

# Electoral systems and their influence on environmental policy design

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Date received: October 30, 2019. Date accepted: May 4, 2020.

## Abstract

This article undertakes a comparative analysis of the respective effects of majority and proportional representation electoral systems on tax policies designed to reduce pollution. The following findings were obtained: in a majority electoral system, environmental regulation is extreme with very low or high taxes compared to a socially optimal policy; in a proportional representation system, environmental policy is moderate (taxes are moderate compared to taxes implemented in a majority system); and environmental policy in proportional representation systems more closely resembles a socially optimal policy. Electoral institutions account for these findings, which are due to the number of effective parties and legislative negotiation in congress.

**Keywords:** pollution; taxes; environmental policy; regulation; theoretical model; electoral system; democracy.

## 1. INTRODUCTION

There is an abundant body of literature which demonstrates that governmental redistribution policies, the provision of public goods, and economic regulations are—in part—determined by political elements such as electoral competition, legislative negotiations between the executive branch and congress, party preferences regarding economic policy, voters' electoral participation, and the electoral engineering of a democracy in general (see Mueller, 2003). The case of environmental regulations, which seek to establish operating rules for economic agents in terms of the negative externalities caused by environmental pollution, is no exception.

Despite growing interest in the area of new political economy in analyzing governments' efforts to regulate economic activities associated with negative externalities such as pollution, very little is known about the role of the electoral system in determining a government's level of environmental regulation. However, the issue is important, since there is significant heterogeneity internationally in terms of the design and implementation of environmental policy. While there are countries that are willing to subscribe to international protocols which seek to regulate pollution, others have refused to adopt such recommendations. This evidence leads to the following question of interest: what explains the fact that certain countries seek to mitigate the negative effects of pollution, while others adopt more flexible environmental regulations?

Traditional economic analyses—which consider the government to be controlled by a benevolent social planner—suggest that each country's willingness to institute environmental regulations is related to a cost-benefit analysis that incorporates the distribution of polluting activities' benefits and marginal social costs. However, this traditional analysis does not take into account the fact that, in practice, governments may not have an incentive to use marginal social cost and benefit curves to guide the design of environmental regulations. This could be the case if the benefit and electoral marginal cost curves that affect a government's economic policy design do not coincide with marginal benefit and cost curves in society.

Since the creation of a government requires a party to win an election, it is important to note that the political parties which comprise a government are incentivized to adopt economic policies which will maximize the number of votes that they receive. While it is true that electoral incentives are not the only determinants of a democratic government's economic policy design, it should be noted that evidence demonstrates the importance of electoral competition as a determinant of economic policy (Mueller, 2003).

The present article recognizes that electoral incentives in the process of forming a government may be fundamental to explain the design of a democratically-elected government's economic policy. Therefore, a study was undertaken of how certain institutions in a democratic electoral system may have an influence on the shaping of flexible environmental regulation policies (that tolerate high levels of pollution) or restrictive ones (that only tolerate low levels of pollution).

In this context, it is important to point out that the institutions that make up a democracy's electoral system are linked to the environmental policies it adopts, since such institutions determine the number of parties that compete in elections as well as each one's level of representation in congress. Given that environmental policy requires simple or qualified majority approval, the type of electoral system adopted—be it a majority, proportional representation, or mixed electoral system—will create incentives (or barriers) for a political party (or parties) to adopt more flexible or more restrictive environmental regulation policies.

In this study, the following question is posed: how does the adoption of a specific electoral system affect environmental regulation design? In other words, does a majority electoral system produce the same type of environmental regulation as a proportional representation one? The study develops a

comparative theoretical analysis of the type of environmental regulation that arises in a democracy with a majority or proportional representation electoral system. A theoretical model of electoral competition is thus developed, in which a government decides on a tax system which seeks to reduce pollution.

In the economy under study, political parties have preferences in terms of public policy instruments. As such, the design of taxes that aim to contain pollution is examined in two cases of interest: 1) an economy with a majority electoral system, and 2) an economy with an electoral system of proportional representation. These different electoral systems imply that in a majority electoral system there are fewer influential parties (Liphart, 1994), which has implications regarding the number of parties represented in congress and in the legislative negotiation process that determines public policy.

The analysis presented here produces several results of interest. First, in an economy with a majority electoral system, environmental regulation policy is polarizing. In other words, environmental taxes are implemented to a significantly higher or lower socially optimal degree, depending on the identity of the ruling political party. In this equilibrium, parties' policies do not converge (unlike what the median voter model proposes—see Downs [1957]), which manages to explain that which is evident in modern economies: left-wing and right-wing parties implement different public policies.

Second, in economies with a proportional representation electoral system, environmental regulation policies are moderate; that is, they do not have an especially high or low level of taxes aimed at reducing pollution, as would occur in the equilibrium of a majority electoral system economy. Third, public policies designed in proportional representation electoral systems are more likely to be closer to those which are considered most socially desirable.

The article is structured as follows. Section two contains a brief review of the existing literature; section three introduces a theoretical model, shows the distribution of preferences for economic environmental policy, and characterizes what is considered socially optimal environmental policy. Section four lays out an environmental policy design model for a majority electoral system economy, while section five examines the case of a proportional representation electoral system. Section six contains a discussion of the results, and finally, conclusions are presented in section seven.

## 2. LITERATURE REVIEW

The clear problems arising from the negative effects of pollution have created a renewed interest in studying the relationship between political competition and environmental policy design and implementation. In the case of the United States, evidence suggests that environmental policies are determined by the lobbying efforts of special interest groups (List and Sturm, 2006); while the extent of democracy has a positive effect on air quality, presidential systems have a negative effect (Bernauer and Koubi, 2009).

The stylized facts also suggest that not only are elections important determinants of public policy design, but that electoral engineering is as well. In particular, evidence indicates that public spending is higher in economies with proportional representation electoral systems than in majority systems (Persson and Tabellini, 2003), and that the provision of public goods in majority and proportional representation systems do not converge (Lizzeri and Persico, 2001). Specifically, in the case of local public goods, evidence suggests that electoral system institutions—in particular the candidate nomination processes and centralization of parties—affect the efficiency of local public spending on health and education (Hankla *et al.*, 2019).

Recent research shows that environmental policies are more restrictive in proportional electoral systems than in majority ones (Fredriksson and Millimet, 2004), and that another important factor in the design and effectiveness of environmental regulations could be governmental structure, i.e., the fiscal centralization or decentralization of the economy (Fredriksson *et al.*, 2010). An empirical analysis by Fredriksson and Millimet (2004) shows that environmental policies are more restrictive in proportional electoral systems than in majority ones.

Despite the contributions of the aforementioned works, some characteristics of electoral systems that could be relevant for environmental policy design (in particular, the number of political parties and negotiations in congress), have not been studied properly. This is precisely the contribution of the present work, as the effects of these two political institutions in environmental policy design—understood as taxes that aim to reduce the negative societal impacts of pollution—are analyzed. In addition, this study contributes to the literature by presenting theoretical propositions that may be empirically verified.

This work differs from the existing literature in that it uses a different conception of electoral competition. While most of the literature uses the Downs (1957) model, which assumes that political parties design economic platforms solely to win elections, a Wittman (1973) model of electoral competition is used here to explain public policy development. Thus, theoretical predictions are produced which differ from those introduced by the median voter or Downs models. Accordingly, one contribution of this study is to propose theoretical propositions that can be verified empirically.

## 3. FAMILY PREFERENCES AND SOCIALLY OPTIMAL ENVIRONMENTAL POLICY

An economy consisting of  $h = 1, 2 \dots H$  families is assumed. The families in this economy consume a single good  $x_h$  that creates a negative externality for the rest of the members of society. To simplify the resource allocation problem for family  $h$ , we assume that family  $h$  decides the optimal level of  $x_h$  to maximize the following problem of allocating resources to:<sup>1</sup>

$$\text{Max}_{\{x_h\}} v_h = \ln(x_h) - \theta_h x_h - p_x x_h \quad (1)$$

Where  $v_h = \ln(x_h) - \theta_h x_h$  represents the preference structure of family type  $h$ , and where  $x_h$  is the private consumption of good  $x$  and  $\theta_h > 0$  is a constant. The consumption of good  $x_h$  causes a negative externality for all families in the economy, since this good causes pollution (consider goods whose consumption induces a residual effect on environmental pollution). However, type  $h$  families only consider how the consumption of this good affects their own well-being, and do not take into account the negative externality that it creates for the rest of the families in society. The personal effect of pollution by good  $x_h$  in type  $h$  families is given by  $-\theta_h x_h$

To simplify the analysis, it is assumed that in this economy there is a perfectly elastic supply of good  $x_h$  at price  $p_x$ . In this case, the form of the economy's aggregate demand curve determines the equilibrium level of consumption in a market economy. To demonstrate this, proposition 1 shows the optimal demand for good  $x_h$  by family type  $h$  and the aggregate consumption level of this good.

**Proposition 1.** The market consumption level of family type  $h$  for good  $x_h^m$  is given by:

$$x_h^m = \frac{1}{p_x + \theta_h} \quad \forall h = 1, 2, \dots, H \quad (2)$$

Which implies a level of aggregate market equilibrium for the polluting good given by:

$$X^m = \sum_{h=1}^H x_h^m = \sum_{h=1}^H \frac{1}{p_x + \theta_h} \quad (3)$$

Proposition 1 shows that families decide their consumption level in a market economy determined by  $x_h^m = \frac{1}{p_x + \theta_h} \quad \forall h$ , which implies that they consider the price of production of good  $p_x$  and the impact of pollution from the production of good  $x_h$  on their own well-being  $\theta_h$ . Price increases of that good and in the family's personal cost of the pollution associated with good  $x_h$  reduce the family's demand for it. The aggregate consumption of this

good in the economy is given by  $X^m = \sum_{h=1}^H x_h^m = \sum_{h=1}^H \frac{1}{p_x + \theta_h}$ , such that at the aggregate level demand for this good depends on its price and on the distribution of the pollution costs that each family perceives. The allocations  $x_h^m$  and  $X^m$ , however, are not Pareto efficient because families and the market price mechanism fail to take into account how their consumption impacts the well-being of the rest of the families in the economy. In other words, families' decisions do not consider the marginal social cost of consuming  $x_h^m$ , so the market equilibrium of that good is higher than its Pareto efficiency level.

### Pareto efficient allocation of the economy

In this section the Pareto efficient allocation of good  $\sum_{h=1}^H x_h$  is characterized. To construct this analysis, an economy is assumed which is controlled by a benevolent social planner who selects the optimal level of consumption for each family, and thus the socially optimal consumption level. The allocation of good  $x_h$  to each family seeks to maximize a symmetrical utilitarian social welfare function  $\Psi$ . Accordingly, the benevolent social planner's resource allocation problem is:

$$\text{Max}_{\{x_h^*\}} \Psi = \sum_{h=1}^H v_h = \sum_{h=1}^H \ln(x_h) - \sum_{h=1}^H \theta_h x_h - p_x \sum_{h=1}^H x_h \quad (4)$$

Next, proposition 2 characterizes the Pareto efficient allocation of the private good in this economy.

**Proposition 2.** The aggregate Pareto efficient consumption level for a type  $h$  family is  $x_h^*$ , which satisfies:

$$x_h^* = \frac{1}{p_x + \sum_{h=1}^H \theta_h} \quad \forall h = 1, 2, \dots, H \quad (5)$$

Which implies that the Pareto efficient aggregate equilibrium level of good  $X^*$  is:

$$X^* = \sum_{h=1}^H x_h^* = \frac{H}{p_x + \sum_{h=1}^H \theta_h} = \frac{1}{\frac{p_x}{H} + E[\theta_h]} \quad (6)$$

Where  $E[\theta_h]$  is the average cost of the private good's pollution, which is given by:

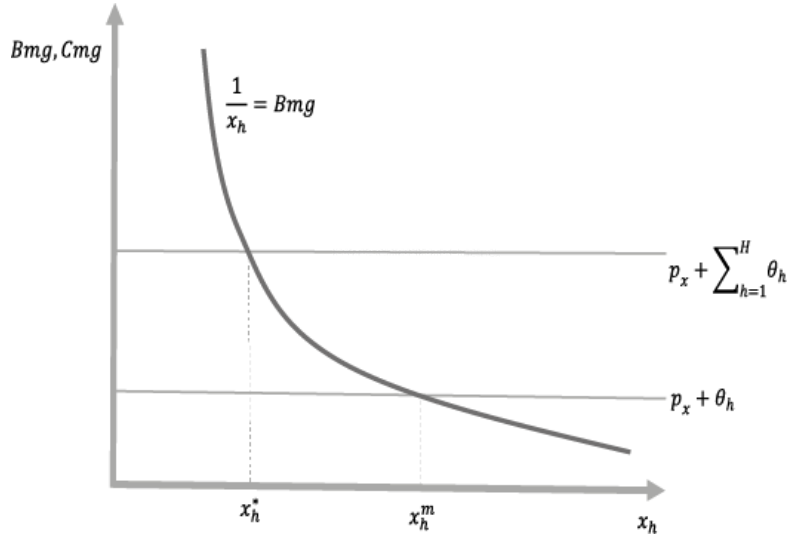
$$E[\theta_h] = \frac{\sum_{h=1}^H \theta_h}{H} \quad (7)$$

A proof appears in the appendix.

Proposition 2 shows the Pareto efficient consumption level of the private good for type  $h$  families, determined by  $x_h^* = \frac{1}{p_x + \sum_{h=1}^H \theta_h}$ , which implies that the determinants of type  $h$  families' socially optimal consumption are the price of production of good  $p_x$ , the impact of pollution in the production of good  $x_h$  on its own well-being  $\theta_h$ , and the impact of pollution or the negative externality in society of the consumption of good  $x$ . The sum of the personal cost of pollution for family  $h$  and the negative externality of its consumption for society is  $\sum_{h=1}^H \theta_h$ . At the aggregate level, the Pareto efficient consumption level is denoted by  $X^*$  and represented in equation (6) of proposition 2. Thus, the socially optimal level of aggregate consumption  $X^*$  negatively depends on the price and effect of negative pollution in society.

Figure 1 shows the differences between the consumption level in market economy  $x_h^m$  and an economy with a Pareto efficient provision  $x_h^*$  for the consumption of family  $h$ .

Figure 1. Market consumption and families' Pareto efficient consumption



Source: prepared by the authors.

**Proposition 3** analyzes the type of economic policies that could implement the socially optimal allocation of pollution. In particular, proposition 3 shows that a Pigouvian tax given by  $\tau_h^* = \sum_{h=1}^H \theta_h - \theta_h$  can lead to a Pareto efficient allocation in a market economy, since the tax prompts consumers to recognize the marginal social cost of consuming a polluting good.

Proposition 3. The tax level that a Pareto efficient allocation leads to in a market economy is:

$$\tau_h^* = \sum_{h=1}^H \theta_h - \theta_h \quad (8)$$

Now consider the problem of the family  $h$ , determined by:

$$\text{Max}_{\{x_h\}} v_h = \ln(x_h) - \theta_h x_h - \{p_x + \tau_h^*\} x_h \quad (9)$$

Which implies that the level of market consumption for family type  $h$  is given by  $\tilde{x}_h^m$ , such that

$$\tilde{x}_h^m = \frac{1}{p_x + \theta_h + \tau_h^*} = \frac{1}{p_x + \sum_{h=1}^H \theta_h} \quad \forall h = 1, 2, \dots, H \quad (10)$$

Which implies a level of market equilibrium given by:

$$\bar{X}^m = \sum_{h=1}^H \tilde{x}_h^m = \sum_{h=1}^H \frac{1}{p_x + \theta_h + \tau_h^*} = \frac{H}{p_x + E[\theta_h]} \quad (11)$$

Such that a market economy with a Pigouvian tax  $\tau_h^* = \sum_{h=1}^H \theta_h - \theta_h$  implies that this equilibrium is Pareto efficient, since

$$\tilde{X}^m = X^*$$

(12)

The proof appears in the appendix.

Proposition 3 illustrates a result which is well-known in the literature: a government can intervene in a market economy by establishing a Pigouvian tax (which in the economy is given by  $\tau_h^* = \sum_{h=1}^H \theta_h - \theta_h$ ), that causes families to recognize—through the market price mechanism—the social costs of consuming a private good that pollutes. Therefore, families' consumption in an economy with the intervention of a government that establishes a Pigouvian tax induces a Pareto efficient allocation.

#### 4. PUBLIC POLICY DESIGN AND POLLUTION LEVELS IN A MAJORITY ELECTORAL SYSTEM

Below, environmental policy design is examined in the case of political parties which have preferences about public policy (Wittman, 1973). In this case, parties do not necessarily design public policies in order to win elections (Downs, 1957) but rather seek to win because their interest is to maximize the gains associated with economic policy design; that is, parties seek to design public policy to benefit their followers. The main distinction between the Downs model and the Wittman model is that in the first model, parties design economic policies to maximize their probability of winning an election, while in the Wittman model, parties decide on economic policies that maximize the preferences of a coalition of individuals within the party (usually comprised of the individuals who control it).

Here, Wittman's model is used to propose a model that allows for predictions regarding the design of environmental policy in modern democracies. In particular, the present study provides a model of electoral competition that imparts an understanding of environmental policy design in economies with different electoral systems. The aim is therefore to study environmental policy design in economies with majority and proportional representation electoral systems; such systems cover the vast majority of modern democracies. It is important to emphasize that electoral systems represent the institutions that regulate elections, political party formation, and parties' degree of representation in congress. Thus, electoral systems create incentives in the formation and maintenance of the number of parties in a democracy, and in the electoral and legislative competition that determines public policy design (see Liphart, 1994).

In the case study, political parties propose political platforms on environmental issues, while voters assess different parties' policies and vote for the one that recommends the economic policy closest to their own preferences. After an election, the winning party takes over (i.e. control of the executive branch and the legislature) and implements economic policies that maximize its interests or preferences. In the economy under study, there are two parties—called  $L$  and  $R$ —whose political platforms are characterized by environmental regulation determined by taxes  $\tau_L^* \geq 0$  and  $\tau_R^* \geq 0$ , which seek to reduce pollution.

At one extreme, one (or both) parties could propose the implementation of a tax equal to zero, which would imply a completely flexible environmental policy under which the market economy operates without state intervention. At the other, one (or both) parties could propose an environmental regulation policy with the maximum tax allowable in the economy, also creating a socially suboptimal pollution level. In the latter case, the cost of allocating resources for society means a massive reduction of polluting private goods.

Thus, in this economy the design of environmental policy is studied through a dynamic game of perfect information, in which the political balance involves the following stages:

**First Stage:** the parties select a political platform on environmental matters  $\tau_L^* \geq 0$  and  $\tau_R^* \geq 0$ .

**Second Stage:** individuals observe both parties' policies and their votes are sequentially rational. That is, voters vote not based on party platforms, but based on the type of policies that each would implement once the winning party forms the government. The calculation of a type  $\theta_h$  voter's well-being is determined by  $\chi_L(\theta_h)$ —whose function is given by  $\chi_L(\theta_h) = v_L(\tau_L^*, \theta_h) - v_R(\tau_R^*, \theta_h)$ —where  $v_L(\tau_L^*, \theta_h) = \ln(x_h) - \theta_h x_h - \{p_x + \tau_L^*\}x_h$  y  $v_R(\tau_R^*, \theta_h) = \ln(x_h) - \theta_h x_h - \{p_x + \tau_R^*\}x_h$ . If  $\chi_L(\theta_h) > 0$  and type  $\theta_h$  voter votes for party  $L$ , and if  $\chi_L(\theta_h) < 0$ , the individual votes for party  $R$ .

**Third Stage:** the party that is elected implements policies which maximize the preferences of the representative individual within the party.

Preferences of parties  $Z = L, R$  are given by  $\mu_z = \ln(x_z) - \theta_z x_z$  where  $x_z$  is a good consumed by the representative individual of party  $Z$  and  $\theta_z > 0$  is a constant. The effect of the pollution from good  $x_z$  on the family that controls party  $Z$  is given by  $-\theta_z x_z$ . Environmental policy is characterized by a tax  $\tau_z^* \geq 0 \forall Z = L, R$ . Thus, the problem of environmental policy design is to establish the level of tax  $\tau_z^* \geq 0 \forall Z = L, R$  which maximizes party preferences, as given by:

$$v_z = \ln(x_z) - \theta_z x_z - \{p_x + \tau_z^*\}x_z \quad \forall Z = L, R \quad (13)$$

For this economy, the political-economic equilibrium is characterized by a subgame Nash perfect equilibrium, as shown in definition 1. Without losing the generality of the analysis,  $\theta_L > E[\theta_h] > \theta_R$  is assumed where  $E[\theta_h] = \frac{\sum_{h=1}^H \theta_h}{H}$ . In other words, the cost of pollution is higher for a family represented by party  $L$  than the average cost of the economy and its corresponding environmental cost for a family represented by party  $R$ .

In what follows, definition 1 characterizes the subgame perfect Nash equilibrium (for an extensive characterization of the game, see appendix figure A.1).

**Definition 1.** The electoral equilibrium in an economy with a majority electoral system including political parties with environmental policy preferences is characterized as follows:

i) In the first stage of the game, the parties propose  $\tau_z^* = \theta_z \quad \forall Z = L, R$ , such that

$$\tau_z^* \in \text{ArgMax } v_z = l n(x_z) - \theta_z x_z - \{p_x + \tau_z^*\} x_z \quad \forall Z = L, R \quad (14)$$

ii) In the second stage, the typical voter votes for party  $L$  if

$$\begin{aligned} \chi_L(\theta_h) &= v_L(\tau_L^*, \theta_h) - v_R(\tau_R^*, \theta_h) > 0 \\ \chi^L(\theta_h) &< 0, \text{ the individual votes for party } R \end{aligned} \quad (15)$$

iii) In the third scenario, the elected party implements  $\tau_z^* = \theta_z \quad \forall Z = L, R$ , such that

$$\tau_z^* \in \text{ArgMax } v_z = l n(x_z) - \theta_z x_z - \{p_x + \tau_z^*\} x_z \quad \forall Z = L, R \quad (16)$$

Based on definition 1, it is easy to see that the heterogeneity of party  $L$  and  $R$ 's preferences necessarily implies that in the last scenario of the game, the parties' environmental policies diverge; that is,  $\tau_L^* \neq \tau_R^*$ .

Next, in proposition 4 the optimal environmental policy level of parties  $Z = L, R$  is characterized. The solution presented in proposition 4 represents the weakly dominant strategies of parties  $Z = L, R$  in the third stage of the economy's political game.

**Proposition 4.** The ideal market consumption level of the family representing party  $Z$  is determined by  $x_z$ , such that

$$x_z = \frac{1}{p_x + \theta_z} \quad \forall Z = L, R \quad (17)$$

Thus, the environmental policy level desired by party  $Z$  is:

$$\tau_z^* = \theta_z \quad \forall Z = L, R \quad (18)$$

Which implies a market equilibrium level given by:

$$X^m(p_x, \tau_z^*) = \sum_{h=1}^H x_z = \sum_{h=1}^H \frac{1}{p_x + \tau_z^*} = \frac{H}{p_x + \theta_z} \quad \forall Z = L, R \quad (19)$$

Proposition 4 indicates that parties have electoral incentives to internalize the negative effects of pollution only for those individuals represented by them. In other words, the parties in this equilibrium have no incentive to recognize how pollution affects individuals who are not represented by them. Therefore, the Pigouvian tax level is  $\tau_z^* = \theta_z \quad \forall Z = L, R$ . Respective to this type of public policy, the consumption equilibrium level in this economy is given by  $X^m(p_x, \tau_z^*) = \frac{H}{p_x + \theta_z} \quad \forall Z = L, R$ .

An interesting result of this equilibrium—which is shown in proposition 5—is that a government's effort to regulate or control pollution depends on the negative effects of pollution on individuals that a political party represents. Since in our economy  $\theta_L > E[\theta_h] > \theta_R$ , there may be equilibria with a strong government commitment to control pollution which corresponds to a high value of  $\tau_L^* = \theta_L$ . At the same time, there may be equilibria with a weak government commitment to control pollution, corresponding to a low value of  $\tau_R^* = \theta_R$ . This result is explained by the heterogeneity of the preferences of families that make up the parties, which then determines the heterogeneity of those environmental policies which the latter consider ideal.

**Proposition 5.** The heterogeneity of the preferences of representative families within a political party determines the environmental policy it will implement, such that

$$\tau_R^* = \theta_R \quad (20)$$

and

$$\tau_L^* = \theta_L \quad (21)$$

So that  $\theta_L > E[\theta_h] > \theta_R$  implies

$$\tau_R^* < \tau_L^* \quad (22)$$

Below, proposition 6 shows that if party  $R$  wins control of a government (by securing and controlling executive and Legislative Power), the level of aggregate pollution in the economy will be higher than what is socially desirable; proposition 7 demonstrates that if party  $L$  wins an election, the level of aggregate pollution in the economy will be less than socially desirable.

**Proposition 6.** If a majority votes for the right-wing party, then  $\tau_R^* = \theta_R$  y  $\theta_L > E[\theta_h] > \theta_R$  imply that in an economy with a majority electoral system it can produce too much pollution, since

$$X^m(p_x, \tau_R^*) > X^* \quad (23)$$

**Proof**

The equilibrium conditions characterized in propositions 2 and 4 are satisfied when  $X^m(p_x, \tau_R^*) = \frac{1}{\frac{p_x + \theta_R}{H}}$ , while  $X^* = \sum_{h=1}^H x_h^* = \frac{1}{\frac{p_x + E[\theta_h]}{H}}$  and where  $E[\theta_h] = \frac{\sum_{h=1}^H \theta_h}{H}$ . As such,  $\theta_L > E[\theta_h] > \theta_R$  implies  $X^m(p_x, \tau_R^*) > X^*$ .

**Proposition 7.** If a majority votes for the left-wing party, then  $\tau^{*L} = \theta_L$  and  $\theta_L > E[\theta_h] > \theta_R$  imply that in an economy with a majority electoral system it can produce a level of contamination lower than that which is socially desirable.

$$X^m(p_x, \tau_L^*) < X^* \quad (24)$$

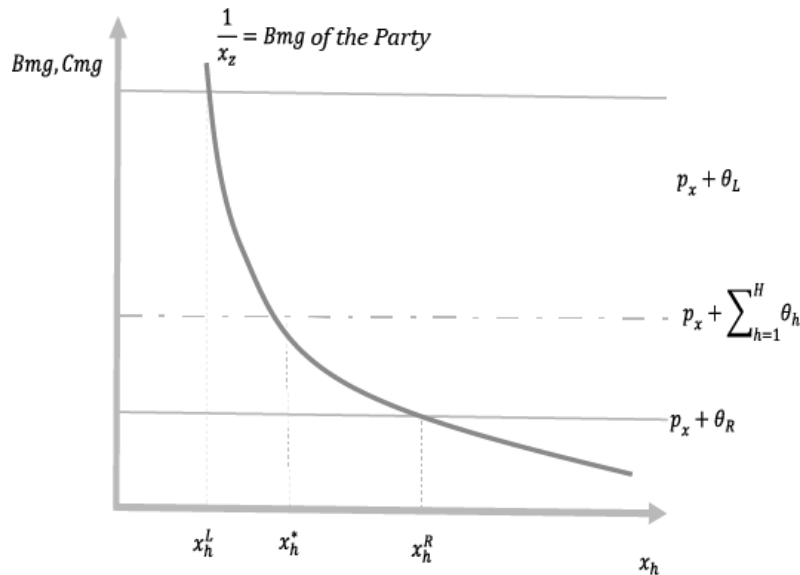
**Proof**

This result follows incidentally from proposition 6.

Propositions 6 and 7 demonstrate the conditions under which, in an economy with a majority electoral system, the government can implement an environmental policy that accepts or tolerates a high level of pollution and identifies conditions under which it establishes environmental over-regulation leading to a pollution level lower than what is socially desirable—which is a Pareto efficient allocation of the economy. A government might not want to fight pollution because the ruling party may be represented by individuals who receive a higher net benefit from consuming the polluting good (i.e., the government could be controlled by a party which in turn is controlled by individuals with a very low level of parameter  $\theta_R$ ); therefore, a government controlled by such a coalition of voters will choose an environmental policy which leads to high pollution levels.

In contrast, a government may wish to significantly reduce pollution if it is represented by individuals who are significantly harmed by the consumption of the polluting good (in this case, the government is controlled by individuals with a high level of parameter  $\theta_L$ ). A government controlled by this type of voter coalition will therefore implement a restrictive environmental policy that leads to low pollution (see figure 2).

Figure 2. Environmental policy in a majority electoral system



Source: prepared by the authors.

It is important to note that in a majority electoral system, the median voter is the decisive one to grant a majority relative to any of the political parties. For this reason, the electoral process—via the median voter—determines which party wins an election with at least a majority of votes, and thus controls environmental policy design.

## 5. ENVIRONMENTAL REGULATION IN A PROPORTIONAL REPRESENTATION SYSTEM

The following presents the development of a model for an economy with a proportional representation electoral system. A distinctive characteristic of such electoral systems is that they promote the existence of more than two political parties, due to the fact that party registration conditions are more flexible than in majority electoral systems. Therefore, the consideration of a proportional representation electoral system involves electoral competition between more than two parties—unlike a majority system, where there are two main parties (Liphart, 1994).

Another important characteristic of multi-party electoral competition is that in proportional representation systems a single party is less likely to control the legislative branch. It is therefore unlikely that a party which receives a relative plurality of votes in an executive branch election will also have an absolute majority in congress, so as to establish public policies. In contrast, in the case of a majority electoral system it is more likely that the party which wins an election could also have an absolute majority in congress. However, in the case of an economy with a proportional electoral system (as the vote is distributed among more parties), it is likely that a party would have to negotiate the design and implementation of public policy with the rest of the parties in congress.

The analysis in this section incorporates these two differences between the majority and proportional electoral systems. First, the number of parties in proportional systems is greater, and therefore, the model used considers electoral competition between two parties in a majority electoral system and between three parties in a proportional representation system. Second, in a proportional representation system, the executive branch has to negotiate public policy design and implementation with the legislative branch. Therefore, a game is explicitly incorporated which includes an electoral process, followed by a game of legislative negotiation in congress.<sup>3</sup>

To examine the case of multi-party electoral competition, a four-stage dynamic model of perfect information was proposed. In the first stage, political parties propose their environmental policy platforms; second, voters assess party platforms and vote for the option that most closely matches their ideal environmental policy. In the third stage, an election takes place and the parties receive a proportion of seats in the legislative branch, equivalent to the proportion of votes received in the election. Finally, in the fourth stage legislative negotiation takes place. The policy design process is as follows: if a party has at least a simple majority in congress, it will propose an environmental policy which maximizes its preferences. If neither party has a majority of the seats in congress, each party will create an environmental policy proposal; all proposals are compared in congress and the proposal that receives a majority of votes is implemented by congress.<sup>4</sup> Since public policies satisfy the requirement of single peaked preferences, the median voter's ideal policy wins the round of comparisons between the various public policy options (for a proof of this result, see Bowen [1943]).

In this economy, it is assumed that there are three political parties, defined by  $Z = L, M, R$ , where party  $L$  will be considered left-wing, party  $R$  will be considered right-wing, and  $M$  will be

the centrist party.

The government intervenes in this economy, and party  $Z$  proposes a Pigouvian tax as a mechanism to internalize the costs caused by pollution. Party preferences are defined based on the preferences of the people who control it (as defined in the previous section). Thus, the resource allocation problem for a representative family in party  $Z$  is as follows:

$$\text{Max}_{\{x_z\}} v_z = \ln(x_z) - \theta_z x_z - \{p_x + \tau_z\} x_z \quad \forall Z = L, M, R \quad (25)$$

As shown in definition 2, the political-economic equilibrium for this economy is characterized by the subgame perfect Nash equilibrium. Without a general loss in the analysis,  $\theta_L > \theta_M > \theta_R$  is assumed (for an extensive characterization of the game, see figure A.2 in the Appendix).

Definition 2. The electoral equilibrium for an economy with a proportional electoral system and parties  $Z = L, M, R$ , which have preferences regarding environmental policy, is characterized as follows:

i) In the first stage of the game, the parties propose  $\theta_L > \theta_M > \theta_R$  such that

$$\tau_z^* \in \text{ArgMax } v_z = \ln(x_z) - \theta_z x_z - \{p_x + \tau_z\} x_z \quad \forall Z = L, M, R \quad (26)$$

ii) In the second stage of the game, type  $\theta_h$  voter votes

$$\text{For party } L \text{ if } \chi_{LR}(\theta_h) = v_L(\tau_L^*, \theta_h) - v_R(\tau_R^*, \theta_h) > 0 \quad (27)$$

$$\text{and } \chi_{LM}(\theta_h) = v_L(\tau_L^*, \theta_h) - v_M(\tau_M^*, \theta_h) > 0 \quad (28)$$

$$\text{For party } M \text{ if } \chi_{MR}(\theta_h) = v_M(\tau_M^*, \theta_h) - v_R(\tau_R^*, \theta_h) > 0 \quad (29)$$

$$\text{and if } \chi_{ML}(\theta_h) = v_M(\tau_M^*, \theta_h) - v_L(\tau_L^*, \theta_h) > 0 \quad (30)$$



$$\text{For party } R \text{ if } \chi_{RM}(\theta_h) = v_R(\tau_R^*, \theta_h) - v_M(\tau_M^*, \theta_h) > 0 \quad (31)$$

$$\text{and } \chi_{RL}(\theta_h) = v_R(\tau_R^*, \theta_h) - v_L(\tau_L^*, \theta_h) > 0 \quad (32)$$

iii) In the third stage of the game, each party receives a proportion  $\Omega_Z$  of the seats in congress, such that  $\Omega_L, \Omega_M, \Omega_R \in [0,1]; \Omega_L + \Omega_M + \Omega_R = 1$

iv) In the fourth stage of the game:

a) If  $\Omega_Z \geq \frac{1}{2}$ , then party Z has a majority in congress; consequently, it implements  $\tau_Z^* = \theta_Z$  such that

$$\tau_Z^* \in \text{ArgMax } v_Z = \ln(x_Z) - \theta_Z x_Z - \{p_x + \tau_Z\} x_Z \quad \forall Z = L, M, R \quad (33)$$

b) On the contrary, if  $\Omega_Z < \frac{1}{2} \quad \forall Z = L, M, R$ , then no party has a majority, so the three environmental policy alternatives  $\tau_L^*, \tau_M^*, \tau_R^*$  are compared and the policy that wins the majority in congress is implemented.

Next, proposition 8 characterizes parties  $Z = L, M, R$  optimal environmental policy levels. The solution posed in this proposition represents the weakly dominant strategies of the parties in the fourth stage of the game.

**Proposition 8.** The ideal market consumption level of the family representing party Z is determined by  $x_h^Z$  such that

$$x_Z = \frac{1}{p_x + \theta_Z} \quad \forall Z = L, M, R \quad (34)$$

Accordingly, the environmental policy level desired by party Z is:

$$\tau_Z^* = \theta_Z \quad \forall Z = L, M, R \quad (35)$$

Which implies a market equilibrium level given by:

$$X^m(p_x, \tau_Z^*) = \sum_{h=1}^H x_h^m = \sum_{h=1}^H \frac{1}{p_x + \tau_Z^*} = \frac{1}{\frac{p_x}{H} + \frac{\theta_Z}{H}} \quad \forall Z = L, M, R \quad (36)$$

Similar to the economic-political equilibrium in the previous section, proposition 8 states that parties have electoral incentives to internalize the negative effects of pollution only for those individuals they represent. In other words, a party does not have an incentive to recognize how pollution affects individuals who are not part of it. Therefore, the Pigouvian tax level is  $\tau_Z^* = \theta_Z \quad \forall Z = L, M, R$ . According to this type of public policy, the equilibrium

level for aggregate consumption in the economy is given by  $X^m(p_x, \tau_Z^*) = \frac{1}{\frac{p_x}{H} + \frac{\theta_Z}{H}} \quad \forall Z = L, M, R$ .

An interesting result of this equilibrium is that a government's effort to regulate pollution depends on the effects of pollution on the individuals the party represents. Therefore, this economy may have equilibria with a high degree of government commitment to regulate pollution, corresponding to a high value of  $\tau_L^* = \theta_L$ . At the same time, equilibria may exist with a low government commitment to regulate pollution, corresponding to a low value of  $\tau_R^* = \theta_R$ . The intermediate level of environmental regulation—in relation to the two extremes described above—is given by a tax determined by  $\tau_M^* = \theta_M$ . This result in particular is identified by proposition 9, which shows that the heterogeneity of preferences of those families that make up specific parties determines the heterogeneity of the environmental policies they considered ideal.

**Proposition 9.** The heterogeneity of the preferences of representative families within a party determines the environmental policy to be implemented by each party, such that

$$\tau_R^* = \theta_R \quad (37)$$

$$\tau_M^* = \theta_M \quad (38)$$

$$\tau_L^* = \theta_L \quad (39)$$

Such that  $\theta_L > \theta_M > \theta_R$  implies

$$\tau_R^* < \tau_M^* < \tau_L^* \quad (40)$$

With more than two parties, the political game for the popular vote changes significantly. If any of the parties wins at least a majority of votes in an election, then its policy is implemented in congress. If no party has a majority in congress, then of the possible policies to vote for in legislative

negotiation—that is,  $\tau_R^* = \theta_R, \tau_M^* = \theta_M, \tau_L^* = \theta_L$ —policy  $\tau_M^* = \theta_M$  is the one that receives a majority of votes in such a negotiation process. To observe this, note that party preferences satisfy what is known in the literature as “singled peaked preferences.” Thus, if neither party has a majority, then party  $M$ ’s policy is the intermediate one of the three alternatives, and it therefore receives the majority of votes in legislative negotiation. This result is formally characterized by proposition 10.

**Proposition 10.** If  $\Omega_z \geq \frac{1}{2}$  for a certain political party  $z$ , then this party has a majority in congress and implements  $\tau_z^* = \theta_z \quad \forall Z = L, M, R$ , such that

$$\tau_z^* \in \text{ArgMax } v_z = \ln(x_z) - \theta_z x_z - \{p_x + \tau_z\}x_z \quad \forall Z = L, M, R \quad (41)$$

On the contrary, if  $\Omega_z < \frac{1}{2} \quad \forall Z$  then no party  $z$  has a majority, and if the three alternative environmental policies  $\tau_L^*, \tau_M^*, \tau_R^*$  are compared, with the intermediate policy of the legislative process being  $\tau_M^* = \theta_M$ .

The main implication of proposition 10 is that—in the absence of any one party obtaining an absolute majority in an election—environmental policy that is expected to be implemented in an economy with a proportional representation electoral system is  $\tau_M^* = \theta_M$  and that it is considered an intermediate or moderate environmental policy based on the existing alternatives. In contrast, in an economy with a majority electoral system, the policies that could be implemented are considered polarizing or extreme; that is, policies in equilibrium could be  $\tau_L^* = \theta_L$  or  $\tau_R^* = \theta_R$ .

Therefore, in an economy with a majority electoral system, the government can implement an environmental policy that accepts or tolerates a high level of pollution,  $\tau_R^* = \theta_R$ , it also identifies conditions under which the government establishes environmental over-regulation that leads to a level of pollution that is lower than the socially desirable level  $X^*$ , which is to say,  $\tau_L^* = \theta_L$ . On the other hand, the legislative negotiation of proportional representation electoral systems encourages the median voter policy in congress, which in this case means a moderate regulation policy for the three alternatives in our economy. In other words, the policy to be implemented is  $\tau_M^* = \theta_M$ .

## 6. DISCUSSION OF RESULTS

A summary of the findings from this study is presented here. The theoretical analysis produces several interesting findings. First, in an economy with a majority electoral system, environmental regulation policies are likely to be polarizing. In other words, taxes that aim to reduce the negative effects of pollution will differ from those that would be socially optimal. This is so because political institutions in a majority electoral system cause an equilibrium in which political parties implement significantly more or less environmental regulation policies than the socially optimal level, depending on the identity of the ruling party. In this equilibrium, party policies do not converge (unlike the proposal of the median voter model in a majority electoral system [Downs, 1957]), which then explains the stylized facts of modern economies in which leftist and rightist political parties implement differing public policies.

In particular, the model predicts that if a left-wing party represents voters who have a (relatively speaking) higher cost of pollution than those represented by the right-wing party, then the environmental regulations proposed by the latter will be more flexible (i.e. more tolerant of contamination) than the corresponding policy proposed by the left-wing party. However, in neither case is environmental policy socially optimal, unless the party that wins elections represents the average voter in the electorate.<sup>5</sup>

Second, in an economy with an electoral system of representation, the environmental regulation equilibrium policy is moderate—that is, it does not have a significantly high or low level of taxes to regulate pollution levels, as would occur in the equilibrium a majority electoral system economy. This makes it more probable that this type of policy, when adopted in an economy with a proportional representation electoral system, is closer to the socially desirable version of it.

This important difference in the type of policies that would be implemented in economies with proportional and majority representation electoral systems has two explanations: *i*) in a proportional representation system, political party registration quotas are lower than those that exist in a majority system, causing there to be more effective parties in such a system than in a majority system (Liphart, 1994). Meanwhile, *ii*) the existence of more parties in a proportional representation system makes it less likely that any one party will have control of the executive and legislative branches (although it is possible, and in fact occasionally happens); therefore, the party in power can design public policies without needing to negotiate with other parties. In other words, in an economy with a proportional representation electoral system, electoral competition in the legislative branch tends to force parties to negotiate more moderate environmental policies, while in a majority electoral system it is more likely that a single party controls the executive and legislative branches—in which case the party in power is not forced to negotiate environmental policy with the other parties.

In the case of a majority electoral system, environmental policy reflects the public policy interests of a minority coalition, translating into polarizing public policies (which reflect the extreme interests of voters in the electorate); meanwhile, in a system of proportional representation, legislative negotiation helps improve the representation of at least a majority’s interests, prompting the implementation of moderate public policies.

## 7. CONCLUSIONS

In this analysis, the impact of electoral systems’ institutions on public policy design has been addressed—in particular, their impact on the design of environmental policy. The institutions that form a democratic electoral system may be linked to the environmental policies a democracy adopts, since such institutions determine the number of parties that compete in elections, as well as each one’s level of representation in congress. In this article, an

electoral competition model was developed that accounts for the design of taxes that seek to reduce the negative effects of pollution, in two cases of interest: 1) economies with a majority electoral system, and 2) economies with a proportional representation electoral system.

Empirical evidence shows that in the practice of majority electoral systems there are fewer political parties, which has implications for the legislative negotiation of parties that are represented in congress. A single party controlling congress is thus more likely in a majority electoral system (in the case of a party that wins and obtains control of the executive and legislative branches, giving it ample possibilities to design economic policies as it wishes). In contrast, in a proportional representation system there are more political parties and it is more likely that public policy as implemented in congress is based on consensus among the various parties.

Several relevant theoretical findings were also obtained. First, in an economy with a majority electoral system, environmental regulation policy is very likely to be polarizing. In other words, environmental taxes are instated which are significantly higher or lower than the socially optimal level, depending on the ruling party's identity. In this equilibrium the parties' policies do not converge, which explains the stylized fact that left-wing and right-wing parties implement differentiated public policies. Second, in an economy with a proportional representation electoral system, the environmental regulation equilibrium policy is moderate—it is not a policy with a significantly high or low level of taxes, as would occur in the equilibrium of an economy with a majority electoral system. Finally, the analysis predicts that the environmental regulation policies implemented in a proportional representation electoral system will be closer to the socially desirable version of such policies.

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## APPENDIX

**Proposition 2.** The Pareto efficient consumption level for type  $h$  family is  $x_h^*$ , which satisfies:

$$x_h^* = \frac{1}{p_x + \sum_{h=1}^H \theta_h} \quad \forall h = 1, 2, \dots, H \quad (\text{A.1})$$

Which implies that the aggregate Pareto efficient equilibrium level of good  $X^*$  is:

$$X^* = \sum_{h=1}^H x_h^* = \frac{H}{p_x + \sum_{h=1}^H \theta_h} = \frac{1}{\frac{p_x}{H} + E[\theta_h]} \quad (\text{A.2})$$

Where  $E[\theta_h]$  is the average personal cost of the private good's pollution, which is given by:

$$E[\theta_h] = \frac{\sum_{h=1}^H \theta_h}{H} \quad (\text{A.3})$$

**Proof**

The problem of the economic policy designer is:

$$Max_{\{x_h^*\}} \Psi = \sum_{h=1}^H v_h = \sum_{h=1}^H \ln(x_h) - \sum_{h=1}^H \theta_h x_h - p_x \sum_{h=1}^H x_h \quad (A.4)$$

First order conditions are given by:

$$\frac{\partial \delta}{\partial x_h} = \frac{1}{x_h} - \sum_{h=1}^H \theta_h - p_x = 0 \quad (A.5)$$

Such that:

$$x_h^* = \frac{1}{p_x + \sum_{h=1}^H \theta_h} \quad \forall h = 1, 2, \dots, H \quad (A.6)$$

Which implies that the aggregate Pareto efficient equilibrium level of good  $X^*$  is:

$$X^* = \sum_{h=1}^H x_h^* = \frac{H}{p_x + \sum_{h=1}^H \theta_h} = \frac{1}{\frac{p_x}{H} + E[\theta_h]} \quad (A.7)$$

**Proposition 3.** The tax level that creates a Pareto efficient allocation in a market economy is:

$$\tau_h^* = \sum_{h=1}^H \theta_h - \theta_h \quad (A.8)$$

Now consider the problem of family  $h$ , determined by

$$Max_{\{x_h^*\}} v_h = \ln(x_h) - \theta_h x_h - \{p_x + \tau_h^*\} x_h \quad (A.9)$$

Which implies that the market consumption level of a type  $h$  family is given by  $\tilde{x}_h^m$  such that

$$\tilde{x}_h^m = \frac{1}{p_x + \theta_h + \tau_h^*} = \frac{1}{p_x + \sum_{h=1}^H \theta_h} \quad \forall h = 1, 2, \dots, H \quad (A.10)$$

Which implies a market equilibrium level given by:

$$\tilde{X}^m = \sum_{h=1}^H \tilde{x}_h^m = \sum_{h=1}^H \frac{1}{p_x + \theta_h + \tau_h^*} = \frac{1}{\frac{p_x}{H} + E[\theta_h]} \quad (A.11)$$

Such that a market economy with a Pigouvian tax  $\tau_h^* = \sum_{h=1}^H \theta_h - \theta_h$  implies that this equilibrium is Pareto efficient, since

$$\tilde{X}^m = X^* \quad (A.12)$$

### Proof

Consider now the problem of family  $h$ , determined by

$$Max_{\{x_h^*\}} v_h = \ln(x_h) - \theta_h x_h - \{p_x + \tau_h^*\} x_h \quad \forall h = 1, \dots, H \quad (A.13)$$

Which implies that the market consumption level for type  $h$  family by  $\tilde{x}_h^m$ , such that

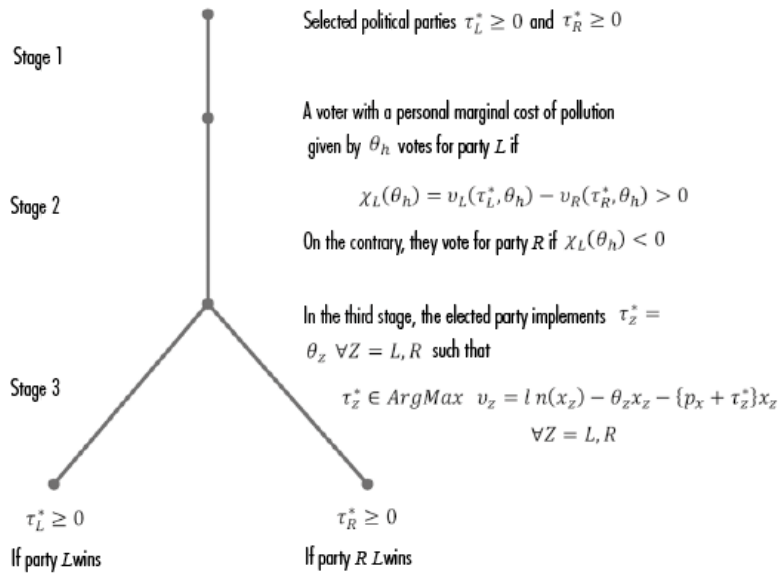
$$\tilde{x}_h^m = \frac{1}{p_x + \theta_h + \tau_h^*} = \frac{1}{p_x + \sum_{h=1}^H \theta_h} \quad \forall h = 1, 2, \dots, H \quad (A.14)$$

Which implies a market equilibrium level given by:

$$\tilde{X}^m = \sum_{h=1}^H \tilde{x}_h^m = \sum_{h=1}^H \frac{1}{p_x + \theta_h + \tau_h^*} = \sum_{h=1}^H \left\{ \frac{1}{p_x + \sum_{h=1}^H \theta_h} \right\} = \frac{1}{\frac{p_x}{H} + E[\theta_h]} \quad (A.15)$$

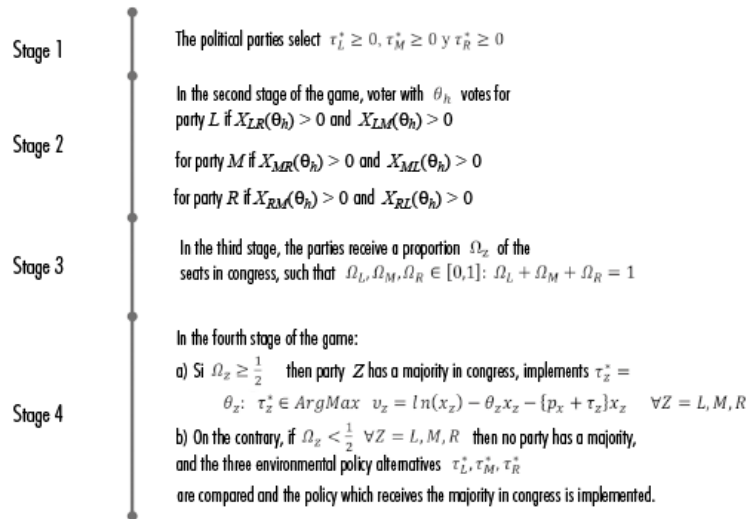
Where  $E[\theta_h]$  is the average personal cost of the private good's pollution, which is given by  $E[\theta_h] = \frac{\sum_{h=1}^H \theta_h}{H}$ .

Figure A1. Electoral equilibrium for an economy with a majority electoral system



Source: prepared by the authors.

Figure A2. Electoral equilibrium for an economy with a proportional electoral system



Source: prepared by the authors.

<sup>1</sup> In the literature, it is common to use indirect functions such as the one provided in equation (1) (see Besley and Coate, 2003, among others).

<sup>2</sup> Equation (2) is easily obtained by solving the family resource allocation problem characterized in equation (1).

<sup>3</sup> In the previous section, and following the literature, it is assumed that, in an economy with a majority electoral system, the party that wins the election "takes all". This assumption means that the party that wins the election forms the executive Branch and has an absolute majority in congress.

<sup>4</sup> The comparison of public policy alternatives is done through voting rounds where option one is compared against option two; the winner of these options is compared with the third one, and so on, until all possible options have been voted on.

<sup>5</sup> It is well established in the literature that parties design environmental policies which maximize the welfare of the average voter, such that these policies also maximize the welfare of society.