|-------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|--------------------------|
|       | 0                     | 1                     | 2                     | 3                     | 4                     |                          |
| 1     | <input type="radio"/> | <input type="checkbox"/> |
| 2     | <input type="radio"/> | <input type="checkbox"/> |
| 3     | <input type="radio"/> | <input type="checkbox"/> |
| 4     | <input type="radio"/> | <input type="checkbox"/> |
| 5     | <input type="radio"/> | <input type="checkbox"/> |
| 6     | <input type="radio"/> | <input type="checkbox"/> |
| 7     | <input type="radio"/> | <input type="checkbox"/> |
| 8     | <input type="radio"/> | <input type="checkbox"/> |
| 9     | <input type="radio"/> | <input type="checkbox"/> |

Consument:

Investeerder:

**bereken**

(translation: “ronde”=round;  
“prijs”=price; “consument”=  
consumer; “investeerder”  
=investor; “bereken”= calculate)

During the experiment you can use this to **try out decisions** and calculate what the consequences are for the earnings. You can choose a **price** for each round and **whether investment has taken place**. This is subject to the following **restrictions**:

- You can only make decisions **from the current round onward**. Previous rounds can no longer be undone. The earnings are calculated for the remaining rounds. Earnings in previous rounds are not taken into account.
- If there was investment in a **previous round**, investment is automatically selected in the current round. You cannot change this.
- If you choose to invest for a round, investment is automatically selected in **all subsequent rounds**.
- the **consumers** only see the **own earnings**, not the earnings of the investor (and winning price determiner).

In the calculation tool you fill out a price for a round. The tool then automatically chooses the same price for the subsequent rounds. You can change this by choosing a different price for a round.

If you undo an investment choice in the calculation tool, then this investment is automatically undone in all previous rounds.

[previous page](#) [next page](#)

---

p. 6/8

## Choosing a Price Determiner

After the investor has decided about the investment we give her or him the opportunity **to indicate the price he or she prefers**. This is only an advice. Price determiners may decide for themselves what to do with it.

After receiving the price advised by the investor, the **price determiners each propose a price**. They also indicate whether the proposed price **would apply only for the current round or for all remaining rounds**. These proposals serve to let consumers know what they are planning. The proposed prices are **not binding**. The selected price determinant can deviate from the proposal when actually setting the price.

After the price determiners have announced a price and how long it would remain valid, the **consumer each vote** for one of the two price determiners.

The price determiner with the **most votes** then determines the **actual price and whether this is only for the current round or for all remaining rounds**. As mentioned, this decision **may differ** from the proposal made prior to the election.

[previous page](#) [next page](#)

---

p. 7/8

## Determining the Price

There may be a **difference** between determining the price in different rounds.

In the **first round** the price determiner can choose **any price between 0 and 5 free of charge**.

In **later rounds** the price determiner can **only choose a price (free of charge) if the price has not previously been fixed for all remaining rounds**.

[previous page](#) [next page](#)

---

## In Summary

Each round consists of **six different stages**. These are indicated on the left-top part of your screen by Roman numerals I-VI.

- I. The investor decides on investing.
- II. The investor indicates a price.
- III. Price determiners propose a price and whether this only holds for the current round.
- IV. The consumers choose a price determiner.
- V. The chosen price determiner chooses a price (unless one was previously fixed).
- VI. The earnings are calculated and communicated.

Below is an example of the screen that will be used in the experiment.

The screenshot shows a software interface titled 'MainForm'. On the left, there are input fields for 'ronde' (1-IV) and 'type' (Consument), and a 'verdiensite' field showing 0,00. The main area contains a text box with instructions: 'De investeerder heeft niet geïnvesteerd. De investeerder adviseert een prijs 3. Prijsbepaler 1 kondigt prijs 2 aan. Deze prijs geldt alleen voor deze ronde. Prijsbepaler 2 kondigt prijs 3 aan. Deze prijs geldt voor alle resterende ronden. Kies welke prijsbepaler u deze ronde de daadwerkelijke prijs wilt laten bepalen.' Below this are two radio buttons for 'Prijsbepaler 1' and 'Prijsbepaler 2', and a 'Bevestiging' button. On the right, a yellow box says 'Druk op [Alles gelezen] wanneer u alles gelezen hebt.' At the bottom, there is a table titled 'NIET geïnvesteerd' showing consumer prices for rounds 0-5, a grid of radio buttons for selecting a price determiner in each round, a 'Consument:' field, and a 'bereken' button.

| NIET geïnvesteerd |       |
|-------------------|-------|
| Consu-<br>prijs   | ment  |
| 0                 | 12,50 |
| 1                 | 8,00  |
| 2                 | 4,50  |
| 3                 | 2,00  |
| 4                 | 0,50  |
| 5                 | 0,00  |

| ronde | prijs                 |                       |                       |                       |                       | invest                   |
|-------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|--------------------------|
|       | 0                     | 1                     | 2                     | 3                     | 4                     | 5                        |
| 1     | <input type="radio"/> | <input type="checkbox"/> |
| 2     | <input type="radio"/> | <input type="checkbox"/> |
| 3     | <input type="radio"/> | <input type="checkbox"/> |
| 4     | <input type="radio"/> | <input type="checkbox"/> |
| 5     | <input type="radio"/> | <input type="checkbox"/> |
| 6     | <input type="radio"/> | <input type="checkbox"/> |
| 7     | <input type="radio"/> | <input type="checkbox"/> |
| 8     | <input type="radio"/> | <input type="checkbox"/> |
| 9     | <input type="radio"/> | <input type="checkbox"/> |

(translation: “ronde”=round; “consument”=consumer; “verdiensite”=earnings; “Niet geïnvesteerd”= no investment; “prijs”=price; “De investeerder heeft niet geïnvesteerd”=The investor has not invested; “De investeerder adviseert een prijs 3”=The investor indicates price 3; “Prijsbepaler 1 kondigt prijs 2 aan. Deze prijs geldt alleen voor deze ronde.”= Price determiner 1 proposes price 2. This price holds only in the current round; “Prijsbepaler 1 kondigt prijs 3 aan. Deze prijs geldt voor alle resterende ronden.”= Price determiner 2 proposes price 3. This price holds for all remaining rounds; “Kies welke prijsbepaler u deze ronde de daadwerkelijke prijs

wilt laten bepalen.”= Choose which price determiner you would like to determine the actual price in this round; “Prijsbepaler”= Price determiner”; “Bevestiging”=Confirmation; “Druk [Alles Gelezen] wanneer u alles gelezen hebt”; “Click [Read everything] after you have read everything; “bereken”= calculate.

The screen consists of five Windows. At the **top left** you see information about the **round and phase**. In this example, you are in phase IV of the first round. You will also see your role. In this example, are you one of the consumers. There you will also see your earnings. Note that this is only an example. The numbers in the experiment itself are different.

**At the top center** you will see a window with **information about previous decisions in the round**. You are also informed about what will happen in this phase (IV). All decisions will be announced to all participants. After each stage you will see at the top of your screen in the middle window an **overview of the decisions in all previous phases**. The decision in the most recent phase is in **Blue**.

**At the top right** is a window which says **what you need to do**. If this is yellow, you must do something before the experiment can proceed. In this example, you must choose a price determiner.<sup>35</sup> Please note: in a phase in which you do not need to do anything, you need to click to confirm that you have read the text on your screen.

**At the bottom left** you will see the tables with **potential earnings in the current round**. Because no investment has taken place in this example, only the table for that case is shown.

Finally you will see **in the bottom right corner** the previously discussed **calculation tool**.

This brings you to **the end of these instructions**. If you wish, you can scroll back to previous pages. When you are finished, you can indicate this by pressing the button below. Then, please wait quietly until everyone is ready.

[previous page](#) [back to top](#)

---

<sup>35</sup> Due to an error in the software, the monitor at this stage of round 1 indicated that they must confirm that they have read everything. The consumer could not proceed without choosing a price determiner, however.