

ESSAYS IN THE POLITICAL ECONOMY OF
ENVIRONMENT AND AGREEMENT

BY

SARA ORNATI

A Dissertation submitted to the Graduate School
in partial fulfillment of the requirements
for the Degree

Doctor of Philosophy

University of Nottingham
Nottingham

September 2014

ABSTRACT

This thesis consists of three substantive chapters on the impact of externalities on policy outcomes in selected contexts.

Chapter 2 develops a theoretical model of international environmental agreements between the high-income countries of the world. It contributes to the literature on carbon leakage by focusing on the investment channel. Three policy scenarios are considered: full agreement, non-cooperative policy and partial agreement. The full agreement is characterised by complete cooperation within the whole high-income bloc, in both deciding the amount of allowed emissions and setting the ad valorem tax on abatement. The non-cooperative policy is characterised by the individual high-income country choosing independently both emissions level and the abatement tax. The partial agreement is characterised by emissions chosen cooperatively within the high-income bloc and the abatement tax set non-cooperatively. Our results show that under full agreement carbon leakage is negative, whilst under the other two policy scenarios it is positive. Indeed, we show that carbon leakage is due to the design of the partial agreement, which leaves the choice of the policy instrument to be implemented to the individual signatory.

The aim of Chapter 3 is to explain why a government signs up to an international environmental agreement (IEA), thereby renouncing the freedom to choose its own environmental policy. In a two-period model of probabilistic voting à la Lindbeck and Weibull (1987), the incumbent government decides on the level of commitment to the IEA in the first period. There are two competing political parties, which care about the environmental policy implemented in the country and about the rents from being elected.

Each party faces a trade-off between implementing its ideal environmental

policy and committing to a policy that increases its chances of reelection. The non-green party's ideal policy requires rejection of the IEA. However, if the electorate is sufficiently green, the party will choose a level of commitment to the IEA that is greater than zero. The green party's ideal policy requires full commitment to the IEA. However, if the electorate is sufficiently green, the party will choose a level of commitment to the IEA that is lower than one.

Chapter 4 develops a static model where there is a political issue of dichotomous type and agents can either be in favour or against it (e. g. peaceful co-living with the members of the other ethnic community). Our model shows that the evolution over time of the idea depends on the fraction of the population supporting it. Indeed, if the proportion of the population supporting an idea is lower than a certain threshold, then the agents supporting it will change their opinion and switch to the opposite opinion. If the proportions of the population are evenly balanced between the two opposite ideas, then agents on either side will stick with their initial opinion.

We apply this model to the Cyprus conflict in order to explain why peace-keeping authorities have unsuccessfully been trying to find a solution since 1974. To that end, we use UNDP-ACT Survey data from the period 2007-2013. These data show that Cypriots are stuck in an impasse, where more than 40% of the population is highly concerned about the situation of the island, but nonetheless the fraction of the population who desires to reach a solution is quite low and the proportion of the population who supports peaceful co-living is stagnant. The aim of the paper is to give a theoretical explanation of this impasse and explain the reason why decades of international efforts miserably failed.

ACKNOWLEDGMENT

First, I wish to express sincere gratitude to my supervisors, Dr. Dijkstra and Dr. Anesi for their invaluable guidance and advice. I would not have been able to achieve this goal without their priceless contributions and encouragement.

Second, I am forever indebted to my family for their support, patience and unconditional love.

I am grateful to the staff members of the School of Economics, University of Nottingham, for their cordiality and kind assistance throughout the PhD programme.

Last but not least, thanks to all my office colleagues for providing me with a supportive and friendly environment.

All remaining errors are solely my responsibility.

CONTENTS

LIST OF FIGURES	ix
LIST OF TABLES	x
1 INTRODUCTION	1
2 ENDOGENOUS CARBON LEAKAGE FROM AN INTERNATIONAL ENVIRONMENTAL AGREEMENT	9
2.1 Introduction	9
2.2 Related Literature	13
Carbon leakage.	15
Size of carbon leakage.	17
Abatement subsidy.	20
Potential policy responses to carbon leakage.	21
Extensions.	23
Negative leakage.	25
Emission pricing.	26
Border tax adjustments.	26
2.3 The Model	29
Firms, emissions and abatement.	30
Consumers.	33
2.3.1 Capital allocation	34
2.3.2 Autarky	36
2.4 Policy scenarios	40
2.4.1 Full Agreement	42
2.4.1.1 Stage two	42
2.4.1.2 Stage one	44

2.4.1.3	Autarky	48
2.4.2	Non Cooperative Policy	50
2.4.2.1	Stage two	51
2.4.2.2	Stage one	55
2.4.2.3	Autarky	58
2.4.3	Partial Agreement	60
2.4.3.1	Stage one	61
2.4.3.2	Autarky	62
2.5	Comparisons between policy scenarios	63
2.5.1	Comparison between full agreement and partial agreement	64
2.5.2	Comparison between non-cooperative policy and partial agree- ment	65
2.5.3	Comparison between full agreement and non-cooperative policy	66
2.6	Conclusion	67
2.7	Appendix A: Autarky Solution	72
	Inequality (2.33).	73
2.8	Appendix B: Full Agreement	74
2.9	Appendix C: Non Cooperative Policy	75
2.10	Appendix D: Proofs	77
	Lemma 1.1.	77
	.2.	77
	Lemma 3.i.	78
	ii.	78
	iii.	79
	iv.	79
	Lemma 3.i.	79

ii.	80
iii.	80
iv.	80
Proposition 6.	80
 3	
INTERNATIONAL ENVIRONMENTAL AGREEMENTS AND DOMESTIC POLITICS	83
3.1 Introduction	83
3.2 The Model	92
Economic Setting.	92
Timing.	94
Electoral Competition.	95
Alternative Setting.	98
3.3 Political Equilibrium	99
3.3.1 Benchmark: Exogenous Probabilities of Victory	99
3.3.2 The Probability of Victory Functions	100
3.3.3 A Non-Green Incumbent May Commit to Protect the Environment	103
3.3.4 A Green Incumbent May Not Commit to Protect the Environment	106
3.3.5 Numerical Simulations	107
3.4 Conclusion	109
 4	
SOCIAL INTERACTIONS IN CYPRUS: AN EVOLUTIONARY APPROACH	113
4.1 Introduction	113
4.2 Related Literature	116
4.3 Theoretical model and general solution	122
Initial fraction of the population supporting	
idea i higher than the threshold.	125

	Initial fraction of the population supporting	
	idea i lower than the threshold. . .	125
	Initial fraction of the population supporting	
	idea i within the area of inertia. . .	126
4.4	Empirical illustration	126
4.4.1	The Cyprus Issue: historical overview	126
4.4.2	Descriptive Statistics	132
4.4.3	Interpretation of results	138
4.5	Conclusion	139
5	CONCLUSION	142

LIST OF FIGURES

2.1	Domestic production and abatement in autarky as a function of domestic emissions ($\bar{K}_h = 18, \theta = 2$).	40
2.2	Sigma in autarky as a function of domestic emissions ($\bar{K}_h = 18, \theta = 2$).	41
4.1	Major issues: Greek Cypriot Community (UNDP-ACT, 2013) . .	133
4.2	Major issues: Turkish Cypriot Community (UNDP-ACT, 2013) .	134
4.3	Peaceful co-living: Greek Cypriot Community (UNDP-ACT, 2013)	135
4.4	Peaceful co-living: Turkish Cypriot Community (UNDP-ACT, 2013)	135
4.5	Expectation of a solution: Greek Cypriot Community (UNDP-ACT, 2013)	137
4.6	Expectation of a solution: Turkish Cypriot Community (UNDP-ACT, 2013)	138

LIST OF TABLES

3.1	Choice of level of commitment for non-green incumbent	109
3.2	Choice of level of commitment for green incumbent	109

CHAPTER 1

INTRODUCTION

This thesis focuses on the impact of externalities on policy outcomes in selected contexts. We take into account three different situations where externalities make a difference, investigate their role and the resulting outcomes. Externalities exist when an agent's utility is affected by the action taken by another agent in an unintended manner and with no compensation (Laffont, 2008). More specifically, we focus on environmental externalities, defined by Chander and Tulkens (1997) as externalities that affect all agents in the economy.

Since Pigou (1946), who first discussed the need for government intervention when externalities arise, they have been widely analysed in economics and their importance has been broadly recognised. Cornes and Sandler (1996) state that externalities are "pervasive features of human society", hence their study is of primary interest for economists. The impact of externalities is not taken into account through market mechanisms, hence they are considered market failures. Indeed, market prices do not represent marginal cost (in the case of negative externalities) or marginal benefit (in the case of positive externalities). Therefore, the outcome is not Pareto optimal. The traditional economic explanation for environmental issues relates to the existence of missing markets for property rights and market failures. Hence, this is considered one of the areas where the intervention of governments can improve welfare levels.

Three externality-generating frameworks are considered: an international environmental agreement with partial coverage, the democratic choice of environmental taxes and social interactions.

The first two topics analyse two different aspects of one of the most well-known negative externalities: pollution. Indeed, pollution causes, amongst other things, climate change which has a dramatic effect on human, animal and vegetal life.

The starting point of the second chapter is that at an international level, each country has the right to decide its own environmental policy and there is no international institution that has the power to make countries ratify international environmental agreements. Moreover, due to the free rider issue, only environmental agreements with only a limited number of signatories have actually come into force. Worldwide full cooperation generates the first best outcome, whilst partial cooperation results in carbon leakage. By carbon leakage we mean the increase in greenhouse gas emissions in countries outside the agreement (IPCC, 2007).

The chapter deals with international environmental agreements with partial geographical coverage and analyses how the existence of a non-internalised externality affects the outcome of the treaty. We consider a world divided into two blocs: high-income and low-income. Three policy scenarios are considered: full agreement, non-cooperative policy and partial agreement. It is assumed that only the high-income bloc has an environmental policy. High-income countries have emission permits and ad valorem abatement taxes available in order to achieve their emissions reduction target. Under a full agreement, both allowed emissions and the ad valorem tax on abatement are chosen cooperatively by the countries constituting the high-income bloc. Therefore, in this policy scenario, high-income bloc's first best policy outcome is reached. On the other hand, under non-cooperative policy both allowed emissions and the ad valorem tax on abatement are chosen independently by each individual country constituting the high-income bloc. In this chapter, the relevant externality derives from the fact

that under a partial agreement, allowed emissions are decided cooperatively within the whole high-income bloc, whilst the ad valorem tax on abatement is chosen independently by the individual high-income country, taking other countries' policy instrument as given. In this policy scenario high-income countries' policies are not coordinated and hence the environmental damage inflicted on the rest of the bloc (through capital movements) is not taken into account. Therefore, the environmental externality is not fully internalised.

The main findings of the chapter are that under full agreement carbon leakage is negative; whilst under the other two policy scenarios carbon leakage is positive. Under full agreement the optimal ad valorem subsidy level is high, thus attracting capital from the low-income bloc. As a consequence, the high-income bloc can reduce its emissions without suffering from a output loss, but at the expense of a higher distortion in the capital market. On the other hand, under non-cooperative policy and partial agreement the optimal ad valorem subsidy is low, thus capital moves away from the high-income bloc. As a consequence, the individual high-income country can reduce its emissions without distorting its capital market, but at the expenses of lower domestic output. Another important result of the chapter is to show that carbon leakage is a by-product of the design of the partial agreement, which leaves the choice of the ad valorem tax on abatement to the individual signatory.

The starting point of the third chapter is that more than 400 international environmental agreements (IEAs) have been ratified in the past 40 years (UNEP, 2012). This is a dramatic number and thus, the analysis of IEAs' participation has attracted a great deal of interest, especially the identification of variables that are significant in order to find out domestic governments' benefits from IEAs (Congleton, 2001). However, there is still a lot of uncertainty on which factors affect

the likelihood of a country to commit to an IEA (Fredriksson et al., 2007) and few studies have been devoted to theoretical modelling. Therefore, this chapter wants to fill this gap in the theoretical literature and analyse the impact of domestic partisan politics on IEAs' ratification choice.

The chapter deals with the democratic choice of environmental taxes, which are instruments to deal with the negative externality at the centre of this chapter, that is pollution. The aim of this chapter is to give a theoretical explanation of the reason why a government might renounce the capability to choose its own environmental policy. Indeed, joining an IEA implies future rules (policy cost) to be taken into account. Citizens are modeled in such a way that they differ in their environmental concern, which is distributed according to a known density function. Two political parties, which differ in their environmental policy preferences, compete in an election to obtain office. Political parties care about both the environmental policy implemented in the country and the rents from being in office. The framework uses a two-period model of probabilistic voting à la Lindbeck and Weibull (1987). There is an international environmental agreement in place and in the first period the incumbent government decides on the level of commitment to the IEA. The level of commitment is defined as the choice of the extent to which signatories decide to commit to the IEA (e.g. Mattes 2012). For example, escape clauses (Pelc, 2009) represent a common mechanism through which governments limit their commitment to IEAs.

In the second period, elections take place and the elected government sets its environmental policy. The level of commitment is modeled as the probability that the government will have to comply with the terms of the IEA. If the level of commitment is equal to zero, then the government does not join the IEA. Hence, the party in power in the second period will set its ideal policy. If the level

of commitment is equal to unity, then party in power in the second period will have to comply with the terms of the IEA with a probability of one. A level of commitment at an intermediate value happens when the incumbent has joined the agreement, but with the future possibility of not fully complying to it.

Two types of incentives, policy and electoral, appear in this model and are important in order to explain whether the government in the first period chooses to commit to the IEA or not. The policy incentive provides a reason for parties to care about which policy shall be implemented. In the benchmark case the probabilities of victory are exogenously fixed and hence, there are no electoral incentives and the only incentive at work is the policy one. In the benchmark case the non-green party always chooses a level of commitment equal to zero, never committing to the IEA because it wants to be able to implement its ideal policy if re-elected. The green party always chooses a level of commitment equal to one, always fully committing to the IEA because it wants to constrain the policy choice of the government in power in the second period, in order to make it as close as possible to its own ideal policy.

With endogenous probability of victory, electoral incentives play a role because parties can affect their probabilities of victory. Therefore, they will try to increase their probability of winning the elections. If the proportion of green citizens is large enough, the non-green party's (green party) probability of winning the elections increases (decreases) with commitment. Indeed, an increase in commitment makes the green citizens better (worse) off in case the non-green (green) party wins and, consequently, more (less) likely to vote for it. An interesting result is that a trade-off exists between policy and electoral incentives: a increase at the margin in the level of commitment has two opposing effects on parties' payoffs.

When the proportion of the population with high environmental concern is

high enough, an increase at the margin in the level of commitment positively affects the non-green party's payoff through an increase in its probability of winning the elections. On the other hand, an increase at the margin in the level of commitment has a cost in terms of policy loss, given that the policy that will be implemented will be far from the parties' ideal one. Consequently, the non-green party chooses a level of commitment strictly positive when the electoral incentive is bigger than the policy incentive. These results are in contrast with those obtained with exogenous probabilities of victory, showing that electoral concerns may be the main reason for a non-green party to join an IEA. When the proportion of the population with high environmental concern is high enough, an increase at the margin in the level of commitment negatively affects the green party's payoff through a reduction in its probability of winning the elections. On the other hand, an increase at the margin in the level of commitment has a positive effect due to the fact that the non-green party will be constrained if elected and hence it will have to implement a policy closer to the green party's ideal one. Consequently, the green party chooses a level of commitment strictly lower than one when the electoral gains exceed policy gains.

The starting point of the fourth chapter is that social interactions generate externalities that have an impact on agents' actions and payoffs. We build up a static theoretical model that focuses on social interactions and we apply it to the Cyprus issue. After 1974, Cyprus has been invaded by Turkey and it has been, since then, a divided island. Over the decades, the UN, the UE and several other organizations have tried, with no tangible result, to negotiate an agreement between the two ethnic communities in order to reunify the island. In the model, utility maximizing agents form their opinions on a salient issue by comparing their payoffs with those of other agents and their payoffs depend on the number

of individuals with the same opinion.

The aim of the chapter is to give a theoretical explanation of the impasse that the situation in Cyprus has reached and explain the reason why hundreds of peace negotiations miserably failed. In our model agents differ only in the opinion they have over a political issue. Agents' opinions are the result of a utility maximizing process. They are randomly matched and meet in pairs at any time period. Agents occasionally compare their current payoffs with the expected payoff they would get if they decided to change their opinion. Moreover, we assume that there is a friction: agents have to bear a strictly positive psychological cost if they decide to change their opinion. This cost represents the difficulty of changing behaviour and adapting to new circumstances.

According to the model, the evolution over time of the idea depends on the fraction of the population supporting it. Indeed, if the proportion of the population supporting either idea is lower than a certain threshold (which is less than half of the population), then over time the agents supporting it will change their opinion and switch to the other idea. If the population is fairly evenly split between both ideas, then all agents will stick with their initial opinion. We define this as the area of inertia.

Using UNDP-ACT Survey data (2007-2013) we show that the situation in Cyprus is consistent with the assumptions of our model, reinforcing the applicability of our model to this issue. Moreover, the prediction of the model is consistent with the behaviour of the two Cypriot Communities. We report descriptive statistics from the surveys to support our claim. Moreover, we state that the impasse in Cyprus is due to the fact that the proportion of the population supporting peaceful co-living is in the area of inertia.

The last chapter sums up the issues analysed in this thesis, its main findings

and limitations. It also provides ideas for future research.

CHAPTER 2

ENDOGENOUS CARBON LEAKAGE FROM AN INTERNATIONAL ENVIRONMENTAL AGREEMENT

2.1 Introduction

In the past few decades the concern about pollution and emissions levels has dramatically increased and, in turn, the efforts in order to cut them down. Indeed, pollution is responsible for negative phenomena, such as climate change, which have devastating impacts on human, animal and vegetal life. The final draft of IPCC (chapter 5, p. 394, 2014) reports that, over the period from 2000 to 2010, GHGs emissions in developing countries have more than doubled. This figure is common amongst developing countries exporting carbon-intensive goods to the developed world. Therefore, IPCC (2014) suggests that this evidence supports the existence of a carbon outsourcing phenomenon from developed countries towards developing ones.

The traditional economic explanation for environmental issues relates to the existence of missing markets for property rights and market failures. Hence, this is considered one of the areas where the intervention of governments can improve welfare levels. International environmental regulations are extremely difficult to implement because each country has the right to decide for itself and no international law is able to force them to ratify any international environmental treaty. Moreover, due to the high incentive for countries to free ride, the only environmental agreements that have been signed included only a limited number of signatories. Worldwide full cooperation does lead to first best outcome, whilst partial

cooperation does not achieve it and, as a consequence, carbon leakage arises.

By carbon leakage we mean the increase in greenhouse gases emissions in certain countries (usually with lenient environmental policies or with no policies at all), due to other countries stricter environmental policies (IPCC, 2007).

The aim of the present chapter is to show that carbon leakage is a by-product of the existence of the agreement itself. Indeed, we shall show that carbon leakage is due to the design of the partial agreement, which leaves the choice of the policy instrument to be implemented to the individual signatory.

There are several channels involved in carbon leakage (Karp, 2011). Three of them are the most analysed in the literature. The first one is referred to as the "investment channel". It predicts the relocation of high-pollutant firms towards countries with more lenient environmental regulation as a consequence of differentials in the return on capital. Indeed, countries with a unilateral stricter environmental policy will experience a reduction in their return on capital, whilst non-environmentally constrained countries will still enjoy higher returns. The second one is the so-called "competitiveness channel". The main focus of this mechanism is the change in the international market share configuration. Indeed, high-polluting industries located in countries with a strict environmental policy will experience an increase in their production costs and, hence, a reduction in their international competitiveness. On the other hand, pollution intensive industries located in countries with no environmental policy will experience an increase in their international competitiveness. Therefore, market shares will re-allocate: the former will face a drop in their international market share, whilst the reverse will happen to the latter. The "fossil fuel price channel" is activated when the reduction in emissions included in an environmental agreement decreases the demand of fuel by the signatories and, in turn, its world price. As a consequence,

the non-signatory countries will be able to enjoy lower prices and hence their fuel demand will increase. This, in turn, will push up their emissions, affecting the outcome of the environmental agreement.

Carbon leakage is particularly of interest because it makes developed countries look greener than they really are. In fact, they seem to have apparently achieved their pollution emissions reduction, due to the fact that their emissions levels are left unchanged whilst their consumption levels have increased. Actually, several papers have demonstrated that a number of developed countries are simply outsourcing their emissions (Cole and Elliott, 2005; Rothman, 2000; Weber and Matthews, 2007; Aichele and Felbermayr, 2012), passing the burden of high pollution rates to developing countries. In particular, Cole and Elliott (2005) found evidence of a pollution haven effect by analysing US FDI to Mexico and Brazil and Aichele and Felbermayr (2012), by using input-output tables, found that the Kyoto Protocol did not have a positive impact on countries' carbon footprints.

This chapter contributes to the literature by focusing on the investment channel. The starting point is the empirical evidence that only partial international environmental agreements have been signed. Carbon leakage is generated as a consequence of the inefficiency of partial international environmental agreements, that do not reach the first best. We consider a world divided into two blocs: high-income and low-income. Three policy scenarios are considered: full agreement, non-cooperative policy and partial agreement. The full agreement and the non-cooperative policy represent our benchmarks, against which the partial agreement outcome shall be compared. In order to represent a partial agreement it is assumed that only the high-income bloc has an environmental policy. High-income countries have emissions permits and ad valorem abatement taxes available in order to achieve their emissions reduction target. Welfare-maximizing governments

cap the total level of emissions and create an amount of emissions permits equal to the allowed quantity. Therefore, this instrument is necessary for the country to comply with the terms of the agreement. The second instrument, the abatement subsidy, regulates how the set target shall be achieved: either through the use of abatement technologies or re-locating capital abroad. The analysis and comparison of the optimal subsidy level in each of the policy scenarios shall be crucial in our framework. The main contribution of this chapter is to explain that carbon leakage is due to the strategic behaviour put into practice by signatories. Indeed, they have an incentive to use policy instruments, such as tax rates on capital and abatement subsidies, in a strategic way, without taking into account the externality they impose on other countries, because the emissions reduction they agreed to achieve is already higher than the non-cooperative outcome. That is to say, each country uses its policy instruments in order to maximise its own welfare, taking the other countries' emissions levels as given.

Our results show that under full agreement carbon leakage is negative; whilst under the other two policy scenarios carbon leakage is positive. Optimality under full agreement requires a high subsidy level and hence, capital inflow from the low-income bloc. Indeed, the high-income bloc can achieve its emissions target without suffering from a output loss, but at the expenses of a higher distortion in the capital market. On the other hand, optimality under non-cooperative policy and partial agreement requires a low subsidy level and hence, capital outflow towards the low-income bloc. Indeed, the individual high-income country can achieve its emissions target without distorting its capital market, but at the expenses of lower domestic output.

When comparing full agreement and non-cooperative policy we found that the impact on domestic production and abatement under non-cooperative policy

is so big that it is the dominant one, regardless of the relative strength of the impact of an increase in the subsidy on foreign production under full agreement and non-cooperative policy. Therefore, the optimal subsidy under full agreement is higher than under non-cooperative policy. When comparing full agreement and partial agreement we found that under full agreement the dominant effect is the impact of an increase in the ad valorem tax on abatement on foreign production. On the other hand, under partial agreement the dominant effect is the impact of an increase in the abatement tax on domestic production and abatement. Therefore, the optimal abatement tax under full agreement is lower than under partial agreement. When comparing partial agreement and non-cooperative policy we found that carbon leakage is higher under partial agreement. Indeed, under partial agreement the individual high-income country has agreed to cut its emissions more than under non-cooperative policy. Therefore, the optimal abatement tax under full agreement is lower than under partial agreement.

The rest of the chapter is organized as follows. Section 2.2 gives an overview of the main findings of the carbon leakage literature, paying particular attention to the extensions of the basic carbon leakage model and the policy-related issues. The model is described in Section 2.3. Section 2.4 analyses how firms and capital owners behave for given policies. The analysis and comparison of full cooperation, non-cooperation and partial agreement policy scenarios is the focus of Section 2.5. Section 2.6 concludes.

2.2 Related Literature

This chapter draws from both the literature on mobile capital and carbon leakage. The former is extremely broad and, for the sake of this chapter's analysis, we are mainly interested in the counter-intuitive result obtained by Oates and Schwab (1988) and Ogawa and Wildasin (2009), that is to say the optimality of

the decentralised policy. Ogawa and Wildasin (2009) build from Oates and Schwab (1988) and add interjurisdictional environmental spillovers. Indeed, in Oates and Schwab (1988) local pollution only depends on local economic activities, whilst Ogawa and Wildasin (2009) introduce a parameter that measures to which extent worldwide production activities impact on local pollution. The current chapter differs from both, given that it assumes perfect environmental spillovers, that is to say that one unit of worldwide production activities generate one unit of local pollution. This is always the case with GHGs emissions.

Ogawa and Wildasin (2009) have shown that under certain conditions, the decentralised equilibrium is Pareto efficient both with and without transboundary pollution. Its implication is that international cooperation is not necessary, because uncoordinated policies can reach Pareto efficiency, but it should be emphasised that a number of crucial assumptions lie behind these findings. For example, efficiency in the latter depends on the existence of price-taking firms, undistorted markets, small countries (with given terms of trade) and the feasibility of lump sum taxation. The Ogawa and Wildasin (2009) finding is only valid when the rate of return on capital and both the total amounts of capital and emissions are given, that is there is no abatement or any other activity that consumes capital. The tax rates are not uniquely defined; hence the efficient allocation of capital in each region is not given by their absolute values, but only by their differences. Eichner and Runkel's (2012) result is coherent with Ogawa and Wildasin (2009). Moreover, they show that when capital supply is not fixed, countries can only reach inefficient outcomes when setting their policy instruments independently. Fell and Kaffine (2014) criticize Ogawa and Wildasin's (2009) finding by highlighting how it entirely relies on the assumptions of fixed capital and environmental damage (per unit of capital). Moreover, they extend Ogawa and

Wildasin's (2009) model and, by relaxing those essential assumptions, show that the non-cooperative outcome is not generally efficient.

The current chapter differs from Oates and Schwab (1988) and Ogawa and Wildasin (2009) in a number of ways. Indeed, it divides the world into two blocs: the high-income countries' bloc and the low-income countries' bloc. Moreover, it introduces an international environmental agreement signed by all the high-income countries and assumes that low-income countries have no environmental policy. Moreover, we introduce a capital-consuming activity in the form of abatement services, that substantially modifies the initial framework by allowing for capital used in production activities and emissions to vary. Ogawa and Wildasin (2009) limit their analysis to the decentralised policy scenario, whilst we expand the analysis to three policy scenarios: cooperative agreement, non-cooperative policy and partial agreement.

Ogawa and Wildasin (2009) reach an interesting counter-intuitive result: decentralised policy is able to reach the first best outcome. We shall see that in the current chapter the non-cooperative scenario does not reach the first best outcome. This result comes from the fact that in the present chapter the amount of capital invested in production is not given. Indeed, in our model an important role is played by abatement services, that use capital and hence, impact on the amount of capital invested in productive activities.

The rest of this section shall introduce the carbon leakage issue and give an overview of the main themes that have been analysed in the literature.

Carbon leakage. The carbon leakage issue derives from the interaction between international trade and transboundary pollution when capital is perfectly mobile. The strict environmental policy in the countries within the agreement causes the

rate of return on capital in the pollution-intensive sectors to fall. If capital is mobile, there will be capital offshoring that will contribute to the growth of foreign production and hence emissions. Linked to carbon leakage there is an important competitiveness issue. Indeed, one of the main arguments used against non-global environmental agreements is that the country's energy intensive industries will be forced to face higher costs than their competitors based in regions with more lenient environmental policies. Hence, environmentally cooperative countries will suffer from a lowering of their investments and flight of capital, leading to lower employment rates and income levels.

The seminal paper in this literature is Markusen (1975), which models pollution in an international externalities framework. This is one of the first papers to analyse the interdependence between two countries when they are tied by a bilateral externality. His main finding is that a production tax is not Pareto efficient by itself, but it becomes so when accompanied with a redistributive payment. The mix of the two policies equalizes the marginal benefits of both countries coming from the other one's emissions cutting, and this condition makes the cooperative solution Pareto optimal. The Pareto efficient outcome can only be reached when the climate policy is implemented as a mixture of optimum production taxes and transfers, under the condition of free trade.

Economists have reached consensus about the existence of carbon leakage associated with environmental agreements with partial geographical coverage. Therefore, a number of studies, both theoretical and empirical, have focussed on analysing and quantifying the size of carbon leakage. For example, Burniaux and Martins (2012) use a two-region, two-goods general equilibrium model in order to analyse the factors that determine the size of carbon leakage. Their simulations are based on data for the year 1995 and on the OECD GREEN database. The

main findings of the paper are that the size of carbon leakage is mainly driven by the coal supply elasticity and the shape of the production function. Moreover, carbon leakage rate estimates are small in magnitude.

Size of carbon leakage. A strand of this literature quantifies the amount of emissions for a number of developed countries using the consumption based criterion, that is to say the emissions generated in other countries in order to produce the goods consumed in the considered country (Ghertner and Fripp, 2007; Levinson, 2010; Fæhn and Bruvoll, 2009) and the carbon leakage embodied in the Kyoto Protocol (Paltsev, 2001; Kuik and Gerlagh, 2003; Aichele and Felbermayr, 2012). The empirical results have been controversial and the estimates of carbon leakage for the signatories with binding targets (the so-called Annex B countries) vary significantly, ranging from 10% (Paltsev, 2001) to 130% (Babiker, 2005). Fæhn and Bruvoll (2009) test empirically whether an increase in economic growth and domestic emissions increases carbon leakage. They compute the amount of pollution embodied in imports and exports in order to quantify the import related leakages and the export related leakages for Norway. A limitation of the validity of the findings of this paper is given by the fact that only direct leakages (due to direct trade) have been considered. The periods considered are from 1980 to 2000 based on historical data and from 2000 to 2030 based on simulations. For the period until 2000, according to their results, the increase in the import related leakages were smaller than the expansion of the export leakages. Hence, the pollution leakage hypothesis finds no support. For the simulations the pollution leakages hypothesis is not supported either. Ghertner and Fripp (2007) and Levinson (2010) use the input-output life cycle model to analyse US environmental policy. The first paper focuses on the Environmental Kuznets Curve (EKC), that is the highly de-

bated relationship between environmental quality and per-capita income found for the first time by Grossman and Krueger (1993). The main result is that with the consumption-based method the EKC is N-shaped instead of having the commonly known inverted U-shape. Levinson (2010) calculates the pollution embodied in all imports and finds a green shift of imports, that is to say the US have increased their imports of clean goods and decreased those of dirty goods. The main results are that the US has changed the composition of its production: higher fraction of cleaner goods and lower fraction of dirty goods (green shift). The same green shift happened in the imports, with even a bigger magnitude than the domestic one and hence, the US does not appear to have offshored pollution.

Carbon leakage due to the Kyoto Protocol is the focus issue of Paltsev (2001). This paper makes use of a static multi-sector, multiregional CGE model in order to quantify the magnitude of the carbon leakage phenomenon, paying particular attention to sectoral and regional differences. Since only a limited number of countries have agreed to be bound by the Kyoto Protocol, the best available outcome in this case is the second best, where additional costs due to this inefficiency have to be taken into account. The carbon leakage rate found for the Kyoto Protocol is around 10 per cent and the sector where leakage occurs the most is the chemical industry with a rate of approximately 20%. The countries responsible for this phenomenon are mainly the EU, whose leakage rate ranges between 36 and 51%, the USA (28-34%) and Japan (13-18%), whilst the most affected areas are China (24-32% of the total increase) and the Middle East (24-30%). Aichele and Felbermayr (2012) analyse the effectiveness of the Kyoto Protocol by quantifying signatories' carbon footprint, as well as domestic and imported emissions. By carbon footprint we mean the total amount of greenhouse gases embodied in goods. According to their findings, national emissions reductions have been essen-

tially counterbalanced by import-related ones, hence carbon footprints remained unchanged. As a consequence, this paper claims the Protocol has been overall ineffective, since it has not lowered worldwide pollution levels, but only relocated their generation.

The effect of trade liberalisation on carbon leakage is analysed in Kuik and Gerlagh (2003), through the empirical test of the Pollution Haven Hypothesis (PHH) and the Factor Endowment Hypothesis (FEH). The PHH states that a stringent environmental regulation can affect the country's comparative advantage and the production pattern. Indeed, countries with more lenient environmental standards, usually developing countries, will develop a comparative advantage in the production of high-polluting goods, thus becoming pollution havens. On the other hand, the FEH claims that pollution intensive firms are relatively more capital intensive and since developed countries are relatively more capital abundant, they will develop a comparative advantage in the production of high-polluting goods. As a consequence, developed countries will be the pollution havens, not the developing ones. They quantify the rate of carbon leakage embodied into the emissions reductions included in the Kyoto Protocol, both with and without trade liberalization. This paper follows the standard decomposition into scale, technique and composition effects implemented by Grossman and Krueger (1993) and applies it to carbon leakage. The results show that trade liberalization in the form of a reduction in import tariffs increases carbon leakage under the Kyoto Protocol, especially for energy goods. Nonetheless, the rate of carbon leakage due to the Kyoto Protocol is around 5% for Annex B countries and 11% for non-Annex I countries (countries not bound by emissions limits). Trade liberalization shows a positive effect in the OECD countries; indeed it partially counterbalances the competitiveness reduction experienced by energy intensive industries, supporting

the FEH. On the other hand, China and the Middle East show a shift towards more energy intensive, thus more polluting goods, supporting the PHH.

Babiker (2005) quantifies the relocation effects caused by the emissions reductions involved in the Kyoto Protocol. This paper challenges the results obtained by previous studies that used the general equilibrium model, because they do not take into account the industry relocation channel. An important feature of this paper is the introduction into the framework of the market structure characteristics, such as economies of scale and market power. The results show that the magnitude of carbon leakage heavily depends on the market structure and the degree of substitutability between pollution intensive goods. When energy intensive goods are of the Heckscher-Ohlin type, the global carbon leakage rate is between 50% and 130% and the emissions reduction policy may increase global emissions, instead of cutting them down. These results show the inefficiency of an environmental agreement that aims at lowering emissions when only a certain number of countries have signed it.

Abatement subsidy. The aim of Fredriksson (1997) is to show why abatement subsidies, even if inefficient compared to a Pigouvian tax, are used as an instrument in environmental policy. This paper is based on a menu auction model, with an environmental and an industrial lobby. The lobbies give political contributions to the government, which then sets the environmental policy. Given the preferences of the government and the lobby groups, the subsidy increases their payoffs, even if it lowers total welfare. Eichner and Runkel (2010) use a mobile capital framework to analyse the impact on country's emissions level of setting emissions taxes or subsidizing green energy production. When a country independently sets emissions taxes as policy instrument in order to reduce pollution emissions, the

resulting policy is inefficient. The reason is that the country does not take into account the externality on the other countries, thus setting the taxes at a too low rate. The emissions taxes lower the country-specific return on capital, whilst leaving the foreign one unaffected. This leads domestic capital to flee abroad in order to enjoy the highest return. As a consequence, country-specific emissions are lower, but there is no impact on global emissions. On the other hand, if the country decides to subsidise the production of renewable energy, domestic capital shifts within the country from dirty to clean production. Consequently, country's production becomes less polluting and, in turn, global emissions are lower than in the previous case.

Potential policy responses to carbon leakage. Böhm (1993) analyses three different policies to address carbon leakage. The first one includes the creation of a second agreement, where those that did not sign the first treaty agree they will not increase their fuel demand. The second policy is based on monetary incentives given by the abating countries to the non-signatories, in order to persuade them to join at least one of the treaties. In the last potential policy the signatory countries commit themselves to purchase fuel deposits. The least costly policy is the one which reduces both fuel demand and supply by the same amount. Harstad (2012) extends Böhm's (1993) framework by including the possibility that countries trade fuel deposits before signing an environmental treaty. Non signatories' economically unprofitable deposits can be bought by the signatories for a reasonable price in order to avoid their exploitation. This equalizes the international price of fossil fuels and makes non signatories' fossil fuel supply curve become locally inelastic. Hence, these countries will not be able to increase their fuel supply as a consequence of the reduction in fuel supply implemented by the signatories of a non-global agreement. The main result is that this supply-

based environmental policy is able to avoid all the drawbacks highlighted in the previous literature and reach the first best.

Sinn (2008) emphasises that policies that only focus on the demand side may not be effective in reducing worldwide emissions. Given that current environmental agreements have only partial geographical coverage, their efforts in limiting their demand of fossil fuels might be completely offset by a corresponding increase in the fossil fuels demand of non-signatories. Worse than that, this scenario could lead to the green paradox. Indeed, if fossil fuels suppliers are worried about a future decrease in demand, they might increase their current supply, with a negative impact on emissions. Moreover, the paper analyses the advantages and disadvantages of several inter-temporal policies that could be better candidates in limiting global warming.

Eichner and Pethig (2011) use a two-period three-country general equilibrium model to analyse the impact of a cap constraint on carbon leakage. Their main results are that the carbon leakage rate is higher than 100% if the country is constrained in the first period. On the other hand, if the constraint is applied in the second period, carbon leakage may not happen. These results depend on the inter-temporal elasticity of substitution of demand. Indeed, if the country reduces its emissions in the first period and the consumption goods produced in the two periods are close substitutes, then the rise in the price of the good produced in the first period makes the agents postpone a large amount of consumption to the second period. Consequently, carbon leakage is low because production is lower than before. On the other hand, if the consumption goods in the two periods are strict complements, then consumption and, in turn, production and emissions are still high in the first period. Ritter and Schopf (2013) build on Eichner and Pethig (2011) by introducing a stock-dependent marginal physical cost of extracting fossil

fuels. They distinguish between a weak and a strong green paradox. The weak green paradox is the one already highlighted in Eichner and Pethig (2011). On the other hand, the strong green paradox happens when environmental regulation generates an increase in the depletion of fossil fuels or even a cumulative effect.

The use of countries' emission levels as the strategy variables done by previous studies is challenged by Hoel (2005). With international trade, pollution damaging a country depends not only on the emission taxes of the country itself, but also on those implemented in all the other countries. This paper claims that the non-cooperative equilibrium is characterised by the use of non-uniform emission taxes. Consequently, the outcome is not cost effective and welfare is not maximised. On the other hand, the Nash equilibrium is characterised by uniform emission taxes when trade tariffs are added. Moreover, welfare is maximised in each country and tariffs might be used in order to manipulate emission levels in other countries. Maestad (2007) challenges the conclusion reached by previous literature that the country should endow the firms with free emissions permits in proportion to the amount of capital used when capital is perfectly mobile. This paper shows that when there are decreasing returns to scale in the foreign country and the domestic country has two sectors, namely a clean and a dirty one, the free emissions permits policy is not the best one. Indeed, this policy determines a distortion in the capital allocation decisions amongst the clean and the dirty sectors, in favour of the latter. Hence, this policy contributes to increase overall pollution, so the government should provide the polluting firms with free emissions permits and tax the labour inputs they use.

Extensions. Several papers have extended the basic framework, adding new important features, such as an endogenous number of firms (Gurtzgen and Rauscher,

2000), technological change (Golombek and Hoel, 2004; Di Maria and Van der Werf, 2008) and international technology spillovers (Gerlagh and Kuik, 2007). Gurtzgen and Rauscher (2000) claim the existence of a further carbon leakage mechanism, called the “market structure effect”. Gurtzgen and Rauscher (2000) show, in contrast with previous literature, that with endogenous market structure stricter domestic environmental regulation does not always increase emissions in foreign countries when demand is very elastic and there is the presence of high fixed costs. Golombek and Hoel (2004) explore the validity of the carbon leakage issue under endogeneity of abatement technologies and allowing for the possibility of technology transmission amongst countries. They use a two-country model and find that carbon leakage is negative under certain conditions, since technology spillovers, due to non-cooperative emissions reductions, reduce the cost of abatement in the country without environmental policy. On the other hand, Di Maria and Van der Werf (2008) argue that the methodology prevalently used in order to analyse the carbon leakage issue overestimates its magnitude. The key point is that the changes in factor (fossil fuels) and product (energy intensive goods) prices due to the signing of the environmental agreement affect the direction and the level of technological innovations. The policy measure more appropriate in order to counterbalance the carbon leakage issue in case of an environmental agreement is the one that makes the innovations in the energy intensive sector more profitable than those for the other one, by affecting the relative prices. With high elasticity of demand for energy even for the unconstrained country the optimal policy is to reduce its emissions levels. Gerlagh and Kuik (2007) introduce international technology spillovers within a carbon leakage framework. They consider two frameworks: the Pollution Haven Hypothesis (PHH) and the “carbon energy market” model. The paper quantifies the leakage rates in the Pollution Haven

model and the "carbon energy market" one and highlights that the latter fits better the findings of previous literature. One of the main results is that the presence of technological spillovers improves environmental quality, because it is associated with very low or negative carbon leakage.

Negative leakage. The possibility of negative carbon leakage has obtained more attention in the recent literature. Baylis et al. (2014) criticise the excessive emphasis given in literature to the extent to which positive carbon leakage occurs. They focus on an individual country with two sectors that produce two non perfectly substitutable goods: one pollutes and the other one doesn't. When the government increases sector-specific carbon taxes, production costs significantly step up for those sectors and so does the price of its final goods. As a consequence, consumers substitute the consumption of this good with that of another one, whose price has remained unchanged. This is the mechanism underlying the existence of positive carbon leakage rates. On the other hand, when the price elasticity of demand in the taxed sector is fairly inelastic, a carbon tax increases the price of the final good, without modifying their demand. Consequently, the firms are willing to abate more without reducing their production levels. An increase in the fraction of capital used for abatement for a certain level of output means that the taxed sector is adding more capital to its share. Hence, if capital supply is fixed, the other sectors have to face a reduction of the capital amount they use for production purposes and thus of their output. This mechanism generating negative carbon leakage represents the main result of the paper. The theoretical predictions of Baylis et al. (2014) have been empirically tested in Elliott and Fullerton (2013). Their simulation is based on the CIM-EARTH model and validates the theoretical predictions about the existence of negative leakage. Moreover, Baylis

et al.'s (2014) model has been extended by Fullerton et al. (2013). The latter focuses on welfare and its main finding is that negative leakage (as computed in Baylis et al. (2014)) is always associated with a welfare loss. On the other hand, positive leakage is associated with a welfare improvement.

Emission pricing. The starting point of Böhringer et al. (2014) is that two of the most popular arguments used in support of the use of emission price differentiation are leakage and terms-of-trade motives. These two effects are interrelated and so, in order to better analyse the role played by each of them, it is essential to be able to disentangle them. First, they decompose the two effects from a theoretical point of view and then use a multi-country, multi-sector general equilibrium model for their simulations. The main result of the paper is that carbon leakage is mainly driven by international energy market effects and therefore, price differentiation and uniform emission pricing achieve similar results.

Jacob et al. (2013) challenges from a theoretical point of view the use of consumption-based pricing of emissions in reducing carbon leakage. This paper uses a two-country trade framework, where only one country sets an environmental policy and shows that consumption-based pricing of emissions is not effective in reducing leakage. Moreover, they empirically test the predictions of their theoretical model by simulating the implementation of a full BTA on bilateral trade between the European Union and China. Their results show that carbon leakage takes place with both production and consumption-based measures, but the rate of leakage associated with the second policy is much higher.

Border tax adjustments. Recent empirical literature has focused on the identification of policy measures able to mitigate carbon leakage. In particular, the use of border tax adjustments (BTAs) for lowering the magnitude and the negative

effects of carbon leakage has attracted a lot of interest. Border tax adjustments are policy measures used to address the polluting industries competitiveness issue. Indeed, taxes on emissions impose a higher burden on national pollution-intensive industries, making them less competitive both nationally and internationally. In order to restore competitiveness, BTAs tax imported goods but not exported ones. Kuik and Hofkes (2010), Bednar-Friedl et al. (2012), Burniaux et al. (2013) and Böhringer et al. (2012) all focus on the impact of BTAs. Their analyses arrive at different conclusions.

Kuik and Hofkes (2010) use a multi-sector, multi-region general equilibrium model to analyse the impact of BTAs in the EU ETS. Their simulations are based only on selected sectors: electricity, mineral products, iron and steel. One of the assumptions of the model is that only total emissions are restricted. The benchmark case is the one without EU ETS. They use it as a reference for comparison with other three different scenarios. In the first one the EU ETS system has no trade restrictions. The other two scenarios consider a situation where the importers of steel and mineral products are required to buy allowances, but they differ from each other according to the design of the BTA. Indeed, there are two main criteria that can be followed in order to quantify the amount of allowances per unit of imports. The first is the direct amount of CO₂ emissions generated in the EU in order to produce a similar good; whilst the second is the average direct amount of CO₂ emissions generated in the exporting country in order to produce that good. Their work shows that these two different BTA designs result in different costs. Hence, one of their main conclusions is that the way the BTA is designed has an impact on its effectiveness. Other findings are that BTAs are valid instruments to lower leakage only in the iron and steel sectors, even if the impact on overall leakage is almost negligible.

The starting point of Bednar-Friedl et al. (2012) is that previous literature has only quantified fuel-related emissions, omitting those coming from industrial processes. The scope of this paper is two-fold. First, they examine the economic impact of a unilateral European environmental policy involving a 20 percent emissions reduction. Second, they assess the effectiveness of BTAs in counterbalancing the magnitude of carbon leakage coming from this unilateral policy. Hence, Bednar-Friedl et al. (2012) use a multi-sectoral multi-regional computable general equilibrium model that includes emissions generated by industrial processes. The base year is 2004 and the benchmark case is unilateral European policy with no carbon leakage mitigation measures. In this case, due to the negative effect of carbon leakage, the actual emissions reductions must be higher than 20%. Their main results are that previous literature has underestimated both the magnitude of carbon leakage and the effectiveness of BTAs.

Burniaux et al. (2013) use a global general equilibrium model to quantify the economic effects of BTAs. They analyse the effects of BTAs in two policy scenarios where signatories reduce their emissions by 20 per cent in 2020 and by 50 per cent in 2050. In the first one only the EU is taken into account; whilst in the second one Annex I countries. By Annex I countries we mean OECD countries and economies in transition. Their main conclusions are that BTAs are effective in lowering carbon leakage only when the number of the signatories is small and, in any case, the welfare improvement is almost negligible.

Böhringer et al. (2012) compare the effectiveness of three different policy measures in reducing carbon leakage. The policy instruments taken into account are: exempting the industry from carbon regulation, BTAs and output-based emission allowances. They use a static multi-region, multi-sector computable general equilibrium model where the benchmark case is unilateral emissions reductions

with no carbon leakage-control policy. Their findings show that none of the instruments is free from drawbacks. Indeed, BTAs are more effective in controlling emissions and more cost-effective, but might increase inequality. On the other hand, the other two instruments do not increase inequality, but are less effective and cost-effective.

2.3 The Model

Before we proceed to introduce all the elements that constitute the model, a clarification on the way we shall prove our results is in order. Once the model will be grounded, the conditions for optimal capital allocation within the economy will be established. Those conditions will prove themselves useful to find the capital market autarky values of the main variables of interest. We shall refer to the autarky solution when evaluating whether each policy scenario involves capital export or import. We shall then discuss and characterise the relevant policy scenarios and, for each of them, the first order conditions for optimal emissions and ad valorem tax on abatement shall be presented. The next step in our analysis will be to evaluate, at the point of autarky in the capital market, the sign of the marginal utility due to an infinitesimal increase in the ad valorem tax on abatement. From an analytical point of view, we will substitute the previously computed autarky values in the equi-marginal rule for the optimal ad valorem tax on abatement. This exercise will represent the key procedure in uncovering what type of capital movements characterise each policy scenario. On the one hand, if marginal utility computed at the point of autarky is negative, then the scenario is characterised by negative leakage. On the other hand, if marginal utility computed at the point of autarky is positive, then the scenario is characterised by positive leakage. Finally, we will compare the results obtained in every policy scenario and discuss their meaning.

The basic structure of the model follows that of Ogawa and Wildasin (2009). We distinguish our analysis by introducing an environmental agreement with partial geographical coverage that takes the form of a two-stage game. In the first stage, the signatory countries decide the maximum amount of allowed emissions, set a cap on them and simultaneously the ad valorem tax on abatement is chosen. In the second stage, illustrated in subsection 2.3.1, capital is allocated. We assume, for comparison purposes, that without environmental policy each high-income country is in autarky, using exactly its own capital endowment in equilibrium. In order to reproduce partial geographical coverage let us assume that only high-income countries agree to sign the treaty. We analyse and compare the policy outcomes deriving from three different policy scenarios: full cooperation, unilateral environmental policy and partial cooperation. Subsection 2.3.2 shall derive the values of output, abatement and environmental policy that implement autarky in the capital market.

Firms, emissions and abatement. Consider a world constituted of N countries, where $N = N_h + N_l$. N_h represents the number of countries constituting the high-income bloc and N_l the number of those constituting the low-income bloc. The bloc of high-income countries is formed by identical countries and so is the bloc of low-income countries. For the rest of the chapter, we shall use the subscripts h and l to indicate the bloc of high and low-income countries, respectively. Throughout we shall use the subscript i to indicate each individual high-income country. For the sake of the analysis, we shall assume through all the chapter that low-income countries do not have their own environmental policy.

Firms in all countries produce a single homogeneous (composite) good, X , through a neoclassical production function with constant returns to scale in all

inputs that uses capital as the only variable input. We refer to K_h^X as the amount of capital used in the high-income bloc for the production of good X . Symmetrically, we refer to K_l as the amount of capital used in the low-income bloc for the production of good X . Good X is set as the numeraire, so its price equals unity. Let us assume that capital is perfectly mobile between the two blocs, but less productive in low-income countries. The other production factors (e.g. labour, land) are immobile and used in production activities in fixed amounts. With regard to industry structure, let us assume perfect competition. For analytical purposes, we assume that there is a continuum of identical firms with mass equal to 1 in both the high and low-income blocs. Therefore, total production in the high and low-income blocs is, respectively:

$$X_h = \sqrt{2K_h^X} \quad (2.1)$$

$$X_l = \sqrt{2\phi K_l} \quad (2.2)$$

where $0 < \phi < 1$ is a parameter measuring the productivity of capital in the low-income bloc relative to the high-income bloc. For the rest of the chapter, we shall use upper and lower case to indicate variables referring to the bloc of countries and each individual country, respectively. From our assumptions regarding the mass of firms in each bloc equal to unity and the symmetry between high-income countries, it immediately derives that each high-income country i houses a mass of $1/N_h$ firms. We refer to k_i^X as the amount of capital used in the individual high-income country for the production of good X . Therefore, production per high-income country, x_i is:

$$x_i = \sqrt{2k_i^X} = \sqrt{2K_i^X/N_h} \quad (2.3)$$

We assume that production activities pollute the environment, but abatement services are available in the high-income bloc for firms to control their emissions. Abatement services, A , are produced by using capital as the only (variable) input, so that

$$A_h = \sqrt{2K_h^A/\theta} \quad (2.4)$$

$$a_i = \sqrt{2k_i^A/\theta} = \sqrt{2K_i^A/\theta N_h}$$

where $\theta > 0$ represents the abatement-cost parameter. We refer to K_h^A and k_i^A as the amount of capital used for abatement services in the high-income bloc and in the individual high-income country, respectively.

Following Ogawa and Wildasin (2009), we assume that pollution is trans-boundary and pollutants are uniformly mixed. This means that each country suffers from environmental damage caused by global emissions. This assumption is consistent with the behaviour of major pollutants, such as greenhouse gases. Total emissions are given by the difference between pollution generated through production activities and abatement. Hence, total emissions in the high-income bloc and in each high-income country are, respectively:

$$E_h = X_h - A_h \quad (2.5)$$

$$e_i = x_i - a_i \quad (2.6)$$

Therefore, worldwide environmental damage E is, from (2.6):

$$E = X_l + \sum_{i=1}^{N_h} e_i = X_l + \sum_{i=1}^{N_h} (x_i - a_i) \quad (2.7)$$

Worldwide environmental damage is given by the sum of pollution generated in the high and low-income blocs.

Let $\bar{K}_h$ and $\bar{K}_l$ represent total capital endowment in the high and low-income bloc, respectively. Consequently, the individual high-income country capital endowment is $\bar{k}_i \equiv \bar{K}_h/N_h$. The global resource constraint for capital is given by the sum of the capital invested in the high and low-income blocs for production and abatement activities and for production activities, respectively:

$$\bar{K}_h + \bar{K}_l = \sum_{i=1}^{N_h} \left(\frac{1}{2} N_h x_i^2 + \frac{1}{2} \theta N_h a_i^2 \right) + \frac{X_l^2}{2\phi} \quad (2.8)$$

From our assumption about identical countries it immediately derives that (2.8) can be expressed such that:

$$\bar{K}_h + \bar{K}_l = \frac{1}{2} X_h^2 + \frac{1}{2} \theta A_h^2 + \frac{X_l^2}{2\phi} \quad (2.9)$$

Consumers. Let us assume that the bloc of high-income countries is composed of a large number of individuals (a continuum of mass 1), who act both as consumers and factor owners. We refer to U_h as the utility of all the individuals residing in this bloc. It positively depends on the amount of good consumed, Y_h , and negatively on environmental damage, E :

$$U_h = \ln(Y_h) - \Lambda E \quad (2.10)$$

where $\Lambda > 0$ represents the degree of harm suffered by consumers due to environmental degradation. From our assumption about symmetric high-income countries, it immediately derives that each high-income country houses a mass of $1/N_h$ consumers. Consequently, total utility in each individual high-income country is:

$$u_i = \frac{\ln(N_h y_i)}{N_h} - \lambda_i E \quad (2.11)$$

with $\lambda_i \equiv \Lambda/N_h$. Consumers in the high-income countries own their own country's capital endowment and the immobile factors of production. The production factors are supplied to local firms: capital is rented at an endogenous world net return equal to $\rho > 0$ and the return on the fixed inputs is quantified as a residual. The total amount of good consumed in every country is given by the sum of its production level and the return on capital invested abroad (expressed in terms of the numeraire good X). Therefore, the total amount of good consumed in the high-income bloc and individual country, respectively, are such that:

$$Y_h = X_h + \rho\Omega_h \quad (2.12)$$

$$y_i = x_i + \rho\omega_i \quad (2.13)$$

where we define Ω_h and ω_i as the difference between the capital endowment and the amount of capital invested domestically in the high-income bloc and individual country, respectively:

$$\Omega_h \equiv \bar{K}_h - \frac{1}{2}X_h^2 - \frac{1}{2}\theta A_h^2 \quad (2.14)$$

$$\omega_i \equiv \bar{K}_i - \frac{1}{2}N_h x_i^2 - \frac{1}{2}\theta N_h a_i^2 \quad (2.15)$$

2.3.1 Capital allocation

For the sake of the analysis we shall abstract from enforceability and stability issues. Let us assume that the total amount of emissions permits issued by high-income country i is e_i^0 and the ad valorem tax or subsidy on abatement in high-income country i is σ_i . It is then straightforward that three scenarios are possible. In the first one the government subsidises abatement, that is $0 < \sigma_i < 1$. In the second one the government taxes abatement, that is $\sigma_i > 1$. In the last one the government neither taxes nor subsidises abatement, that is $\sigma_i = 1$. For

the rest of the chapter, we shall use the subscript f to indicate the individual firm in the individual high-income country. Let us assume that every high-income country has its own domestic emission trading scheme and that emissions trading between high-income countries is not allowed. Tradable permit schemes with international tradability (e. g. the EU ETS and the flexibility mechanisms in the Kyoto Protocol) are used when the emission ceilings have been set cooperatively. Our chapter focuses on three policy scenarios: full agreement, non-cooperative scenario and partial agreement. On the one hand, we could have assumed international tradability in the full and partial agreement scenarios, where emissions reductions are set in a cooperative fashion. On the other hand, it doesn't seem plausible that when countries set their emission ceilings non-cooperatively, they would allow for international tradability. Therefore, allowing for international tradability would introduce another difference between these scenarios and the non-cooperative case. Hence, if we relax this assumption, our results would be much more difficult to interpret.

Each high-income country's government gives an initial allocation of E_f^0 per-

mits to each domestic firm, where $\int_0^f E_f^0 = e_i^0$, that is the sum of all the endowments

is equal to the country's emissions allowances. From our assumption of a continuum of firms of mass 1, it immediately follows that in the high-income bloc firms take the permit price as given and equal to p_h . Therefore, the cost of polluting for the firm is

$$p_h (e_i^0 - E_h^0) \tag{2.16}$$

The high-income bloc's firm objective is to maximise its profit π_h with respect to X_h and A_h , subject to non-negativity constraints for output and abatement.

Taking (2.1), (2.5) and (2.16) into account, the firm's maximization problem becomes

$$\max_{X_h \geq 0, A_h \geq 0} \pi_h = X_h - p_h (X_h - A_h - E_h^0) - \rho \left(\frac{1}{2} X_h^2 + \frac{1}{2} \theta \sigma_h A_h^2 \right) \quad (2.17)$$

The first order conditions for profit maximization are such that

$$\frac{d\pi_h}{dX_h} = 1 - p_h - \rho X_h = 0 \quad (2.18)$$

$$\frac{d\pi_h}{dA_h} = p_h - \rho \theta \sigma_h A_h = 0 \quad (2.19)$$

The two conditions (2.18) and (2.19) can be simplified by eliminating the permit price, p_h . This yields

$$1 - \rho \theta \sigma_h A_h - \rho X_h = 0 \quad (2.20)$$

Condition (2.20) can be re-written for each high-income country i such that

$$1 - \rho \theta \sigma_i N_h a_i - \rho N_h x_i = 0 \quad (2.21)$$

Low-income bloc l 's firm optimization problem is to maximise its profit π_l

$$\max_{X_l \geq 0} \pi_l = X_l - \frac{1}{2\phi} \rho X_l^2$$

with respect to X_l and subject to non-negativity constraint for output. The first order condition for profit maximization is:

$$\phi = \rho X_l \quad (2.22)$$

2.3.2 Autarky

For comparison purposes, let us assume that with an unlimited supply of permits and without an abatement tax or subsidy, that is to say without environmental policy, each high-income country is in autarky, using exactly its own capital endowment in equilibrium. If this were not the case, each high-income country would have an incentive to set up an environmental policy (even if it was not concerned about environmental damage) in order to affect in its favour the return on capital, ρ . This assumption will make comparison of the sign of carbon leakage in different policy scenarios possible. This subsection shall derive the solution of the autarkic equilibrium and for the rest of the chapter we shall use the superscript hat to indicate it. From (2.15) it immediately follows that the capital market autarky condition for every high-income country is $\omega_i = 0$.

In order to find the values of output, $\hat{x}_i$ and $\hat{X}_i$, abatement, $\hat{a}$, return to capital, $\hat{\rho}$ and environmental policy, $\hat{\sigma}$, that implement autarky in the capital market we need to notice that when the high-income country government decides not to apply any environmental policy, emissions are not restricted. Therefore, firms in the high-income country have no incentive to abate and, in turn, abatement a is zero. It is important to notice that when firms are not abating emissions coincide with output. Moreover, from our assumption about the symmetry of high-income countries, it immediately follows that when the high-income bloc is in autarky, then every high-income country is also in autarky. Consequently, for sake of simplicity, we shall use the aggregate variables $\hat{X}_h$ and $\hat{A}$ in our discussion of the autarky solution. We can then re-write the autarky condition in aggregate terms as $\Omega_h = 0$ in (2.14). Substituting this into (2.12) yields:

$$\hat{X}_h = \hat{Y}_h \tag{2.23}$$

i.e. per-capita production equals per-capita consumption in autarky.

In order to find the autarky value of the return to capital we solve expression (2.20) for the non-restricted emissions case (that is $A = 0$), such that:

$$\rho X_h = 1 \quad (2.24)$$

Substituting (2.1) into (2.24) yields the return to capital autarky value:

$$\hat{\rho} = \frac{1}{\sqrt{2\bar{K}_h}} \quad (2.25)$$

Substituting (2.25) into (2.22) we obtain the autarky value of the low-income bloc output:

$$\hat{X}_l = \phi \sqrt{2\bar{K}_h} \quad (2.26)$$

The autarky solution for output, $\hat{X}_h$, abatement, $\hat{A}$, and environmental policy, $\hat{\sigma}$, is determined by a system of three equations: (2.5), (2.20) and $\Omega_h = 0$ in (2.14), that can be re-written such that

$$\begin{aligned} \hat{X}_h &= E_h + \hat{A} \\ \hat{A} &= \frac{1}{\theta} \sqrt{\theta \left(2\bar{K}_h - \hat{X}_h^2 \right)} \\ \hat{\sigma} &= \frac{1}{\rho \theta \hat{A}} \left(1 - \hat{\rho} \hat{X}_h \right) \end{aligned} \quad (2.27)$$

Solving the system (2.27) and substituting (2.25) where appropriate, yields

the following solution:

$$\hat{X}_h = \frac{1}{\theta + 1} \left(\theta E_h + \sqrt{2(\theta + 1)\bar{K}_h - \theta E_h^2} \right) \quad (2.28)$$

$$\hat{A} = \frac{1}{\theta + 1} \left(\sqrt{2(\theta + 1)\bar{K}_h - \theta E_h^2} - E_h \right) \quad (2.29)$$

$$\hat{\sigma} = \frac{\sqrt{2(\theta + 1)\bar{K}_h - \theta E_h^2} - \sqrt{2\bar{K}_h}}{\theta \left(E_h + \sqrt{2\bar{K}_h} \right)} \quad (2.30)$$

In Appendix A we prove that the autarky solutions (2.28), (2.29) and (2.30) are feasible. Moreover, we can show that:

Lemma 1 *In autarky, when emissions in the high-income bloc are below emissions without environmental policy:*

1. *Abatement is subsidised, that is $0 < \hat{\sigma} < 1$ in (2.30).*
2. *$\hat{A} - \hat{\sigma}\hat{X}_h > 0$.*

Proof. See Appendix D. ■

It follows from the system (2.28) to (2.30) that:

$$\frac{d\hat{X}_h}{dE_h} = \frac{\theta \left(\sqrt{2(\theta + 1)\bar{K}_h - \theta E_h^2} - E_h \right)}{(\theta + 1) \sqrt{2(\theta + 1)\bar{K}_h - \theta E_h^2}} > 0 \quad (2.31)$$

$$\frac{d\hat{A}}{dE_h} = -\frac{\theta E_h + \sqrt{2(\theta + 1)\bar{K}_h - \theta E_h^2}}{(\theta + 1) \sqrt{2(\theta + 1)\bar{K}_h - \theta E_h^2}} < 0 \quad (2.32)$$

$$\frac{d\hat{\sigma}}{dE_h} = -\frac{\sqrt{2\bar{K}_h} \left(\theta E_h + (\theta + 1)\sqrt{2\bar{K}_h} - \sqrt{2(\theta + 1)\bar{K}_h - \theta E_h^2} \right)}{\theta \left(E_h + \sqrt{2\bar{K}_h} \right)^2 \sqrt{2(\theta + 1)\bar{K}_h - \theta E_h^2}} < 0 \quad (2.33)$$

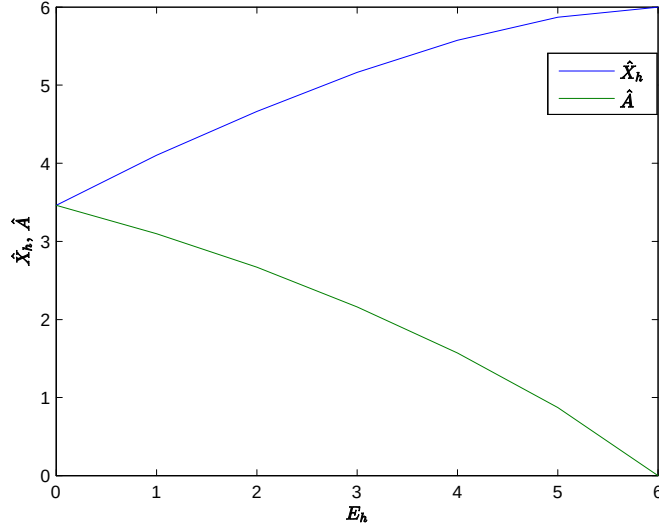


Figure 2.1: Domestic production and abatement in autarky as a function of domestic emissions ($\bar{K}_h = 18$, $\theta = 2$).

Appendix A proves the inequality for equation (2.33). System (2.31), (2.32) and (2.33) shows the sign of the impact of a small increase in emissions in autarky on domestic production, abatement and the ad valorem tax on abatement, respectively. Intuitively, as the amount of allowed emissions increases, firms face an incentive to increase their production and reduce their abatement. In autarky, this reduction in abatement pushes domestic production further up. Therefore, as emissions approach their no-environmental policy value, the subsidy needed for firms to abate is higher and higher.

From Lemma 1 we know that in autarky $0 < \hat{\sigma} < 1$ and, as emissions approach their no-environmental policy level, from (2.5), (2.1) and (2.31) we know that emissions increase and tend to production, that is $E_h \rightarrow \sqrt{2\bar{K}_h}$. We see from (2.30) that $\hat{\sigma} \rightarrow 0$ as $E_h \rightarrow \sqrt{2\bar{K}_h}$. Figure 2.1 and 2.2 show these results. They have been plotted for $\bar{K}_h = 18$ and $\theta = 2$.

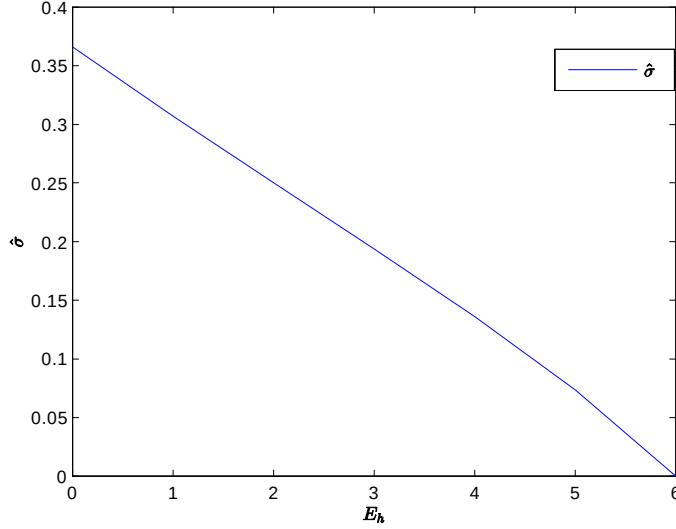


Figure 2.2: Sigma in autarky as a function of domestic emissions ($\bar{K}_h = 18, \theta = 2$).

2.4 Policy scenarios

This section shall analyse three different policy scenarios. The first scenario represents a situation where both allowed emissions and ad valorem abatement tax are chosen by the signatories in a cooperative fashion. In this case, signatories fully internalise the environmental externality and we shall see that there is negative carbon leakage. We then derive the outcome of non-cooperative environmental policy. In this case, each high-income country chooses its own emissions level and policy instrument independently. We shall see that non-cooperative policy does not fully internalise the environmental externality, causing positive carbon leakage towards low-income countries. In the last scenario the signatories decide cooperatively the emissions reductions but the policy instrument choice is left independent. We shall see that the partial agreement does not fully internalise the environmental externality, causing positive carbon leakage towards low-income countries. Moreover, we shall see in subsection 2.5.2 that carbon leakage under partial agreement is of a bigger magnitude than under non-cooperative policy.

This section shall derive the first order conditions for each policy scenario. In order to analyse the sign of carbon leakage, let us assume that without environmental policy every high-income country is at the capital market autarky equilibrium point. We will then evaluate the sign of the first order condition at the point of autarky, in order to analyse the sign of the leakage effect in every scenario.

2.4.1 Full Agreement

We begin our analysis by characterizing the full agreement solution. For all the rest of the chapter we shall use the subscript c to denote the cooperative outcome. In this subsection we assume that the bloc of high-income countries participates in the environmental agreement. As previously mentioned, we abstract from enforceability and stability issues, in order to focus on the sign of carbon leakage. In this policy scenario, the bloc of high-income countries quantifies the amount of emissions permits and the subsidy such that the joint welfare of their residents is maximised. Therefore, the environmental externality is fully internalised by the signatories and the first best outcome is achieved.

2.4.1.1 Stage two

Totally differentiating (2.5), (2.9), (2.20) and (2.22) with respect to E_i yields the following system:

$$\begin{aligned} \frac{dX_h}{dE_h} - \frac{dA_h}{dE_h} &= 1 \\ \theta A_h \frac{dA_h}{dE_h} + X_h \frac{dX_h}{dE_h} + \frac{X_l}{\phi} \frac{dX_l}{dE_h} &= 0 \\ \theta \rho \sigma_h \frac{dA_h}{dE_h} + \rho \frac{dX_h}{dE_h} + (\theta \sigma_h A_h + X_h) \frac{d\rho}{dE_h} &= 0 \\ \rho \frac{dX_l}{dE_h} + X_l \frac{d\rho}{dE_h} &= 0 \end{aligned} \tag{2.34}$$

Using the first order conditions for firms' profit maximization in the high and low-income blocs, that is (2.20) and (2.22), respectively, we obtain the following matrix:

$$\begin{pmatrix} -1 & 1 & 0 & 0 \\ \theta A_h & X_h & \frac{1}{\rho} & 0 \\ \theta \rho \sigma_h & \rho & 0 & \frac{1}{\rho} \\ 0 & 0 & \rho & X_l \end{pmatrix} * \begin{pmatrix} dA_h/dE_h \\ dX_h/dE_h \\ dX_l/dE_h \\ d\rho/dE_h \end{pmatrix} = \begin{pmatrix} 1 \\ 0 \\ 0 \\ 0 \end{pmatrix} \tag{2.35}$$

Solving system (2.35) by applying Cramer's rule and using (2.22) yields:

$$\frac{dA_h}{dE_h} = \frac{-(X_h + X_l)}{\Delta_h} < 0 \tag{2.36a}$$

$$\frac{dX_h}{dE_h} = \frac{\theta (A_h + \sigma_h X_l)}{\Delta_h} > 0 \tag{2.36b}$$

$$\frac{dX_l}{dE_h} = \frac{\phi \theta (A_h - \sigma_h X_h)}{\Delta_h} > 0 \quad \text{in autarky} \tag{2.36c}$$

$$\frac{d\rho}{dE_h} = \frac{-\theta \rho^2 (A_h - \sigma_h X_h)}{\Delta_h} < 0 \quad \text{in autarky} \tag{2.36d}$$

where Δ_h represents the determinant of the matrix (2.35) and it is such that

$$\Delta_h = X_h + \theta A_h + X_l (1 + \theta \sigma_h) \quad (2.37)$$

Inequalities (2.36c) and (2.36d) follow from Lemma 1.2.

Totally differentiating (2.5), (2.9), (2.20) and (2.22) with respect to σ_h yields:

$$\begin{aligned} \frac{dX_h}{d\sigma_h} - \frac{dA_h}{d\sigma_h} &= 0 \\ \theta A_h \frac{dA_h}{d\sigma_h} + X_h \frac{dX_h}{d\sigma_h} + \frac{X_l}{\phi} \frac{dX_l}{d\sigma_h} &= 0 \\ \theta \rho \sigma_h \frac{dA_h}{d\sigma_h} + \rho \frac{dX_h}{d\sigma_h} + (\theta \sigma_h A_h + X_h) \frac{d\rho}{d\sigma_h} &= -\rho \theta A_h \\ \rho \frac{dX_l}{d\sigma_h} + X_l \frac{d\rho}{d\sigma_h} &= 0 \end{aligned} \quad (2.38)$$

Applying the first order conditions for firms' profit maximization in the high and low-income blocs, that is (2.20) and (2.22), respectively, we obtain the following matrix:

$$\begin{pmatrix} -1 & 1 & 0 & 0 \\ \theta A_h & X_h & \frac{1}{\rho} & 0 \\ \theta \rho \sigma_h & \rho & 0 & \frac{1}{\rho} \\ 0 & 0 & \rho & X_l \end{pmatrix} * \begin{pmatrix} dA_h/d\sigma_h \\ dX_h/d\sigma_h \\ dX_l/d\sigma_h \\ d\rho/d\sigma_h \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ -\rho \theta A_h \\ 0 \end{pmatrix} \quad (2.39)$$

Solving system (2.39) by applying Cramer's rule and using (2.22) yields:

$$\frac{dA_h}{d\sigma_h} = \frac{dX_h}{d\sigma_h} = \frac{-\theta A_h X_l}{\Delta_h} < 0 \quad (2.40a)$$

$$\frac{dX_l}{d\sigma_h} = \frac{\phi \theta A_h (\theta A_h + X_h)}{\Delta_h} > 0 \quad (2.40b)$$

$$\frac{d\rho}{d\sigma_h} = \frac{-\rho^2 \theta A_h (\theta A_h + X_h)}{\Delta_h} < 0 \quad (2.40c)$$

2.4.1.2 Stage one

In stage one, the high-income bloc sets the emission ceiling E_c and the abatement subsidy σ_c that maximise their joint welfare (2.10). The first order conditions for the welfare maximization are:

$$\frac{dU_c}{dE_c} = \frac{1}{Y_c} \frac{dY_c}{dE_c} - \Lambda_c \frac{dE}{dE_c} = 0 \quad (2.41a)$$

$$\frac{dU_c}{d\sigma_c} = \frac{1}{Y_c} \frac{dY_c}{d\sigma_c} - \Lambda_c \frac{dE}{d\sigma_c} = 0 \quad (2.41b)$$

Totally differentiating (2.7) with respect to E_c and σ_c yields:

$$\frac{dE}{dE_c} = 1 + \frac{dX_l}{dE_c} \quad (2.42a)$$

$$\frac{dE}{d\sigma_c} = \frac{dX_l}{d\sigma_c} \quad (2.42b)$$

Totally differentiating (2.12) with respect to E_c and σ_c yields, using (2.14) and (2.38):

$$\frac{dY_c}{dE_c} = (1 - \rho X_c) \frac{dX_c}{dE_c} + \Omega_c \frac{d\rho}{dE_c} - \rho\theta A_c \frac{dA_c}{dE_c} \quad (2.43a)$$

$$\frac{dY_c}{d\sigma_c} = (1 - \rho X_c - \rho\theta A_c) \frac{dX_c}{d\sigma_c} + \Omega_c \frac{d\rho}{d\sigma_c} \quad (2.43b)$$

Substituting (2.20) into (2.43b) yields:

$$\frac{dY_c}{d\sigma_c} = -(1 - \sigma_c) \rho\theta A_c \frac{dX_c}{d\sigma_c} + \Omega_c \frac{d\rho}{d\sigma_c} \quad (2.44)$$

Equation (2.44) represents the effect of a marginal change in the subsidy on domestic consumption. A glance at it reveals that there are two effects associated

with a marginal increase in the ad valorem tax on abatement. The first effect is due to the impact that the subsidy has on domestic production and abatement, whilst the second one is due to the impact on the return to capital. First, let us consider the effect on production and abatement. An increase in the ad valorem tax on abatement at the margin increases the cost of abating, hence reducing abatement and production. When the high-income bloc does not implement any environmental policy, the effect on consumption is null. This is due to our assumption of perfectly mobile capital, that implies the equality between marginal product of capital in both blocs. When the high-income bloc decides to cap emissions (without subsidizing or taxing), the effect on consumption is also zero. Indeed, an increase in domestic production due to an increase in the amount of capital invested must be followed by an increase in abatement (to keep emissions at the set level). Therefore, with perfectly mobile capital and fixed capital endowment, the increase in domestic production will be offset by the reduction in production in the low-income bloc.

When the policy in place is constituted of both an emissions cap and a subsidy, the effect on consumption of increasing the ad valorem tax on abatement is positive because firms are investing in domestic activities (both in production and abatement) an amount of capital in excess of the consumption maximizing level. Given that a marginal increase in the ad valorem tax on abatement will lower the level of the subsidy, it will reduce the distortion in the investment choices and the amount of capital invested in abatement, thus having a positive impact on production and consumption. In autarky the only effect that plays a role is the one on production and abatement. When the policy in place is constituted of both an emissions cap and a tax on abatement, the effect on consumption is negative because firms shall reduce their abatement level. The outstanding amount

of capital shall be exported to the low-income bloc.

Second, let us consider the effect on the return to capital. An increase in the ad valorem tax on abatement at the margin lowers the return to capital. This has a negative impact on consumption when the high-income bloc is exporting capital and a positive impact when capital is being imported.

Substituting (2.12), (2.43a) and (2.42a) into (2.41a) yields the first order condition for E_c :

$$\frac{dU_c}{dE_c} = \frac{1}{Y_c} \left[(1 - \rho X_c) \frac{dX_c}{dE_c} + \Omega_c \frac{d\rho}{dE_c} - \rho \theta A_c \frac{dA_c}{dE_c} \right] - \Lambda_c \left(1 + \frac{dX_l}{dE_c} \right) = 0 \quad (2.45)$$

From (2.20) and given the non-negativity constraints on our variables and parameters, we know that

$$1 - \rho X_h = \rho \theta \sigma_h A_h > 0$$

Expression (2.45) represents the full agreement equi-marginal rule for allowed emissions: the first term represents the marginal benefit and the second one the marginal cost of an increase in allowed emissions. The marginal benefit is due to the fact that an increase in allowed emissions makes an increase in domestic output possible and, by reducing abatement, increases the amount of capital that could be used in productive activities. The marginal cost associated with an increase in allowed emissions is due to the fact that the amount of capital not used for abatement activities anymore, shall be invested abroad, thus increasing foreign output. In autarky, the term $\left(\Omega_c \frac{d\rho}{dE_c} \right)$ represents a benefit when $\Omega_c < 0$, that is when foreign capital is invested domestically. On the other hand, when $\Omega_c > 0$, that is when domestic capital is invested abroad, it represents a cost.

Substituting (2.36a), (2.36b), (2.36c) and (2.36d) into (2.45), solving for Λ_c

and then simplifying, we obtain:

$$\Lambda_c = \frac{\theta [A_c + \sigma_c X_l + (A_c - \sigma_c X_c) (\phi - \rho^2 \Omega_c)]}{Y_c [X_l (1 + \theta \sigma_c) + X_c + \theta A_c + \phi \theta (A_c - \sigma_c X_c)]} \quad (2.46)$$

Substituting (2.12), (2.44) and (2.42b) into (2.41b) yields the first order condition for σ_c :

$$\frac{dU_c}{d\sigma_c} = \left[-(1 - \sigma_c) \left(\frac{\rho \theta A_c}{Y_c} \right) \frac{dX_c}{d\sigma_c} + \frac{\Omega_c}{Y_c} \frac{d\rho}{d\sigma_c} \right] - \Lambda_c \frac{dX_l}{d\sigma_c} = 0 \quad (2.47)$$

Expression (2.47) represents the full agreement equi-marginal rule: the first term represents the marginal benefit and the second one the marginal cost of an increase in the ad valorem tax on abatement. The marginal benefit coincides with (2.44) and hence, it has already been discussed. The marginal cost associated with an increase in the ad valorem tax on abatement is due to the corresponding reduction in the return to capital that stimulates capital re-location abroad, hence increasing foreign production and emissions.

Substituting (2.40a), (2.40b) and (2.40c) into (2.47) we obtain:

$$\begin{aligned} \frac{dU_c}{d\sigma_c} = & \frac{\phi \theta^2 A_c^2 (1 - \sigma_c)}{Y_c [X_l (1 + \theta \sigma_c) + X_c + \theta A_c]} - \frac{\Lambda_c \phi \theta A_c (X_c + \theta A_c)}{X_l (1 + \theta \sigma_c) + X_c + \theta A_c} - \\ & \frac{\theta \rho^2 A_c \Omega_c (X_c + \theta A_c)}{Y_c [X_l (1 + \theta \sigma_c) + X_c + \theta A_c]} = 0 \end{aligned} \quad (2.48)$$

2.4.1.3 Autarky

In order for us to be able to say whether there is carbon leakage associated with the full agreement outcome, we evaluate the sign of $dU_c/d\sigma_c$ at the point of autarky in the capital market. A value of the derivative $dU_c/d\sigma_c$ equal to zero at the point of autarky means that the optimal subsidy set under full agreement is

exactly the same as the one that implements autarky. In this case there would be no capital movements and, in turn, no leakage associated with restricting high-income bloc's emissions. On the other hand, a negative (positive) value of the derivative means that autarky in the capital market is not an optimal outcome because the high-income bloc's utility is lower than at the optimum. The optimal policy for the high-income bloc is to act strategically and set a subsidy higher (lower) than the one that implements autarky. In this case, the distortion in the capital market will be larger (smaller) than in autarky and, as a consequence, there will be a capital inflow to (outflow from) the high-income bloc.

We shall now evaluate the derivative in (2.48) at the point of autarky. Substituting the autarky condition $\Omega_c = 0$ and (2.23) into (2.46) and (2.48) and using (2.22) yields, respectively:

$$\Lambda_c = \frac{\theta \left[\hat{A} + \hat{\sigma} \hat{X}_l + \phi \left(\hat{A} - \hat{\sigma} \hat{X}_h \right) \right]}{\hat{X}_h \left[\hat{X}_h + \hat{X}_l + \theta \left(\hat{A} + \hat{\sigma} \hat{X}_l \right) + \phi \theta \left(\hat{A} - \hat{\sigma} \hat{X}_h \right) \right]} \quad (2.49)$$

$$\frac{dU_c}{d\sigma_c} = \frac{\phi \theta \hat{A} \left[\theta \hat{A} (1 - \hat{\sigma}) - \Lambda_c \hat{X}_h \left(\hat{X}_h + \theta \hat{A} \right) \right]}{\hat{X}_h \left[\hat{X}_l (1 + \theta \hat{\sigma}) + \hat{X}_h + \theta \hat{A} \right]} \quad (2.50)$$

Plugging (2.49) into (2.50) yields:

$$\frac{dU_c}{d\sigma_c} = \frac{\phi \theta^2 \hat{A}^2 (1 - \hat{\sigma})}{\hat{X}_h \left[\hat{X}_l (1 + \theta \hat{\sigma}) + \hat{X}_h + \theta \hat{A} \right]} - \quad (2.51)$$

$$\frac{\theta \left[\hat{A} + \hat{\sigma} \hat{X}_l + \phi \left(\hat{A} - \hat{\sigma} \hat{X}_h \right) \right]}{\hat{X}_h \left[\hat{X}_h + \hat{X}_l + \theta \left(\hat{A} + \hat{\sigma} \hat{X}_l \right) + \phi \theta \left(\hat{A} - \hat{\sigma} \hat{X}_h \right) \right]} \left[\frac{\phi \theta \hat{A} \left(\hat{X}_h + \theta \hat{A} \right)}{\hat{X}_l (1 + \theta \hat{\sigma}) + \hat{X}_h + \theta \hat{A}} \right]$$

We refer to Appendix B for a detailed explanation of the calculations that

lead (2.51) to become:

$$\frac{dU_c}{d\sigma_c} = \frac{-\phi\theta^2\hat{\sigma}\hat{A}^2}{\hat{X}_h \left[\hat{X}_h + \theta\hat{A} + \phi\theta\hat{A}(\theta\hat{\sigma}^2 + 1) + \hat{X}_l \right]} < 0 \quad (2.52)$$

This inequality implies:

Proposition 2 *There is negative leakage in the full agreement.*

According to our result, $dU_c/d\sigma_c$ shows a negative sign when evaluated at the point of autarky. We can see from (2.47) that high-income bloc's utility under autarky is lower than under full agreement and, in turn, autarky is not an optimal outcome because the ad valorem tax on abatement is higher than at the optimum and hence the marginal benefit is smaller than at the optimum. It immediately follows that optimality under full agreement requires a higher level of subsidy (compared to autarky), that attracts a capital flow from the low-income bloc. Therefore, the full agreement outcome is characterised by negative leakage. A subsidy higher than the one implementing autarky induces domestic firms to cut their emissions by increasing abatement rather than reducing production. The high-income bloc, by subsidizing abatement draws resources away from the low-income bloc, hence reducing the latter's production and emissions. Therefore, the high-income bloc can achieve its emissions reduction target without suffering from output loss, but at the expense of a much more distorted capital market.

2.4.2 Non Cooperative Policy

This subsection shall characterize the non-cooperative policy solution. For all the rest of the chapter we shall use the subscript j to denote an individual high-income country, where $j \neq i$. In this subsection we assume that every high-income

country has its own unilateral environmental policy, set in a non-cooperative fashion. In this policy scenario, each high-income country i maximises its residents' welfare by quantifying the amount of emissions permits e_i and the ad valorem tax on abatement σ_i , taking other countries' environmental policies as given. This implies that country i decides its environmental policy without taking the environmental damage inflicted to the rest of the bloc into account. Therefore, the environmental externality is not fully internalised and the outcome shall not be optimal.

2.4.2.1 Stage two

Totally differentiating (2.6), (2.8), (2.21) and (2.22) with respect to e_i yields the following system:

$$\begin{aligned} \frac{dx_i}{de_i} - \frac{da_i}{de_i} &= 1 \\ \frac{dx_j}{de_i} - \frac{da_j}{de_i} &= 0 \\ N_h x_i \frac{dx_i}{de_i} + \sum_{j=1, j \neq i}^{N_h} X_j \frac{dx_j}{de_i} + \theta N_h a_i \frac{da_i}{de_i} + \sum_{j=1, j \neq i}^{N_h} \theta N_h a_j \frac{da_j}{de_i} + \frac{X_l}{\phi} \frac{dX_l}{de_i} &= 0 \\ \theta \rho \sigma_i \frac{da_i}{de_i} + \rho \frac{dx_i}{de_i} + (\theta \sigma_i a_i + x_i) \frac{d\rho}{de_i} &= 0 \\ \theta \rho \sigma_j \frac{da_j}{de_i} + \rho \frac{dx_j}{de_i} + (\theta \sigma_j a_j + x_j) \frac{d\rho}{de_i} &= 0 \\ \rho \frac{dX_l}{de_i} + X_l \frac{d\rho}{de_i} &= 0 \end{aligned}$$

We shall use our assumption about the symmetry of all the high-income countries in order to simplify this system. For the rest of the chapter we shall use the

subscript n to denote the non-cooperative solution. Using the first order conditions for firms' profit maximization in the high and low-income blocs, that is (2.20) and (2.22), respectively, we obtain the following matrix:

$$\begin{pmatrix} -1 & 0 & 1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 1 & 0 & 0 \\ \theta A_h & (N_h - 1)\theta A_h & X_h & (N_h - 1)X_h & \frac{1}{\rho} & 0 \\ \theta \rho \sigma_i & 0 & \rho & 0 & 0 & \frac{1}{\rho} \\ 0 & \theta \rho \sigma_i & 0 & \rho & 0 & \frac{1}{\rho} \\ 0 & 0 & 0 & 0 & \rho & X_l \end{pmatrix} * \begin{pmatrix} da_i/de_i \\ da_j/de_i \\ dx_i/de_i \\ dx_j/de_i \\ dX_l/de_i \\ d\rho/de_i \end{pmatrix} = \begin{pmatrix} 1 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix} \quad (2.53)$$

Solving system (2.53) by applying Cramer's rule and using (2.22) yields:

$$\frac{da_i}{de_i} = \frac{-(\theta \sigma_i + 1)(X_l + X_h) - (N_h - 1)(X_h + \theta A_h)}{\Delta_i} < 0 \quad (2.54a)$$

$$\frac{da_j}{de_i} = \frac{dx_j}{de_i} = \frac{\theta(A_h - \sigma_i X_h)}{\Delta_i} > 0 \quad \text{in autarky} \quad (2.54b)$$

$$\frac{dx_i}{de_i} = \frac{\theta[(\theta \sigma_i + 1)(A_h + \sigma_i X_l) + (N_h - 1)\sigma_i X_h]}{\Delta_i} > 0 \quad (2.54c)$$

$$\frac{dX_l}{de_i} = \frac{\phi \theta (A_h - \sigma_i X_h) (\theta \sigma_i + 1)}{\Delta_i} > 0 \quad \text{in autarky} \quad (2.54d)$$

$$\frac{d\rho}{de_i} = \frac{-\theta \rho^2 (A_h - \sigma_i X_h) (\theta \sigma_i + 1)}{\Delta_i} < 0 \quad \text{in autarky} \quad (2.54e)$$

where Δ_i represents the determinant of the matrix (2.53) divided by ρ and it is such that:

$$\Delta_i = (\theta \sigma_i + 1) [X_l (\theta \sigma_i + 1) + N_h (X_h + \theta A_h)] \quad (2.55)$$

Inequalities (2.54b), (2.54d) and (2.54e) follow from Lemma 1.2.

To compare the relative magnitude of the effects of an increase in emissions on non-cooperative and cooperative variables, we first multiply (2.54a) and (2.54c) by

N_h to obtain the per-capita values X_h and A_h and we can then have the following result:

Lemma 3 *Given X_h , A_h , X_l , ρ , $\sigma_h = \sigma_i$, an increase in allowed emissions will lead to:*

- (i) *bigger impact on A_n compared to A_c ;*
- (ii) *bigger impact on X_n compared to X_c ;*
- (iii) *smaller impact on non-cooperative X_l compared to the full agreement;*
- (iv) *smaller impact on non-cooperative ρ compared to the full agreement.*

Proof. See Appendix D. ■

In order to see the intuition behind the first two results, we first need to notice that abatement and domestic production are much lower in the individual high-income country than in the whole bloc. Hence, the impact of a given increase in emissions on domestic production and abatement will be of a bigger magnitude under non-cooperative policy, rather than under full agreement. In order to see the intuition behind the last two results, we first need to notice that the whole high-income bloc's capital endowment is much bigger than that of the individual high-income country. Consequently, a given increase in emissions reduces capital relocation abroad much more under full agreement and, hence, has a bigger impact on ρ and X_l than under non-cooperative policy.

Totally differentiating (2.6), (2.8), (2.21) and (2.22) with respect to σ_i yields:

$$\begin{aligned}
\frac{dx_i}{d\sigma_i} - \frac{da_i}{d\sigma_i} &= 0 \quad (2.56) \\
\frac{dx_j}{d\sigma_i} - \frac{da_j}{d\sigma_i} &= 0 \\
N_h x_i \frac{dx_i}{d\sigma_i} + \sum_{j=1, j \neq i}^{N_h} N_h x_j \frac{dx_j}{d\sigma_i} + \theta N_h a_i \frac{da_i}{d\sigma_i} + \sum_{j=1, j \neq i}^{N_h} \theta N_h a_j \frac{da_j}{d\sigma_i} + \frac{X_l}{\phi} \frac{dX_l}{d\sigma_i} &= 0 \\
\theta \rho \sigma_i \frac{da_i}{d\sigma_i} + \rho \frac{dx_i}{d\sigma_i} + (\theta \sigma_i a_i + x_i) \frac{d\rho}{d\sigma_i} + \rho \theta a_i &= 0 \\
\theta \rho \sigma_j \frac{da_j}{d\sigma_i} + \rho \frac{dx_j}{d\sigma_i} + (\theta \sigma_j a_j + x_j) \frac{d\rho}{d\sigma_i} &= 0 \\
\rho \frac{dX_l}{d\sigma_i} + X_l \frac{d\rho}{d\sigma_i} &= 0
\end{aligned}$$

We shall use our assumption about the symmetry of all the high-income countries in order to simplify this system. Using the first order conditions for firms' profit maximization in the high and low-income blocs, that is (2.20) and (2.22), respectively, we obtain the following matrix:

$$\begin{pmatrix}
-1 & 0 & 1 & 0 & 0 & 0 \\
0 & -1 & 0 & 1 & 0 & 0 \\
\theta A_h & \theta A_h(N_h - 1) & X_h & X_h(N_h - 1) & \frac{1}{\rho} & 0 \\
\theta \rho \sigma_i & 0 & \rho & 0 & 0 & \frac{1}{\rho} \\
0 & \theta \rho \sigma_i & 0 & \rho & 0 & \frac{1}{\rho} \\
0 & 0 & 0 & 0 & \rho & X_l
\end{pmatrix} * \begin{pmatrix} da_i/d\sigma_i \\ da_j/d\sigma_i \\ dx_i/d\sigma_i \\ dx_j/d\sigma_i \\ dX_l/d\sigma_i \\ d\rho/d\sigma_i \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \\ -\rho \theta a_i \\ 0 \\ 0 \end{pmatrix} \quad (2.57)$$

Solving system (2.57) by applying Cramer's rule and using (2.22) yields:

$$\frac{da_i}{d\sigma_i} = \frac{dx_i}{d\sigma_i} = \frac{-\theta A_h [X_l (\theta\sigma_i + 1) + (X_h + \theta A_h) (N_h - 1)]}{N_h \Delta_i} < 0 \quad (2.58a)$$

$$\frac{da_j}{d\sigma_i} = \frac{dx_j}{d\sigma_i} = \frac{\theta A_h (X_h + \theta A_h)}{\Delta_i} > 0 \quad (2.58b)$$

$$\frac{dX_l}{d\sigma_i} = \frac{\phi \theta A_h (X_h + \theta A_h) (\theta\sigma_i + 1)}{N_h \Delta_i} > 0 \quad (2.58c)$$

$$\frac{d\rho}{d\sigma_i} = \frac{-\rho^2 \theta A_h (X_h + \theta A_h) (\theta\sigma_i + 1)}{N_h \Delta_i} < 0 \quad (2.58d)$$

where Δ_i is given by (2.55).

To compare the relative magnitude of the effects of an increase in the ad valorem tax on abatement on non-cooperative and cooperative variables, we first multiply (2.58a) by N_h and we can then have the following result:

Lemma 4 *Given X_h , A_h , X_l , ρ , $\sigma_h = \sigma_i$, an increase in the ad valorem tax on abatement will lead to:*

- (i) *bigger impact on A_n compared to A_c ;*
- (ii) *bigger impact on X_n compared to X_c ;*
- (iii) *smaller impact on non-cooperative X_l compared to the full agreement;*
- (iv) *smaller impact on non-cooperative ρ compared to the full agreement.*

Proof. See Appendix D. ■

In order to see the intuition behind the first two results, we first need to notice that an increase in the ad valorem tax on abatement under non-cooperative policy generates capital re-location towards the low-income bloc and the other high-income countries as well; whilst under full agreement capital can only re-locate

towards the low-income bloc. Hence, the impact on domestic production and abatement will be of a bigger magnitude under non-cooperative policy, rather than under full agreement. The intuition behind the last two results, is that a given increase in the ad valorem tax on abatement moves much more capital under full agreement and, hence, has a bigger impact on ρ and X_l than under non-cooperative policy.

2.4.2.2 Stage one

In stage one, the high-income country sets the emission ceiling e_n and the abatement subsidy σ_n that maximise its own welfare (2.11). The first order conditions for the welfare maximization are:

$$\frac{du_n}{de_n} = \frac{1}{Y_n} \frac{dy_n}{de_n} - \lambda_n \frac{dE}{de_n} = 0 \quad (2.59a)$$

$$\frac{du_n}{d\sigma_n} = \frac{1}{Y_n} \frac{dy_n}{d\sigma_n} - \lambda_n \frac{dE}{d\sigma_n} = 0 \quad (2.59b)$$

Totally differentiating (2.7) with respect to e_n and σ_n yields:

$$\frac{dE}{de_n} = 1 + \frac{dX_l}{de_n} \quad (2.60a)$$

$$\frac{dE}{d\sigma_n} = \frac{dX_l}{d\sigma_n} \quad (2.60b)$$

Totally differentiating (2.13) with respect to e_n and σ_n yields, using (2.15), (2.20) and (2.56):

$$\frac{dy_n}{de_n} = (1 - \rho X_n) \frac{dx_n}{de_n} + \omega_n \frac{d\rho}{de_n} - \rho \theta A_n \frac{da_n}{de_n} \quad (2.61a)$$

$$\frac{dy_n}{d\sigma_n} = -(1 - \sigma_n) \rho \theta A_n \frac{dx_n}{d\sigma_n} + \omega_n \frac{d\rho}{d\sigma_n} \quad (2.61b)$$

Substituting (2.60a) to (2.61b) into (2.59a) and (2.59b) yields the first order conditions:

$$\frac{du_n}{de_n} = \frac{(1 - \rho X_n)}{Y_n} \frac{dx_n}{de_n} + \frac{\omega_n}{Y_n} \frac{d\rho}{de_n} - \left(\frac{\rho \theta A_n}{Y_n} \right) \frac{da_n}{de_n} - \quad (2.62a)$$

$$\lambda_n \left(1 + \frac{dX_l}{de_n} \right) = 0$$

$$\frac{du_n}{d\sigma_n} = -(1 - \sigma_n) \left(\frac{\rho \theta A_n}{Y_n} \right) \frac{dx_n}{d\sigma_n} - \left[\lambda_n \frac{dX_l}{d\sigma_n} - \frac{\omega_n}{Y_n} \frac{d\rho}{d\sigma_n} \right] = 0 \quad (2.62b)$$

Expressions (2.62a) and (2.62b) represent the non-cooperative equi-marginal rules. The first term in (2.62a) represents the marginal benefit and the second one the marginal cost of an increase in allowed emissions. Symmetrically, the first term in (2.62b) represents the marginal benefit and the second one the marginal cost of an increase in the ad valorem tax on abatement. In order to obtain the per-capita values we multiply (2.62a) and (2.62b) by N_h , such that

$$N_h \frac{du_n}{de_n} = \frac{N_h (1 - \rho X_n)}{Y_n} \frac{dx_n}{de_n} + \frac{\Omega_n}{Y_n} \frac{d\rho}{de_n} - \left(\frac{\rho \theta N_h A_n}{Y_n} \right) \frac{da_n}{de_n} - \quad (2.63a)$$

$$N_h \lambda_n \left(1 + \frac{dX_l}{de_n} \right) = 0$$

$$N_h \frac{du_n}{d\sigma_n} = -(1 - \sigma_n) \left(\frac{\rho \theta N_h A_n}{Y_n} \right) \frac{dx_n}{d\sigma_n} - \quad (2.63b)$$

$$\left[N_h \lambda_n \frac{dX_l}{d\sigma_n} - \frac{\Omega_n}{Y_n} \frac{d\rho}{d\sigma_n} \right] = 0$$

We shall refer to these expressions when comparing the non-cooperative policy outcome with the other scenarios.

Substituting (2.54a), (2.54c), (2.54d) and (2.54e) into (2.62a) and simplifying

by using (2.22), we obtain:

$$\begin{aligned}
\frac{du_n}{de_n} = & \frac{\theta(1 - \rho X_n) [\sigma_n X_l (\theta \sigma_n + 1) + \sigma_n N_h (X_n + \theta A_n) - \sigma_n X_n + A_n]}{Y_n (\theta \sigma_n + 1) [X_l (\theta \sigma_n + 1) + N_h (X_n + \theta A_n)]} + \\
& \frac{\rho \theta A_n [N_h (X_n + \theta A_n) + X_l (\theta \sigma_n + 1) + \theta (\sigma_n X_n - A_n)]}{Y_n (\theta \sigma_n + 1) [X_l (\theta \sigma_n + 1) + N_h (X_n + \theta A_n)]} + \\
& \frac{\theta \rho^2 \omega_n (\sigma_n X_n - A_n)}{Y_n [X_l (\theta \sigma_n + 1) + N_h (X_n + \theta A_n)]} - \\
& \lambda_n \left[1 + \frac{\phi \theta (A_n - \sigma_n X_n)}{X_l (\theta \sigma_n + 1) + N_h (X_n + \theta A_n)} \right] = 0
\end{aligned} \tag{2.64}$$

Simplifying by using (2.20) and then solving (2.64) for λ_n yields:

$$\begin{aligned}
\lambda_n = & \rho \theta A_n \frac{(\theta \sigma_n^2 + 1) [N_h (X_n + \theta A_n) + X_l (\theta \sigma_n + 1)] + \theta (A_n - \sigma_n X_n) (\sigma_n - 1)}{(\theta \sigma_n + 1) Y_n [X_l (\theta \sigma_n + 1) + N_h (X_n + \theta A_n) + \phi \theta (A_n - \sigma_n X_n)]} + \\
& \frac{\theta \rho^2 \omega_n (\sigma_n X_n - A_n)}{Y_n [X_l (\theta \sigma_n + 1) + N_h (X_n + \theta A_n) + \phi \theta (A_n - \sigma_n X_n)]}
\end{aligned} \tag{2.65}$$

Substituting (2.58a), (2.58c) and (2.58d) into (2.62b) and then simplifying by using (2.20), yields the first order condition for σ_n :

$$\begin{aligned}
\frac{du_n}{d\sigma_n} = & \frac{\rho \theta^2 A_n^2 (1 - \sigma_n) [X_l (\theta \sigma_n + 1) + (X_n + \theta A_n) (N_h - 1)]}{N_h Y_n (\theta \sigma_n + 1) [X_l (\theta \sigma_n + 1) + N_h (X_n + \theta A_n)]} - \\
& \frac{\rho^2 \theta A_n \omega_n (X_n + \theta A_n)}{N_h Y_n [X_l (\theta \sigma_n + 1) + N_h (X_n + \theta A_n)]} - \\
& \frac{\lambda_n \phi \theta A_n (X_n + \theta A_n)}{N_h [X_l (\theta \sigma_n + 1) + N_h (X_n + \theta A_n)]} = 0
\end{aligned} \tag{2.66}$$

2.4.2.3 Autarky

Substituting the autarky condition $\omega_n = 0$ into (2.65) and (2.66) yields, respectively:

$$\lambda_n = \hat{\rho}\theta\hat{A} \frac{(\theta\hat{\sigma}^2 + 1) \left[\hat{X}_l (\theta\hat{\sigma} + 1) + N_h \left(\hat{X}_h + \theta\hat{A} \right) \right] + \theta (\hat{\sigma} - 1) \left(\hat{A} - \hat{\sigma}\hat{X}_h \right)}{\hat{X}_h (\theta\hat{\sigma} + 1) \hat{H}_n} \quad (2.67)$$

$$\begin{aligned} \frac{du_n}{d\sigma_n} = & \frac{\hat{\rho}\theta^2\hat{A}^2(1-\hat{\sigma}) \left[\hat{X}_l (\theta\hat{\sigma} + 1) + \left(\hat{X}_h + \theta\hat{A} \right) (N_h - 1) \right]}{N_h\hat{X}_h (\theta\hat{\sigma} + 1) \left[\hat{X}_l (\theta\hat{\sigma} + 1) + N_h \left(\hat{X}_h + \theta\hat{A} \right) \right]} - \\ & \frac{\lambda_n\phi\theta\hat{A} \left(\hat{X}_h + \theta\hat{A} \right)}{N_h \left[\hat{X}_l (\theta\hat{\sigma} + 1) + N_h \left(\hat{X}_h + \theta\hat{A} \right) \right]} \end{aligned} \quad (2.68)$$

where $\hat{H}_n$ is defined such that:

$$\hat{H}_n \equiv \hat{X}_l (\theta\hat{\sigma} + 1) + N_h \left(\hat{X}_h + \theta\hat{A} \right) + \phi\theta \left(\hat{A} - \hat{\sigma}\hat{X}_h \right) \quad (2.69)$$

From (2.36a), (2.36b), (2.36c), (2.54a), (2.54c) and (2.54d) we know that, in autarky, an increase in emissions has a positive impact on domestic and foreign production and a negative impact on abatement. From (2.45) and (2.63a) in autarky and Lemma 3 we know that the marginal benefit under non-cooperative policy is larger than under full agreement; whilst the reverse is valid for the marginal cost if $N_h\lambda_n = \Lambda_c$. Given that the optimality condition requires both expressions to be equal to zero, the next lemma immediately follows.

Lemma 5 *In autarky $N_h\lambda_n > \Lambda_c$.*

In autarky, for a given level of emissions, marginal environmental damage in per-capita terms is bigger under non-cooperative policy than under full agreement.

Plugging (2.67) into (2.68) yields:

$$\begin{aligned} \frac{du_n}{d\sigma_n} = & \frac{\hat{\rho}\theta^2\hat{A}^2(1-\hat{\sigma})\left[\hat{X}_l(\theta\hat{\sigma}+1)+\left(\hat{X}_h+\theta\hat{A}\right)(N_h-1)\right]}{N_h\hat{X}_h(\theta\hat{\sigma}+1)\left[\hat{X}_l(\theta\hat{\sigma}+1)+N_h\left(\hat{X}_h+\theta\hat{A}\right)\right]} - \\ & \frac{\phi\hat{\rho}\theta^2\hat{A}^2\left(\hat{X}_h+\theta\hat{A}\right)(\theta\hat{\sigma}^2+1)\left[\hat{X}_l(\theta\hat{\sigma}+1)+N_h\left(\hat{X}_h+\theta\hat{A}\right)\right]}{N_h\hat{X}_h\hat{H}_n(\theta\hat{\sigma}+1)\left[\hat{X}_l(\theta\hat{\sigma}+1)+N_h\left(\hat{X}_h+\theta\hat{A}\right)\right]} + \\ & \frac{\phi\hat{\rho}\theta^3\hat{A}^2\left(\hat{X}_h+\theta\hat{A}\right)\left(\hat{A}-\hat{\sigma}\hat{X}_h\right)(1-\hat{\sigma})}{N_h\hat{X}_h\hat{H}_n(\theta\hat{\sigma}+1)\left[\hat{X}_l(\theta\hat{\sigma}+1)+N_h\left(\hat{X}_h+\theta\hat{A}\right)\right]} \end{aligned} \quad (2.70)$$

We refer to Appendix C for a detailed explanation of the calculations that lead (2.70) to become:

$$\frac{du_n}{d\sigma_n} = \frac{\hat{\rho}\theta^2\hat{A}^2\left[(N_h-1)(1-\hat{\sigma})\left(\hat{X}_h+\theta\hat{A}\right)-\hat{\sigma}\hat{X}_l(\theta\hat{\sigma}+1)\right]}{N_h\hat{X}_h(\theta\hat{\sigma}+1)\left[\hat{X}_l+N_h\left(\hat{X}_h+\theta\hat{A}\right)+\phi\theta\hat{A}(\theta\hat{\sigma}^2+1)\right]} \quad (2.71)$$

Proposition 6 *There is positive leakage in the non-cooperative equilibrium.*

Proof. See Appendix D. ■

According to our result, $du_n/d\sigma_n$ shows a positive sign when evaluated at the point of autarky. In autarky, the marginal benefit is larger than the marginal cost. This is due to the fact that the optimal value of the ad valorem tax on abatement is higher than the autarky one. It immediately follows that optimality under unilateral policy requires capital outflow towards the low-income bloc. Therefore, the non-cooperative outcome is characterised by positive leakage. On the one hand, a subsidy lower than the one implementing autarky induces domestic firms to cut

their emissions by re-locating capital abroad rather than increasing abatement. The individual high-income country, through capital re-location injects resources into the low-income bloc, hence increasing the latter's production and emissions. On the other hand, domestic production and the distortion in the domestic capital market both decrease. Therefore, the high-income country can achieve its emissions reduction target without distorting its domestic capital market, but at the expense of lower domestic output.

2.4.3 Partial Agreement

This subsection shall characterize the partial agreement solution. In this policy scenario we assume that the bloc of high-income countries participates in the environmental agreement. As previously mentioned, we abstract from enforceability and stability issues, in order to focus on the sign of carbon leakage at the point of autarky in the capital market. The bloc of high-income countries quantifies the amount of emissions permits in a cooperative fashion, such that the joint welfare of their residents is maximised. The difference with the full agreement scenario is that now the choice of the ad valorem tax on abatement is left to the individual country. Therefore, every high-income country chooses the subsidy to be implemented by maximizing the welfare of its own residents and taking other countries' policy instrument as given. In this scenario high-income countries' policies are not coordinated and this implies that the environmental damage inflicted on the rest of the bloc (through capital movements) is not taken into account. Therefore the environmental externality is not fully internalised and the outcome shall not be optimal. For the rest of the chapter we shall use the subscript p to denote the partial agreement solution.

2.4.3.1 Stage one

Under partial agreement the country chooses its emissions allowances cooperatively and the ad valorem tax on abatement non-cooperatively. Therefore, the first order conditions for welfare maximization are (2.45) or (2.46) for E and (2.62b) for σ . In order to obtain the per-capita values we multiply (2.62b) by N_h , such that

$$N_h \frac{du_p}{d\sigma_p} = -(1 - \sigma_p) \left(\frac{\rho \theta N_h A_p}{Y_p} \right) \frac{dx_p}{d\sigma_p} - \left[N_h \lambda_p \frac{dX_l}{d\sigma_p} - \frac{\Omega_p}{Y_p} \frac{d\rho}{d\sigma_p} \right] = 0 \quad (2.72a)$$

We shall refer to this expression when comparing partial agreement with the other scenarios.

The first order conditions (2.46) and (2.66) can be written as:

$$\lambda_p = \frac{\theta [A_p + \sigma_p X_l + (A_p - \sigma_p X_p) (\phi - \rho^2 \Omega_p)]}{N_h Y_p [X_l (\theta \sigma_p + 1) + (X_p + \theta A_p) + \phi \theta (A_p - \sigma_p X_p)]} \quad (2.73)$$

$$\begin{aligned} \frac{du_p}{d\sigma_p} &= \frac{\rho \theta^2 A_p^2 (1 - \sigma_p) [X_l (\theta \sigma_p + 1) + (X_p + \theta A_p) (N_h - 1)]}{N_h Y_p (\theta \sigma_p + 1) [X_l (\theta \sigma_p + 1) + N_h (X_p + \theta A_p)]} - \\ &\quad \frac{\theta \rho^2 \Omega_p A_p (X_p + \theta A_p)}{N_h^2 Y_p [X_l (\theta \sigma_p + 1) + N_h (X_p + \theta A_p)]} - \lambda_p \frac{\phi \theta A_p (X_p + \theta A_p)}{N_h [X_l (\theta \sigma_p + 1) + N_h (X_p + \theta A_p)]} = 0 \end{aligned} \quad (2.74)$$

2.4.3.2 Autarky

Substituting the autarky condition $\Omega_p = 0$ into (2.73) and (2.74) yields, respectively:

$$\lambda_p = \frac{\theta [\hat{A} + \hat{\sigma} \hat{X}_l + \phi (\hat{A} - \hat{\sigma} \hat{X}_h)]}{N_h \hat{X}_h [\hat{X}_l (\theta \hat{\sigma} + 1) + (\hat{X}_h + \theta \hat{A}) + \phi \theta (\hat{A} - \hat{\sigma} \hat{X}_h)]} \quad (2.75)$$

$$\begin{aligned} \frac{du_p}{d\sigma_p} = & \frac{\hat{\rho}\theta^2\hat{A}^2(1-\hat{\sigma})\left[\hat{X}_l(\theta\hat{\sigma}+1)+\left(\hat{X}_h+\theta\hat{A}\right)(N_h-1)\right]}{N_h\hat{X}_h(\theta\hat{\sigma}+1)\left[\hat{X}_l(\theta\hat{\sigma}+1)+N_h\left(\hat{X}_h+\theta\hat{A}\right)\right]} - \\ & \lambda_p \frac{\phi\theta\hat{A}\left(\hat{X}_h+\theta\hat{A}\right)}{N_h\left[\hat{X}_l(\theta\hat{\sigma}+1)+N_h\left(\hat{X}_h+\theta\hat{A}\right)\right]} \end{aligned} \quad (2.76)$$

From (2.58a) and (2.58c) we know that an increase in the ad valorem tax on abatement has a negative impact on domestic production and abatement and a positive impact on foreign production. In addition, from (2.62b) in autarky, we can see that the non-cooperative and the partial agreement only differ for the values of λ_n and λ_p and from Lemma 5 we know that $\lambda_n N_h < \Lambda_c = \lambda_p N_h$. Therefore, given that from Proposition 6 we know that there is positive carbon leakage under non-cooperative policy, then it must be the case under partial agreement as well.

Proposition 7 *There is positive leakage in the partial agreement.*

According to our result, $du_p/d\sigma_p$ shows a positive sign when evaluated at the point of autarky. In autarky, the marginal benefit is larger than the marginal cost. This is due to the fact that the autarky value of the ad valorem tax on abatement is lower than in the optimum. It immediately follows that optimality under partial agreement requires a capital outflow towards the low-income bloc. Therefore, partial agreement is characterised by positive leakage. The mechanism is similar to the one described for the non-cooperative policy and the differences shall be highlighted in subsection 2.5.2.

2.5 Comparisons between policy scenarios

This section shall compare the policy scenarios previously analysed and their policy outcomes. The first comparison shall be between the policy outcomes under full agreement and partial agreement. We already know that in autarky carbon leakage under full agreement is negative, whilst under partial agreement it is positive. We shall see that under full agreement the dominant effect is the impact of an increase in the abatement tax on foreign production. On the other hand, under partial agreement the dominant effect is the impact of an increase in the abatement tax on domestic production and abatement. Therefore, the optimal ad valorem tax on abatement under full agreement is lower than under partial agreement. Then, we shall compare the policy outcomes under non-cooperative policy and partial agreement. We shall see that under partial agreement the individual high-income country has agreed to cut its emissions more than under non-cooperative policy. Therefore, the optimal ad valorem tax on abatement under full agreement is lower than under partial agreement. Moreover, we shall show that, for a given level of domestic emissions, the partial agreement outcome is always characterised by higher carbon leakage than under non-cooperative policy. Finally, the last comparison shall be between the policy outcomes under full agreement and non-cooperative policy. We already know that carbon leakage under full agreement is negative, whilst under non-cooperative policy it is positive. The impact on domestic production and abatement under non-cooperative policy is so big that it is the dominant one, regardless of the relative strength of the impact of an increase in the ad valorem tax on abatement on foreign production under full agreement and non-cooperative policy. Therefore, the optimal subsidy under full agreement is higher than under non-cooperative policy.

2.5.1 Comparison between full agreement and partial agreement

This subsection focuses on the comparison between the full agreement and the partial agreement policy outcomes. To this end, we shall recall that from Proposition 2 we know that under full agreement there is negative leakage and from Proposition 7 we know that under partial agreement there is positive leakage. Hence, it is straightforward to conclude that under partial agreement the magnitude of carbon leakage is bigger than under full agreement.

From Lemma 3 we know that an increase in the ad valorem tax on abatement has a bigger impact on domestic production and abatement under partial agreement than under full agreement. Therefore, from (2.47), (2.72a) and Lemma 3 it immediately follows that the marginal benefit of an increase in the ad valorem tax on abatement under full agreement is smaller than under partial agreement. On the other hand, from Lemma 3 we know that an increase in the ad valorem tax on abatement has a smaller impact on low-income country production under partial agreement than under full agreement. Therefore, the marginal cost under full agreement is bigger than under partial agreement. Therefore, the optimal ad valorem tax on abatement under full agreement is lower than under partial agreement.

2.5.2 Comparison between non-cooperative policy and partial agreement

This subsection focuses on the comparison between non-cooperative policy and partial agreement policy outcomes. From Proposition 6 and Proposition 7 we know that both scenarios are characterised by positive leakage. Therefore, in order to find out the relative magnitude of carbon leakage in the two scenarios, we need to compare them directly for a given level of domestic emissions.

The noncooperative policy equilibrium is given by $du_n/de_n = 0$ in (2.62a) and $du_n/d\sigma_n = 0$ in (2.62b). Define $\tilde{\lambda}_n \equiv \lambda_n(e_i, \tilde{\sigma}_n)$ and $\tilde{\sigma}_n \equiv \sigma_n(e_i, \tilde{\lambda}_n)$ as the environmental damage parameter and the ad valorem tax rate on abatement under which (2.62a) and (2.62b) hold for a given e_i .

We now analyse how the same e_i would be implemented in a partial agreement. The partial agreement is characterized by $du_p/d\sigma_p = 0$, as with non-cooperative policy, and $dU_p/dE_p = 0$ as in (2.45). For a given e_i , we can determine from (2.73) for which $\lambda_p(e_i, \tilde{\sigma}_n)$ the partial agreement would result in the same $\tilde{\sigma}_n$ as would non-cooperative policy. The equilibrium capital allocation would then be exactly the same. However, the countries would now want to set a different ad valorem tax on abatement in the partial equilibrium. From (2.62b) and since $du_i(\tilde{\lambda}, \tilde{\sigma}_n)/d\sigma_i = 0$ by definition:

$$\frac{du_i(\lambda_p(e_i, \tilde{\sigma}_n), \tilde{\sigma}_n)}{d\sigma_i} = \left[\tilde{\lambda}_n - \lambda_p(e_i, \tilde{\sigma}_n) \right] \frac{dX_l}{d\sigma_i} \quad (2.77)$$

By (2.58c), the sign of the LHS is the sign of $\left[\tilde{\lambda}_n - \lambda_p(e_i, \tilde{\sigma}_n) \right]$. Thus there is higher leakage, i.e. the ad valorem tax on abatement is higher, in the partial agreement if and only if (2.77) is positive, which happens if and only if $\tilde{\lambda}_n > \lambda_p(e_i, \tilde{\sigma}_n)$. From (2.65) and (2.73) this inequality holds if and only if, in the non-cooperative policy equilibrium for a given e_i :

$$\frac{\rho A_n \{ (\theta \sigma_n^2 + 1) [N_h(X_n + \theta A_n) + X_l(\theta \sigma_n + 1)] + \theta \xi_n(\sigma_n - 1) \}}{\vartheta_n(\theta \sigma_n + 1)} + \frac{-(\theta \sigma_n + 1) \rho^2 \omega_n \xi_n}{\vartheta_n(\theta \sigma_n + 1)} > \frac{A_n + \sigma_n X_l + \xi_n(\phi - \rho^2 \Omega_n)}{X_l(\theta \sigma_n + 1) + X_n + \theta A_n + \phi \theta \xi_n}$$

with

$$\begin{aligned}\xi_n &\equiv (A_n - \sigma_n X_n) \\ \vartheta_n &\equiv [X_l(\theta\sigma_n + 1) + N_h(X_n + \theta A_n) + \phi\theta\xi_n]\end{aligned}$$

2.5.3 Comparison between full agreement and non-cooperative policy

This subsection focuses on the comparison between full agreement and non-cooperative policy outcomes. From Lemma 5 we know that in autarky, for a given level of emissions, the marginal environmental damage in per-capita terms is bigger under non-cooperative policy than under full agreement. In (2.47) and (2.62b) in autarky (i.e. with $\Omega_c = 0$ and $\omega_n = 0$), we can recall that the first term represents the marginal benefit and the second one the marginal cost of an increase in the ad valorem tax on abatement. From Lemma 3 we know that an increase in the ad valorem tax on abatement has a bigger impact on non-cooperative domestic production and abatement than under full agreement. Therefore, from (2.47), (2.62b) and Lemma 3 it immediately follows that in autarky the marginal benefit under full agreement is lower than under non-cooperative policy. On the other hand, from (2.47) and (2.62b) we can see that in autarky the marginal cost is constituted of two parts: the impact on foreign production of a change in the ad valorem tax on abatement and the optimal emissions target. From Lemma 3 and Lemma 5 we know that the former is bigger under full agreement and the latter is bigger under non-cooperative policy. Therefore, using this approach we cannot state the relative magnitude of the marginal costs. However, we know from Proposition 2 and Proposition 6, that in autarky carbon leakage is negative under full agreement and positive under non-cooperative policy. The impact on domestic production and abatement under non-cooperative policy is so big that it

is the dominant one, regardless of the relative strenght of the impact of an increase in the ad valorem tax on abatement on foreign production under full agreement and non-cooperative policy. Therefore, the optimal subsidy under full agreement is higher than under non-cooperative policy.

2.6 Conclusion

In the past 40 years environmental issues have attracted a great deal of attention and significant improvements have been made towards environmental awareness. To that end, a number of international environmental agreements (IEAs) have been ratified. Unfortunately, those agreements are either bilateral or, even if of a multilateral nature, have only been ratified by a limited number of countries. Amongst the IEAs with the highest geographical coverage, the most famous is probably the Kyoto Protocol (1997), that aimed at reducing the greenhouse gases (GHGs) emissions during the period 2008-2012. Its ratification and entry into force created the illusion of further steps made towards the mitigation of climate change. Actually, the final draft of IPCC (chapter 5, p. 394, 2014) found evidence that during the period 2000-2010, GHGs emissions in developing countries more than doubled.

We argue that this counter-intuitive evidence does not come as a surprise, but actually it should have been foreseen from the structure of the IEA itself. Indeed, we argue that IEAs with partial geographical coverage that leave it to the individual signatory to set its own policy instrument (in order to achieve the agreed target), generate carbon leakage. Carbon leakage can be defined as the increase in non-signatories emissions due to capital inflows from the emissions-restricted countries. The aim of the chapter is to show how carbon leakage arises from an IEA with partial geographical coverage. We distinguish between high and

low-income countries and assume that only the former join the IEA.

Three policy scenarios are considered: full agreement, non-cooperative policy and partial agreement. The full agreement is characterised by complete cooperation within the whole high-income bloc, in both deciding the amount of allowed emissions and setting the policy instrument. The non-cooperative policy is characterised by the individual high-income country choosing independently both emissions level and the policy instrument. The partial agreement is characterised by emissions chosen cooperatively within the high-income bloc and the policy instrument set non-cooperatively.

Our results show that under full agreement carbon leakage is negative; whilst under the other two policy scenarios carbon leakage is positive. Optimality under full agreement requires a high subsidy level and hence, capital inflow from the low-income bloc. Indeed, the high-income bloc can achieve its emissions target without suffering from a output loss, but at the expenses of a higher distortion in the capital market. On the other hand, optimality under non-cooperative policy and partial agreement requires a low subsidy level and hence, capital outflow towards the low-income bloc. Indeed, the individual high-income country can achieve its emissions target without distorting its capital market, but at the expense of lower domestic output.

When comparing full agreement and non-cooperative policy we found that the impact on domestic production and abatement under non-cooperative policy is so big that it is the dominant one, regardless of the relative strength of the impact of an increase in the ad valorem tax on abatement on foreign production under full agreement and non-cooperative policy. Therefore, the optimal subsidy under full agreement is higher than under non-cooperative policy. When comparing full agreement and partial agreement we found that under full agreement the

dominant effect is the impact of an increase in the ad valorem tax on abatement on foreign production. On the other hand, under partial agreement the dominant effect is the impact of an increase in the ad valorem tax on abatement on domestic production and abatement. Therefore, the optimal ad valorem tax on abatement under full agreement is lower than under partial agreement. When comparing partial agreement and non-cooperative policy we found that carbon leakage is higher under partial agreement. Indeed, under partial agreement the individual high-income country has agreed to cut its emissions more than under non-cooperative policy. Therefore, the optimal ad valorem tax on abatement under full agreement is lower than under partial agreement.

These results show that carbon leakage shall inevitably arise whenever an IEA, that leaves to the individual signatory the choice of how to reach the emissions target, is signed. Our chapter suggests that, instead of adding further policy instruments (e.g. BTAs), the most effective way to avoid carbon leakage is to include the choice of the carbon tax or abatement subsidy within the terms of the IEA. Insofar as all the policy instruments are chosen cooperatively, there will be no capital outflows towards the non-signatories.

Our model has enabled us to better understand IPCC (2014) empirical evidence about emissions' increase in developing countries. Nonetheless, there are undoubtedly other factors that can affect capital inflows towards developing countries, such as availability of cheap labor, lower taxation and more lenient health and safety regulations. Taking those factors into account could impact on full cooperation's optimality conditions, thus resulting in negative leakage of smaller magnitude or even positive leakage (depending on the relative importance of those factors). The IEA could circumvent these issues by further lowering the cost of abatement services up to the point where firms are indifferent between producing

nationally or abroad.

Moreover, we did not include low-income countries' welfare considerations. Indeed, the model does not feature welfare functions due to our focus on environmental policy. Providing in-depth consideration to the matter is beyond the scope of this chapter, but a note on this issue is in order. Given that positive carbon leakage provides capital inflows to developing countries, they might well experience an increase in welfare due to it. Indeed, the theoretical literature has emphasized a number of ways in which FDI might positively impact on economic growth. For example, an increase in the capital stock is the way in which FDI triggers economic growth according to the standard Solow-type neoclassical model. The works of Romer (1990), Aghion and Howitt (1992), Grossman and Helpman (1991) and Rivera-Batiz and Romer (1991) have started a whole strand in the economic literature, based on the assumption that the productivity of foreign-owned firms is higher than that of those domestically-owned. There are two main channels involved in productivity-increasing technological knowledge transfers from developed to developing countries. The first one focuses on the transmission of ideas and the second one on internationally traded technology-intensive intermediate and capital goods. This strand of the literature claims that FDI generates endogenous growth through both these channels. Another strand in the literature, pioneered by Agosin and Machado (2005) warns about the importance of distinguishing between different FDI types. Indeed, they claim that mergers and acquisitions might just relocate resources and not generate capital stock accumulation and that FDI might negatively perturb domestic investments. In addition, foreign-owned firms might accelerate human capital formation and improve its quality, due to their impact on both demand and supply of skilled labour (Krammer, 2010; Belderbos et al., 2014). Indeed, there are two channels involved in

human capital formation: education and professional experience. The former generates the so-called "generic" human capital and the latter a more "specific" one, but both play an extremely important role in co-determining firm's productivity. The empirical literature on spillovers has highlighted that, if FDI recipients protect investors' rights and intellectual property rights, FDI will play a key role in boosting economic growth. Otherwise, recipient countries might not experience any tangible improvement from FDI. Indeed, due to a lack of protection, firms might fear to invest in the country, with a negative impact on technology transfer and human capital formation.

In the context of our chapter, technological transfer and improvements in human capital would imply that in the long term low-income countries would gain the technology and the technical knowledge and skills to produce in a cleaner way. Applying the findings of this literature to our chapter would probably lead, in a long-term perspective and provided that local institutions and governance are able to capture the positive effects of capital inflows, to the prediction that current carbon leakage might actually generate a reduction in future emissions (due to worldwide adoption of cleaner production technologies) and higher standards of living for low-income countries. This prediction could provide an explanation of why a number of developing countries have taken part to the Kyoto Protocol (1997) as Non-Annex 1 parties. Indeed, through some mechanisms, such as the Clean Development Mechanism, they could benefit from technological cooperation and emissions reductions projects funded by Annex 2 parties, that is to say developed countries.

2.7 Appendix A: Autarky Solution

For the solutions (2.28), (2.29) and (2.30) to be feasible, the square root $\sqrt{2(\theta + 1)\bar{K}_h - \theta E_h^2}$ must exist and output, $\hat{X}_h$, abatement, $\hat{A}$, and the effective price of abatement, $\hat{\sigma}$, must be non-negative.

First, we will prove that the square root $\sqrt{2(\theta + 1)\bar{K}_h - \theta E_h^2}$ exists. This is the case if and only if:

$$2(\theta + 1)\bar{K}_h - \theta E_h^2 > 0 \quad (2.78)$$

From (2.1), (2.4) and (2.12) with $\Omega_h = 0$ and $\hat{A}_h > 0$ it immediately follows that

$$E_h < \hat{X}_h < \sqrt{2\bar{K}_h}$$

so that:

$$E_h^2 < 2\bar{K}_h \quad (2.79)$$

If we plug condition (2.79) into (2.78) we obtain:

$$2\bar{K}_h(1 + \theta) - \theta E_h^2 > 2\bar{K}_h(1 + \theta) - 2\theta\bar{K}_h = 2\bar{K}_h > 0 \quad (2.80)$$

We now turn to the non-negativity conditions. From (2.28) it immediately follows that $\hat{X}_h > 0$.

We shall now see that abatement $\hat{A}$ in (2.29) is positive because:

$$\sqrt{2(\theta + 1)\bar{K}_h - \theta E_h^2} > E_h$$

Raising both sides by the power of two and simplifying yields:

$$(\theta + 1)(2\bar{K}_h - E_h^2) > 0$$

This inequality holds by (2.79).

Finally, we shall see that the effective price of abatement $\hat{\sigma}$ in (2.30) is positive, because:

$$\sqrt{2(\theta + 1)\bar{K}_h - \theta E_h^2} > \sqrt{2\bar{K}_h} \quad (2.81)$$

Raising both sides by the power of two and simplifying yields:

$$\theta (2\bar{K}_h - E_h^2) > 0$$

The inequality follows from (2.79).

□

Inequality (2.33). We can show that

$$(\theta + 1)\sqrt{2\bar{K}_h} + \theta\sqrt{2\bar{K}_h} + \theta E_h > \sqrt{2(\theta + 1)\bar{K}_h - \theta E_h^2}$$

Raise both sides at the power of two, such that

$$\left(\sqrt{2\bar{K}_h} + \theta\sqrt{2\bar{K}_h} + \theta E_h \right)^2 > 2\theta\bar{K}_h - \theta E_h^2 + 2\bar{K}_h$$

Expanding and simplifying yields:

$$\theta (\theta + 1) \left(\sqrt{2\bar{K}_h} + E_h \right)^2 > 0$$

□

2.8 Appendix B: Full Agreement

Equation (2.51) can be rewritten as:

$$\frac{dU_c}{d\sigma_c} = - \frac{\phi\theta^2\hat{A}\Gamma_c}{\hat{X}_h \left[\hat{X}_h + \theta\hat{A} + \hat{X}_l(1 + \theta\hat{\sigma}) \right] \left[\hat{X}_h + \hat{X}_l + \theta \left(\hat{A} + \hat{\sigma}\hat{X}_l \right) + \phi\theta \left(\hat{A} - \hat{\sigma}\hat{X}_h \right) \right]} \quad (2.82)$$

where Γ_c is defined such that

$$\begin{aligned} \Gamma_c \equiv & \left(\theta\hat{A} + \hat{X}_h \right) \left[\hat{A} + \hat{\sigma}\hat{X}_l + \phi \left(\hat{A} - \hat{\sigma}\hat{X}_h \right) \right] - \\ & \hat{A}(1 - \hat{\sigma}) \left[\hat{X}_h + \hat{X}_l + \theta \left(\hat{A} + \hat{\sigma}\hat{X}_l \right) + \phi\theta \left(\hat{A} - \hat{\sigma}\hat{X}_h \right) \right] \end{aligned} \quad (2.83)$$

Expanding the right hand side of (2.83) yields:

$$\begin{aligned} \Gamma_c \equiv & \left(\theta\hat{A} + \hat{X}_h \right) \left(\hat{A} + \hat{\sigma}\hat{X}_l \right) + \phi \left(\theta\hat{A} + \hat{X}_h \right) \left(\hat{A} - \hat{\sigma}\hat{X}_h \right) + \\ & \hat{\sigma}\hat{A} \left(\hat{X}_h + \hat{X}_l + \theta \left(\hat{A} + \hat{\sigma}\hat{X}_l \right) \right) - \phi\theta\hat{A}(1 - \hat{\sigma}) \left(\hat{A} - \hat{\sigma}\hat{X}_h \right) - \\ & \hat{A} \left[\hat{X}_h + \hat{X}_l + \theta \left(\hat{A} + \hat{\sigma}\hat{X}_l \right) \right] \end{aligned}$$

Re-arranging the terms yields:

$$\begin{aligned} \Gamma_c \equiv & \left(\theta\hat{A} + \hat{X}_h \right) \left(\hat{A} + \hat{\sigma}\hat{X}_l \right) - \hat{A} \left(\hat{X}_h + \hat{X}_l + \theta \left(\hat{A} + \hat{\sigma}\hat{X}_l \right) \right) + \\ & \phi \left(\hat{A} - \hat{\sigma}\hat{X}_h \right) \left(\hat{X}_h + \theta\hat{\sigma}\hat{A} \right) + \hat{\sigma}\hat{A} \left(\hat{X}_h + \hat{X}_l + \theta \left(\hat{A} + \hat{\sigma}\hat{X}_l \right) \right) \end{aligned}$$

Simplifying and using (2.22) we obtain:

$$\begin{aligned} \Gamma_c \equiv & \hat{\sigma}\hat{A} \left[\hat{X}_h + \hat{X}_l + \theta \left(\hat{A} + \hat{\sigma}\hat{X}_l \right) \right] + \\ & X_l \left[\left(\hat{\sigma}\hat{X}_h - \hat{A} \right) + \hat{\rho} \left(\hat{A} - \hat{\sigma}\hat{X}_h \right) \left(\hat{X}_h + \theta\hat{\sigma}\hat{A} \right) \right] \end{aligned} \quad (2.84)$$

We can re-arrange further the second term on the right hand side of (2.84) such that

$$\Gamma_c \equiv \hat{\sigma} \hat{A} \left[\hat{X}_h + \hat{X}_l + \theta \left(\hat{A} + \hat{\sigma} \hat{X}_l \right) \right] + X_l \left[\left(\hat{A} - \hat{\sigma} \hat{X}_h \right) \left(\hat{\rho} \hat{X}_h + \hat{\rho} \theta \hat{\sigma} \hat{A} - 1 \right) \right]$$

By (2.20), this simplifies to:

$$\Gamma_c \equiv \hat{\sigma} \hat{A} \left[\hat{X}_h + \hat{X}_l + \theta \left(\hat{A} + \hat{\sigma} \hat{X}_l \right) \right]$$

Substituting this into (2.82) yields:

$$\frac{dU_c}{d\sigma_c} = \frac{-\phi \theta^2 \hat{\sigma} \hat{A}^2}{\hat{X}_h \left[\hat{X}_h + \hat{X}_l + \theta \left(\hat{A} + \hat{\sigma} \hat{X}_l \right) + \phi \theta \left(\hat{A} - \hat{\sigma} \hat{X}_h \right) \right]} \quad (2.85)$$

Using (2.20) and (2.22), this becomes (2.52).

2.9 Appendix C: Non Cooperative Policy

Equation (2.70) can be re-written as:

$$\frac{du_n}{d\sigma_n} = \frac{\hat{\rho} \theta^2 \hat{A}^2 \Gamma_n}{N_h \hat{X}_h \hat{H}_n (\theta \hat{\sigma} + 1) \left[N_h \left(\hat{X}_h + \theta \hat{A} \right) + \hat{X}_l (\theta \hat{\sigma} + 1) \right]} \quad (2.86)$$

where Γ_n is defined such that

$$\begin{aligned} \Gamma_n \equiv & \hat{H}_n (1 - \hat{\sigma}) \left[N_h \left(\hat{X}_h + \theta \hat{A} \right) + \hat{X}_l (\theta \hat{\sigma} + 1) \right] - \hat{H}_n (1 - \hat{\sigma}) \left(\hat{X}_h + \theta \hat{A} \right) - \\ & \phi \left(\hat{X}_h + \theta \hat{A} \right) (\theta \hat{\sigma}^2 + 1) \left[N_h \left(\hat{X}_h + \theta \hat{A} \right) + \hat{X}_l (\theta \hat{\sigma} + 1) \right] + \\ & \phi \theta (1 - \hat{\sigma}) \left(\hat{X}_h + \theta \hat{A} \right) \left(\hat{A} - \hat{\sigma} \hat{X}_h \right) \end{aligned} \quad (2.87)$$

Expanding the right hand side of (2.87) yields, using (2.69):

$$\begin{aligned}
\Gamma_n \equiv & \hat{H}_n (1 - \hat{\sigma}) \left[N_h \left(\hat{X}_h + \theta \hat{A} \right) + \hat{X}_l (\theta \hat{\sigma} + 1) \right] - \\
& (1 - \hat{\sigma}) \left(\hat{X}_h + \theta \hat{A} \right) \left[N_h \left(\hat{X}_h + \theta \hat{A} \right) + \hat{X}_l (\theta \hat{\sigma} + 1) \right] - \\
& \phi \theta (1 - \hat{\sigma}) \left(\hat{X}_h + \theta \hat{A} \right) \left(\hat{A} - \hat{\sigma} \hat{X}_h \right) - \\
& \phi \left(\hat{X}_h + \theta \hat{A} \right) (\theta \hat{\sigma}^2 + 1) \left[N_h \left(\hat{X}_h + \theta \hat{A} \right) + \hat{X}_l (\theta \hat{\sigma} + 1) \right] + \\
& \phi \theta (1 - \hat{\sigma}) \left(\hat{X}_h + \theta \hat{A} \right) \left(\hat{A} - \hat{\sigma} \hat{X}_h \right)
\end{aligned}$$

Re-arranging the terms and using (2.22) and (2.69) yields:

$$\begin{aligned}
\Gamma_n \equiv & -\hat{X}_l \left[N_h \left(\hat{X}_h + \theta \hat{A} \right) + \hat{X}_l (\theta \hat{\sigma} + 1) \right] (\theta \hat{\sigma} + 1) \left(\hat{\rho} \hat{X}_h + \hat{\rho} \theta \hat{\sigma} \hat{A} - 1 \right) + \\
& \left[N_h \left(\hat{X}_h + \theta \hat{A} \right) + \hat{X}_l (\theta \hat{\sigma} + 1) \right] \left[(N_h - 1) (1 - \hat{\sigma}) \left(\hat{X}_h + \theta \hat{A} \right) - \hat{\sigma} \hat{X}_l (\theta \hat{\sigma} + 1) \right]
\end{aligned}$$

Since the last term in brackets on the RHS equals zero by (2.20), this simplifies to:

$$\Gamma_n \equiv \left[N_h \left(\hat{X}_h + \theta \hat{A} \right) + \hat{X}_l (\theta \hat{\sigma} + 1) \right] \left[(N_h - 1) (1 - \hat{\sigma}) \left(\hat{X}_h + \theta \hat{A} \right) - \hat{\sigma} \hat{X}_l (\theta \hat{\sigma} + 1) \right]$$

Substituting this into (2.86) yields:

$$\frac{du_n}{d\sigma_n} = \frac{\hat{\rho} \theta^2 \hat{A}^2 \left[(N_h - 1) (1 - \hat{\sigma}) \left(\hat{X}_h + \theta \hat{A} \right) - \hat{\sigma} \hat{X}_l (\theta \hat{\sigma} + 1) \right]}{N_h \hat{X}_h (\theta \hat{\sigma} + 1) \left[N_h \left(\hat{X}_h + \theta \hat{A} \right) + \hat{X}_l (\theta \hat{\sigma} + 1) + \phi \theta \left(\hat{A} - \hat{\sigma} \hat{X}_h \right) \right]}$$

Using (2.20) and (2.22) this becomes (2.71).

2.10 Appendix D: Proofs

Lemma 1.1. In equation (2.81) we have already shown that $\hat{\sigma} > 0$. From (2.30), $\hat{\sigma} < 1$ if and only if:

$$\sqrt{2(\theta+1)\bar{K}_h - \theta E_h^2} - \sqrt{2\bar{K}_h} < \theta \left(\sqrt{2\bar{K}_h} + E_h \right) \quad (2.88)$$

We can re-write (2.88) as

$$\sqrt{2(\theta+1)\bar{K}_h - \theta E_h^2} < (\theta+1)\sqrt{2\bar{K}_h} + \theta E_h$$

Raising both sides by the power of two and re-arranging the expression yields:

$$0 < (\theta+1) \left(\theta E_h^2 + 2\theta E_h \sqrt{2\bar{K}_h} + 2\theta \bar{K}_h \right)$$

□

.2. From (2.28) to (2.30) we obtain:

$$\begin{aligned} \hat{A} - \hat{\sigma} \hat{X}_h &= \frac{\left(\sqrt{2(\theta+1)\bar{K}_h - \theta E_h^2} - E_h \right)}{(\theta+1)} - \\ &\frac{\left(\sqrt{2(\theta+1)\bar{K}_h - \theta E_h^2} - \sqrt{2\bar{K}_h} \right) \left(\theta E_h + \sqrt{2(\theta+1)\bar{K}_h - \theta E_h^2} \right)}{\theta(\theta+1) \left(E_h + \sqrt{2\bar{K}_h} \right)} > 0 \end{aligned}$$

By simplifying, we obtain the following

$$\frac{\sqrt{2\bar{K}_h} \left(\sqrt{2(\theta+1)\bar{K}_h - \theta E_h^2} - \sqrt{2\bar{K}_h} \right)}{\theta \left(E_h + \sqrt{2\bar{K}_h} \right)} > 0$$

□

Lemma 3.i. From (2.54a) and (2.55) we find:

$$N_h \frac{da_i}{de_i} = \frac{-N_h [X_l (\theta \sigma_i + 1) + (N_h + \theta \sigma_i) X_h + (N_h - 1) \theta A_h]}{(\theta \sigma_i + 1) [X_l (\theta \sigma_i + 1) + N_h (X_h + \theta A_h)]}$$

We see that the numerator on the RHS is decreasing in N_h and the denominator is increasing in N_h . Thus:

$$\frac{\partial}{\partial N_h} \left(N_h \frac{da_i}{de_i} \right) < 0 \quad (2.89)$$

Since $dA_h/dE_h = N_h da_i/de_i$ at $N_h = 1$, it follows from (2.89) and dA_h/dE_h ,

$da_i/de_i < 0$ in (2.36a) and (2.54a) respectively that $\left| \frac{dA_h}{de_i} \right| > \left| \frac{dA_h}{dE_h} \right|$.

ii. Differentiating $N_h dx_i/de_i$ with respect to N_h yields, from (2.54c):

$$\frac{\partial}{\partial N_h} \left(N_h \frac{dx_i}{de_i} \right) = \frac{\theta \Psi}{(\theta \sigma_i + 1) [X_l (\theta \sigma_h + 1) + N_h (X_h + \theta A_h)]^2} \quad (2.90)$$

with Ψ defined such that

$$\begin{aligned} \Psi \equiv & [(\theta \sigma_i + 1) (A_h + \sigma_i X_l) + (2N_h - 1) \sigma_i X_h] [X_l (\theta \sigma_h + 1) + N_h (X_h + \theta A_h)] - \\ & N_h (X_h + \theta A_h) [(\theta \sigma_i + 1) (A_h + \sigma_i X_l) + (N_h - 1) \sigma_i X_h] > 0 \end{aligned} \quad (2.91)$$

The inequality follows from the fact that we can re-write (2.91) such that

$$\begin{aligned} \Psi \equiv & [(\theta \sigma_i + 1) (A_h + \sigma_i X_l) + (N_h - 1) \sigma_i X_h] X_l (\theta \sigma_h + 1) + \\ & N_h \sigma_i X_h [X_l (\theta \sigma_h + 1) + N_h (X_h + \theta A_h)] > 0 \end{aligned}$$

Since $dX_h/dE_h = N_h da_i/de_i$ at $N_h = 1$, it follows from (2.90) and dX_h/dE_h ,

$dx_i/de_i < 0$ in (2.36b) and (2.54c) respectively that $\left| \frac{dX_h}{de_i} \right| > \left| \frac{dX_h}{dE_h} \right|$.

iii. We can re-write (2.54d) as:

$$\frac{dX_l}{de_i} = \psi X_l (A_h - \sigma_h X_h)$$

where the sign of dX_l/de_i is the sign of $(A_h - \sigma_h X_h)$, because:

$$\psi \equiv \frac{\rho\theta}{X_l(\theta\sigma_h + 1) + N_h(X_h + \theta A_h)} > 0 \quad (2.92)$$

We see that ψ is decreasing in N_h . Combining this with the fact that from (2.36c) and (2.54d), $dX_l/de_i = dX_l/dE_h$ at $N_h = 1$, we find that $\left| \frac{dX_l}{de_i} \right| < \left| \frac{dX_l}{dE_h} \right|$.

iv. We can re-write (2.54e) as:

$$\frac{d\rho}{de_i} = \psi \rho (A_h - \sigma_h X_h)$$

where the sign of $d\rho/de_i$ is the sign of $(A_h - \sigma_h X_h)$, because $\psi > 0$ by (2.92).

Combining this with the fact that from (2.36d) and (2.54e), $d\rho/de_i = d\rho/dE_h$ at

$N_h = 1$, we find that $\left| \frac{d\rho}{de_i} \right| < \left| \frac{d\rho}{dE_h} \right|$.

□

Lemma 3.i. From (2.55) and (2.58a) we find:

$$N_h \frac{da_i}{d\sigma_i} = \frac{-\theta A_h [X_l(\theta\sigma_i + 1) + (X_h + \theta A_h)(N_h - 1)]}{(\theta\sigma_i + 1) [X_l(\theta\sigma_h + 1) + N_h(X_h + \theta A_h)]^2}$$

We see that the numerator on the RHS is decreasing in N_h and the denominator is increasing in N_h . Thus:

$$\frac{\partial}{\partial N_h} \left(N_h \frac{da_i}{d\sigma_i} \right) < 0 \quad (2.93)$$

Since $dA_h/d\sigma_h = N_h da_i/d\sigma_i$ at $N_h = 1$, it follows from (2.93) and $dA_h/d\sigma_h$,

$$da_i/d\sigma_i < 0 \text{ in (2.40a) and (2.58a), respectively that } \left| \frac{dA_h}{d\sigma_i} \right| > \left| \frac{dA_h}{d\sigma_h} \right|.$$

ii. Follows from (2.56) and Lemma 3.i.

iii. We can re-write (2.58c) as:

$$\frac{dX_l}{d\sigma_i} = \phi \zeta (X_h + \theta A_h)$$

where the sign of $dX_l/d\sigma_i$ is positive, because:

$$\zeta \equiv \frac{\theta A_h}{N_h [X_l (\theta \sigma_h + 1) + N_h (X_h + \theta A_h)]} > 0 \quad (2.94)$$

We see that ζ is decreasing in N_h . Combining this with the fact that from (2.40b) and (2.58c), $dX_l/d\sigma_i = dX_l/d\sigma_h$ at $N_h = 1$, we find that $\left| \frac{dX_l}{d\sigma_i} \right| < \left| \frac{dX_l}{d\sigma_h} \right|$.

iv. We can re-write (2.58d) as:

$$\frac{d\rho}{d\sigma_i} = -\rho^2 \zeta (X_h + \theta A_h)$$

with ζ defined as in (2.94). Combining this with the fact that from (2.40c) and

(2.58d), $d\rho/d\sigma_i = d\rho/d\sigma_h$ at $N_h = 1$, we find that $\left| \frac{d\rho}{d\sigma_i} \right| < \left| \frac{d\rho}{d\sigma_h} \right|$.

□

Proposition 6. The sign of the RHS of (2.71) is the sign of:

$$\mu_c = (N_h - 1) (1 - \hat{\sigma}) \left(\hat{X}_h + \theta \hat{A} \right) - \hat{\sigma} \hat{X}_l (\theta \hat{\sigma} + 1)$$

We shall prove that $\mu_c > 0$. Note that μ_c is increasing in N_h . In order to prove that $\mu_c > 0$, it is thus sufficient to prove that $\mu_c > 0$ for $N_h = 2$, or:

$$(1 - \hat{\sigma}) \left(\hat{X}_h + \theta \hat{A} \right) - \hat{\sigma} \hat{X}_l (\theta \hat{\sigma} + 1) > 0 \quad (2.95)$$

If we substitute the solutions for autarky (2.28), (2.29) and (2.30) for $\hat{X}_h$, $\hat{A}$ and $\hat{X}_l$ into (2.95) and re-arrange the expression, we obtain

$$(1 - \hat{\sigma}) \sqrt{2(\theta + 1)\bar{K}_h - \theta E_h^2} - \phi \hat{\sigma} (\theta \hat{\sigma} + 1) \sqrt{2\bar{K}_h} > 0$$

Since $0 < \phi < 1$, a sufficient condition for this inequality to hold is:

$$(1 - \hat{\sigma}) \sqrt{2(\theta + 1)\bar{K}_h - \theta E_h^2} - \hat{\sigma} (\theta \hat{\sigma} + 1) \sqrt{2\bar{K}_h} > 0$$

By (2.81), a sufficient condition for this inequality to hold is:

$$1 - \theta \hat{\sigma}^2 - 2\hat{\sigma} > 0 \quad (2.96)$$

Substituting (2.30) into (2.96) yields:

$$1 - \theta \left[\frac{\left(\sqrt{2(\theta + 1)\bar{K}_h - \theta E_h^2} - \sqrt{2\bar{K}_h} \right)^2}{\theta \left(E_h + \sqrt{2\bar{K}_h} \right)} \right] - 2 \frac{\left(\sqrt{2(\theta + 1)\bar{K}_h - \theta E_h^2} - \sqrt{2\bar{K}_h} \right)}{\theta \left(E_h + \sqrt{2\bar{K}_h} \right)} > 0$$

Re-arranging the terms we obtain:

$$\frac{2E_h \left(\theta E_h - \sqrt{2(\theta + 1)\bar{K}_h - \theta E_h^2} + (\theta + 1)\sqrt{2\bar{K}_h} \right)}{\theta \left(\sqrt{2\bar{K}_h} + E_h \right)^2} > 0 \quad (2.97)$$

The inequality holds if and only if:

$$\theta E_h + (\theta + 1)\sqrt{2\bar{K}_h} > \sqrt{2(\theta + 1)\bar{K}_h - \theta E_h^2} \quad (2.98)$$

If we raise both sides of (2.98) to the power of two and then simplify, we obtain:

$$\theta(\theta + 1)\left(\sqrt{2\bar{K}_h} + E_h\right)^2 > 0$$

□

CHAPTER 3

INTERNATIONAL ENVIRONMENTAL AGREEMENTS AND DOMESTIC POLITICS

3.1 Introduction

In the past few decades, environmental concerns have increased their importance in worldwide politics. Evidence of this growing relevance can be found by noticing that more than 400 international environmental agreements (IEAs) have been signed and ratified in the past 40 years (UNEP, 2012). IEAs' participation has captured the interest of environmental scientists, especially the identification of variables that impact domestic governments' benefits from joining IEAs (Congleton, 2001). Despite the great deal of effort in analysing it, there is still a lot of uncertainty on which factors affect the likelihood of a country to commit to an IEA (Fredriksson et al., 2007). Moreover, the majority of these analyses focus on the empirical side and few studies have been devoted to theoretical modelling. Therefore, we want to help bridge this gap in the theoretical literature and analyse the impact of domestic partisan politics on IEAs' ratification choice.

There is general consensus on the importance of domestic institutions on IEAs' ratification. Congleton (1992) was the first to model and estimate the role of democracy; after it, a number of other studies (Murdoch and Sandler, 1997; Fredriksson and Gaston, 2000; Neumayer, 2002; Beron et al., 2003) confirmed Congleton (1992)'s finding that democratic countries are more likely to join IEAs. Therefore, we narrow our research area and focus on the role of domestic political parties' environmental concerns on IEAs' ratification decision in democratic

countries. In contrast with previous studies, whose analyses of domestic politics mainly focussed on the impact of environmental and industrial lobbying groups (Conconi, 2002, 2003; Neumayer, 2002; Fredriksson and Ujhelyi, 2006) or corruption (Fredriksson and Svensson, 2003; Pellegrini and Gerlagh, 2006; Fredriksson et al., 2007) or left-right dichotomy (Jahn, 1998; Neumayer, 2003, 2004; Knill et al., 2010), we introduce electoral concerns. We shall see that, when electoral concerns are introduced into the model, counter-intuitive results are found. In addition, the body of research on partisan politics has centred its attention on domestic environmental policy (Neumayer, 2003; List and Sturm, 2006); our model extends those analyses and shows that domestic parties' preferences have an impact on international commitment as well.

The aim of the chapter is to explain why a government may decide to renounce the freedom to choose its own environmental policy. Indeed, if it joins an IEA, in the future it will have to comply with its rules (policy cost). The starting point of our analysis is that citizens differ in their environmental concern, which is distributed according to a known density function. In the economy there are two competing political parties, which differ for their environmental policy preferences. Political parties care about the environmental policy implemented in the country and about the rents from being elected. Our framework is based on a two-period probabilistic voting framework à la Lindbeck and Weibull (1987). Comaner (1976) and Hinich (1977) pioneered in the application of probabilistic voting theory to the analysis of unidimensional policy issues. They both proved that, when voters' preferences are single-peaked, setting a policy equivalent to the median voter's preferences may not be an equilibrium. Subsequently, Hinich (1978) extended Hinich's analysis to multidimensional policy spaces. Amongst the most notable characteristics of probabilistic voting models is the uncertainty

about voters' behaviour, which is modeled by using a probabilistic distribution over voters' behaviour. Several papers in the empirical literature attempted to test the capability of probabilistic voting models to correctly predict real world voters' behaviour. For example, Fiorina (1981), Enelow and Hinich (1984), Merrill and Grofman (1999) and Enelow, Hinich, and Mendell (1986), challenge the predictive power of deterministic voting models and, by means of empirical tests, argue that probabilistic voting models possess a better explanatory power. In Lindbeck and Weibull (1987), the utility function of the voters has two components. The first depends upon the policy implemented by the incumbent political party or candidate. The second accounts for all the other factors that might impact on voter's preferences for different candidates.

Following probabilistic voting theory, in our framework parties differ not only in regard to their preferred environmental policy platform, but also in another dimension, unrelated to the environmental dimension. The latter can be interpreted as voters' ideology or sympathy towards a specific political party. Indeed, voters care about the policy platform offered by the party along with the ideology. Furthermore, they differ in the way ideology or sympathy is evaluated. An important feature that our model shares with probabilistic voting theory is that voters close to the swing voter are targeted by office-seeking politicians, who modify their policy in order to gain votes.

In addition, our framework applies the standard probabilistic voting model to a setting where an environmental agreement is in place at the international level. In the first period the incumbent government decides on the level of commitment to the IEA. By level of commitment we refer to the opportunity that an international agreement's signatories have to choose to what extent they commit to its rules (e.g. Mattes 2012). For instance, escape clauses, designed in order to

increase flexibility and encourage membership of the agreement (Pelc, 2009), constitute a typical mechanism through which governments limit their commitment to IEAs. Indeed, they allow signatories to temporarily get round the terms of the agreement or even to completely withdraw from it (Rosendorff and Milner, 2001). This is the main argument of Rosendorff (2005) and Johns and Rosendorff (2009). Both papers focus on international trade agreements and the Dispute Settlement Procedure (DSP) in particular. Indeed, they argue that the Dispute Settlement Procedure (DSP) is a flexibility mechanism that increases countries' participation and, by allowing them to temporarily not comply with the terms of the agreement, has the merit of avoiding the collapse of international trade agreements. Kucik and Reinhardt (2008) support a similar argument and find that the use of flexibility mechanisms has a positive impact on international cooperation. According to Koremenos (2005) policymakers introduce flexibility mechanisms within international agreements in order to reduce uncertainty about future situations that could impact on their payoffs. Hafner-Burton, Helfer, and Fariss (2011) use the same argument, applied to human rights treaties violations. An example relevant to our IEAs' case refers to the Kyoto Protocol (1997), where there are several escape clauses: the clean development mechanism, joint implementation and emission trading (Karp and Zhao, 2007). We take this feature into account by modelling the level of commitment as the probability that the period-2 government will have to comply with the terms of the IEA. A level of commitment equal to zero is interpreted as the government deciding not to join the IEA. This in turn implies that the party in power in the second period will be able to implement its ideal policy, unbound by international commitments. On the other extreme, when the level of commitment is equal to unity, the period-2 government will have to comply with the terms of the IEA with a probability of one. All the intermediate

values represent situations where the incumbent has joined the agreement, but with the possibility of not complying to it in the future. In the second period, elections takes place and the period-2 government implements its environmental policy possibly constrained by the IEA joined in period 1.

The aim of the chapter is to analyse incumbent governments' choices of commitment level. The incumbent government chooses the level of commitment that maximises its own expected payoff. The expected payoff depends on the probability of victory weighted by the utility gain or loss engendered by the policy implemented in period 2. This is the approach developed by Wittman (1973), whose seminal paper introduced policy preferences into political parties' objectives. Indeed, before its publication, the main model of electoral competition was that of Downs (1957), in which political parties were only office-motivated and did not care about the implemented policy. Our model differs from the traditional partisan theory based on Downs (1957) because parties' payoffs include two components: one is Downs's (1957) rents from being in power; the other one the utility derived from the implemented policy.

Thus, one of the main features of our model is that period-1 incumbents' decisions are driven by two types of incentives: policy and electoral incentives. According to the former, parties want their ideal policy to be implemented. This is the only effect present in our benchmark case, where probabilities of victory are exogenously fixed. In this case, there are no electoral incentives as incumbent governments cannot affect their parties' probability of winning the elections. The main result in this benchmark case is that the non-green party always chooses a level of commitment equal to zero; that is, it never commits to the IEA. This results from the fact that the non-green party wants to be able to implement its ideal policy if re-elected. On the other hand, the green party's optimal level

of commitment is one, that is it always fully commits. Indeed the green party wants to constrain the period-2 government policy choice and make it as green as possible — i.e. as close as possible to its own ideal policy.

When we endogenize the probability of victory and the proportion of green citizens is large enough, the non-green party's (green party) probability of victory increases (decreases) with commitment. Indeed, an increase in commitment makes the green citizens better off in case of party 1's victory and, consequently, more likely to vote for it. Therefore, when this proportion is sufficiently large, party 1's probability of winning the election increases with the level of commitment κ . The reverse is true for party 2. Therefore, parties can affect their own probability of winning the elections. This introduces electoral incentives into the model. Owing to these electoral incentives, parties will try to increase their probability of victory, in order to enjoy the benefits from being in office. For both parties there is a trade-off between policy and electoral incentives, reflected in the fact that a marginal increase in the level of commitment has two opposing effects on their payoffs.

Let us first consider the non-green party's payoff. The first effect is positive and is due to the fact that a marginal increase in the level of commitment increases its probability of winning the elections. Indeed, when the proportion of the population with high environmental concern is high enough, an increase in the non-green government's commitment level increases the probability that period-2 environmental policy will be stricter and so closer to the green population's policy preferences. The second effect is negative and represents the utility loss due to the cost of commitment. When choosing a strictly positive level of commitment, the non-green party increases the probability that, if re-elected, it will have to choose a policy different from its ideal one in period-2. Consequently, the non-green party chooses a level of commitment that is greater than zero when the electoral incen-

tive is bigger than the policy incentive. These results are in contrast with those obtained with exogenous probabilities of victory, showing that electoral concerns may be the main reason for a non-green party to join an IEA.

Considering now the case of a green incumbent party, a marginal increase in the level of commitment has a positive impact on the green party's payoff. This effect is due to the fact that the non-green party will be constrained if elected and hence it will have to implement a greener policy — closer to the green party's ideal policy — with positive probability. The negative effect is given by the fact that a marginal increase in the level of commitment decreases the green party's probability of victory. Consequently, the green party will choose not to fully commit to protect the environment when the electoral gains exceed policy gains.

The rest of the chapter is organised as follows: Section 3.2 introduces the model. In Section 3.3, the optimal choice of the level of commitment is derived with both exogenous and endogenous probabilities of victory. Finally, Section 3.4 concludes. Before introducing the model, the next subsection shall discuss the main relevant literature.

Related Literature

This chapter is related to two main strands of literature. Within the first strand, a number of political science papers acknowledge that an important role is played by incumbent governments' incentives to constrain future policymakers' decisions (Mattes, 2012). Those papers argue that precommitting future leaders enables current incumbents to maintain their preferred policies in the long run. For example, this is the thesis supported by Lipson (1991) and Abbott and Snidal (2000) with regard to alliance treaties. Along this line Moravcsik (2000) empirically tests the same hypothesis, but with regard to the creation of human

rights international organizations. His argument is that the creation of international organizations is a strategic way in which incumbents try to prevent future governments from becoming dictatorships. This is true in particular for newly democratized countries, where the incumbent wants to avoid the anti-democratic drift. He uses data on the negotiation of the European Convention for the Protection of Human Rights and Fundamental Freedoms (ECHR) and his findings fully support his argument. Mansfield and Pevehouse (2006, 2008) use a similar argument and argue that countries self-bind in order to increase the costs associated with going back to a non-democratic situation. Mattes (2012) empirically tests the reliability of democratic countries as military allies. She distinguishes between defence pacts and consultation pacts, and analyses when each of them is more likely to be signed. Defence pacts are more structured military cooperation alliances, whilst consultation pacts are less structured. The argument is that governments decide to sign a defence pact if polarisation of policy preferences between the incumbent and the potential successor is high and if the associated political costs are low. On the other hand, governments sign consultation pacts when the policy preferences are less polarised. This analysis uses the Alliance Treaty Obligations and Provisions (ATOP) data between 1945 and 2003 and the findings are consistent with the tested hypotheses.

In the economic literature, Brett and Keen (2000) apply a similar argument to earmarking of environmental taxes. They suggest that the incumbent may earmark the revenues from environmental taxes in order to constrain future governments and avoid a dissipation of the revenues. Moreover, North and Weingast (1989) apply this argument to the analysis of the evolution of institutions in England in the seventeenth century. Incumbent's strategic behaviour in constraining its successors is the topic of Persson and Svensson (1989) and Alesina and Tabellini

(1990). They argue that the incumbent strategically decides to bind the future government in presence of differences in policy preferences: differences in levels of public expenditure for Persson and Svensson (1989) and differences in its composition for Alesina and Tabellini (1990).

The second strand in the literature is based on the idea that pre-committing future leaders is considered a strategic behaviour to increase the chances of being re-elected. There is a well-known line of research that analyses political business cycles, that is the empirical evidence according to which next to the elections, the incumbent decides to cut taxes and expand public expenditure. Along this line are the papers by Rogoff and Sibert (1988) and Rogoff (1990). They aim at building the theoretical foundations to explain this empirical evidence. Their analyses shows that the incumbent government uses policy instruments to signal to the voters that its competency shock is high and gain an electoral advantage. Anesi (2006) also belongs to this second strand and focusses on tax earmarking using a probabilistic voting model à la Lindbeck and Weibull (1987). Anesi's (2006) argument is that the incumbent government might increase its probability of winning the elections by the means of earmarking. This might happen when a high proportion of citizens has preferences over the public good valued less by the incumbent. The mechanism is that binding future governments to provide this public good will positively impact on the incumbent's probability of victory. Therefore, Anesi (2006) shows the importance of electoral incentives with regard to tax earmarking decisions.

The present chapter differs from the existing literature in two respects. First, it focuses on IEAs. Second, and more importantly, it combines the arguments developed in the two strands of literature discussed above: as in the first strand, our model captures incumbent governments' incentives to constrain future policy-

makers; as in the second strand, it captures incumbents' incentives to use current policies to affect electoral outcomes in their favour.

3.2 The Model

Economic Setting. Consider a two-period economy with two sectors. The first one is a green sector that produces the numeraire good c without emissions. The second is a polluting sector that produces good x . Both goods are produced and consumed in the second period. The economy is populated by a large number of citizens — i.e. a continuum of size 1 — who act both as consumers and as voters. They differ according to their environmental concern $\alpha \in [0, 1]$, which is distributed according to a continuous, positive density function f with full support. The consumers derive utility from consuming the two goods and experience disutility from environmental degradation associated with production activities. Individuals of type α are assumed to maximise the following utility function:

$$c + u(x) - \alpha X \tag{3.1}$$

where c and x are individual consumption of the numeraire and the polluting good, respectively. X stands for aggregate consumption of the polluting good. All the agents have the same taste for individual consumption of good x , which is represented by the continuous function u . This function is at least twice differentiable and has the following properties: $u' > 0$, $u'' < 0$. Both goods are produced at a constant marginal cost, normalized to unity. Markets are perfectly competitive, so that prices are equal to unity.

Assume further that all citizens have the same (exogenous) income I . At the start of the second period, the government in office implements an environmental tax on the consumption of the polluting good, $t \in [0, 1]$, the proceeds of which are redistributed lump sum to all citizens. Consumers of type α choose their con-

sumption levels of both goods by maximizing (3.1) subject to the private budget constraint

$$c + (1 + t)x \leq I + T$$

where T represents the lump sum transfer from the government. Hence, the type- α consumer chooses x to maximise:

$$\max_{x \geq 0} I + T - (1 + t)x + u(x) - \alpha X \quad (3.2)$$

From the first order condition of the consumer's maximization problem (3.2), we obtain that each consumer's demand for the polluting good, x , satisfies

$$u'(x) = 1 + t \quad (3.3)$$

Let $x(t)$ be the unique solution of equation (3.3); that is $x(t)$ is the consumption of the polluting good as a function of the environmental tax t . It is readily checked that citizens will reduce consumption of good x as the tax increases: $x' < 0$. Tax revenues are used to finance the lump sum transfer T to all citizens. Hence, the government budget constraint is

$$T = tX \quad (3.4)$$

Each agent consumes the same quantity of the good x ; hence $X = x(t)$. This is due to the quasi-linearity of preferences and the fact that average consumption is not affected by the small size of individual consumption.

Plugging (3.3) into (3.1) and using (3.4), we obtain the policy preferences of a type- α citizen:

$$v(t, \alpha) \equiv u(x(t)) - (1 + \alpha)x(t) \quad (3.5)$$

Differentiating v with respect to t yields

$$\frac{\partial v}{\partial t} = [u'(x(t)) - 1 - \alpha] x'(t) = (t - \alpha)x'(t) \quad (3.6)$$

We know from (3.3) and (3.6) that $x'(t) < 0$ and $\partial v / \partial t = 0$ at $t = \alpha$. Consequently, when $(t - \alpha) < 0$, function (3.5) is increasing. When $t - \alpha > 0$, function (3.5) is decreasing. Moreover, when $t - \alpha < 0$ ($t - \alpha > 0$), the above derivative is positive (negative); so that $v(\cdot, \alpha)$ increases (decreases). We have thus established that $v(\cdot, \alpha)$ is single-peaked with a peak at $t = \alpha$. Hence, the ideal policy of type- α citizens is $t = \alpha$.

Policy is chosen through electoral competition between parties 1 and 2, whose policy preferences are exogenously given by $v(\cdot, \alpha_1)$ and $v(\cdot, \alpha_2)$, respectively. Party $i = 1, 2$ thus shares the same policy preferences of a citizen of type α_i . We assume, without loss of generality, that $\alpha_1 < \alpha_2$.

Timing. The timing is as follows:

(1) In the first period, the incumbent party has a chance to join an international environmental agreement (IEA), which requires the signatories to maintain their emissions below some exogenous level $\bar{x}$. The incumbent decides whether to commit to the IEA and chooses the level of commitment κ the period 2 government will have to commit to.

(2) At the start of the second period, elections take place.

(3) The elected party takes office and sets the environmental tax t for period 2.

When constrained by the IEA (i.e. with probability κ), the period 2 government must choose an environmental tax $t \geq u'(\bar{x}) - 1 \equiv \tau$. In order to avoid trivialities, we assume the following throughout: $\tau \in (\alpha_1, \alpha_2)$.

Before we proceed any further, an explanation of the predictions of the model when $\tau < \alpha_1$ or $\tau > \alpha_2$ is in order. Let us consider the scenario where $\tau < \alpha_1$ first. When $\tau < \alpha_1$, regardless of who the incumbent is, if the IEA is signed,

both parties will choose to set their preferred policy, if elected. As a consequence, in this scenario electoral incentives do not play a role for parties' choice of level of commitment. Therefore, there is no need to analyse this scenario specifically within the chapter, given that its outcome will coincide with that of the benchmark case. Let us now consider the scenario where $\tau > \alpha_2$. In this case, regardless of who will be elected, if the IEA is signed, the policy will be set equal to τ . Therefore, signing an IEA has no impact on the electorate's choice and so, when $\tau > \alpha_2$, the party with the highest ideological bias will win the elections.

Electoral Competition. We assume that parties cannot make credible commitments before the election. As a consequence, the elected party will implement its deal policy in $[\tau, 1]$ with probability κ , and its ideal policy in $[0, 1]$ with probability $(1 - \kappa)$. Hence, party 1 (if elected) implements τ with probability κ and α_1 with probability $(1 - \kappa)$. On the other hand, given that we assumed $\tau < \alpha_2$, party 2 (if elected) always implements its ideal policy α_2 .

Following Lindbeck and Weibull (1987), we use a probabilistic framework to model electoral competition between the two parties. Parties not only differ with regard to their policy platforms, but also with respect to specific characteristics. We assume that citizens differ in the way they evaluate those party-specific characteristics. The utility received by a voter of type α when party 1 is elected is given by

$$V^1(\kappa, \alpha) \equiv \kappa v(\tau, \alpha) + (1 - \kappa)v(\alpha_1, \alpha) + (b_\alpha + r) \quad (3.7)$$

where b_α is an individual-specific parameter that measures a voter's ideological bias in favour of party 1. This represents the idiosyncratic component of the noise and it is distributed independently throughout the electorate. For every $\alpha \in [0, 1]$, we assume that b_α is distributed according to a strictly positive, continuous density

function g_α , with support $[-\beta, \beta]$, where $\beta > 0$ is an arbitrarily large parameter. A positive value of b_α stands for a positive bias towards party 1 and the reverse for a negative value. If $b_\alpha = 0$ for some type- α voter, then she only cares about the policy platform offered by the party. The parameter r can be interpreted as party 1's relative (average) popularity or sympathy within the population. We assume it is distributed according to a continuous density function h with support $[-\rho, \rho]$, where $\rho > 0$ is an arbitrarily large parameter. This term represents average voter's preferences, it is common throughout the electorate and unknown. The parameter r plays an extremely important role in our model, because it constitutes a source of uncertainty over voters' behaviour and thus, over the elections' outcome. From a more technical point of view, the parameter r guarantees uncertainty by making the probability of victory stochastic.

In this setting, voters care about the policy platform along with other dimensions unrelated to environmental policy. Therefore, these two terms might be considered as accounting for all the not explicitly modeled factors that impact on voter's preferences for different candidates. According to an alternative interpretation, these components summarise voters' preferences over parties' characteristics, like parties' competences, image, personality and likeability, the way they handle electoral campaigns or even scandals. An extensive political literature has been developed on these components, defined as candidate's valence advantage. For example, Groseclose (2001) defines it as superior character, charisma, name recognition or intelligence; Snyder and Ting (2002) as party discipline and Bruter et al. (2010) as vestigial party loyalties. In the literature, a great deal of attention has been devoted to the study of candidate's valence advantage and how the uncertainty faced by political parties affects their decisions. A number of papers reached the finding that, within this setting, the median voter position does not

represent an equilibrium. As a consequence, if the electorate is biased against a party, it should avoid to choose the median voter position (Ansolabehere and Snyder, 2000; Groseclose, 2001; Aragonés and Palfrey, 2002; Carrillo and Castanheira, 2008; Ashworth and Bueno de Mesquita, 2008).

After the period-1 decision is taken and just before the elections, the actual value of r is realized. Hence, when the incumbent decides whether or not to join the IEA in period 1, there is still uncertainty on the future winner of the elections.

The utility received by a type- α citizen when party 2 is elected is given by

$$V^2(\kappa, \alpha) \equiv v(\alpha_2, \alpha) \quad (3.8)$$

Given the value of κ inherited from period 1, each voter compares the payoff expected upon re-electing the incumbent to that following the election of the challenger. Given κ , a type- α citizen votes for party 1 if and only if $V^1(\kappa, \alpha) > V^2(\kappa, \alpha)$ or, equivalently, from (3.7) and (3.8):

$$b_\alpha > v(\alpha_2, \alpha) - \kappa v(\tau, \alpha) - (1 - \kappa)v(\alpha_1, \alpha) - r \equiv \Delta(\kappa, \alpha, r)$$

The proportion of type- α citizens who vote for party 1 is therefore

$$p_1(\kappa, \alpha, r) \equiv \int_{\Delta(\kappa, \alpha, r)}^{\beta} g_\alpha(b) db \quad (3.9)$$

so that the total vote share going to party 1 is:

$$P_1(\kappa, r) \equiv \int_0^1 p_1(\kappa, \alpha, r) f(\alpha) d\alpha$$

Finally, we obtain party 1's probability of victory as the probability that $P_1(\kappa, r) \geq 1/2$. Given that $P_1(\kappa, r) = 1/2$ is a zero-probability event, we can

restrict our attention to the case when $P_1(\kappa, r) > 1/2$ and party 1's probability of victory becomes

$$\pi_1(\kappa) \equiv \int_{\{r \in [-\rho, \rho] : P_1(\kappa, r) > 1/2\}} h(r) dr \quad (3.10)$$

Party 2's probability of victory is then $\pi_2(\kappa) \equiv 1 - \pi_1(\kappa)$ for all $\kappa \in [0, 1]$.

Party $i \in \{1, 2\}$ seeks to maximise:

$$\Omega_i(\kappa) \equiv \pi_1(\kappa) [\kappa v(\tau, \alpha_i) + (1 - \kappa)v(\alpha_1, \alpha_i)] + \pi_2(\kappa)v(\alpha_2, \alpha_i) + \pi_i(\kappa)R \quad (3.11)$$

where $R \geq 0$ stands for the office-holding rents received by the winner of the election.

Alternative Setting. Before we proceed any further, a remark on the way we model commitment to the IEA is in order. As we discussed in the introduction, the probability κ must be thought of as the extent to which the period-1 government constrains future governments to abide to the terms of the IEA. It is worth noting, however, that alternative ways of modeling commitment would yield similar conclusions. For instance, we could instead assume that the period-1 government signs a completely binding IEA, but chooses (i.e. commits future governments to) the period-2 environmental tax τ . In this alternative setting, the party in power in the second period would be compelled to implement the environmental tax prescribed by the IEA (i.e. the tax chosen by the period-1 government). It is readily checked that this alternative approach would yield exactly the same conclusions as ours. Indeed, increasing κ in our model has the same impact on parties and citizens' expected payoffs as increasing τ in the alternative model. This is mainly a matter of relabeling.

3.3 Political Equilibrium

In this section we characterise commitment levels κ in subgame perfect equilibria — simply referred to as "equilibria" in what follows — of the political game introduced in the previous section. Therefore, equilibrium values of κ are obtained by maximising incumbent parties' objective functions in (3.11) with respect to $\kappa \in [0, 1]$. The existence of an equilibrium follows directly from the application of Weierstrass' Theorem (Chiang, 2005).

3.3.1 Benchmark: Exogenous Probabilities of Victory

Our aim is to analyse the effect of electoral competition on the incumbent's party decision to join the IEA. It is therefore useful to start with the benchmark case in which probabilities of victory are exogenously fixed, so that parties are not able to modify their probability of winning the election. In this case, the period-1 decision is not influenced by future electoral prospects. Let $\bar{\pi}_i \in (0, 1)$, with $i \in \{1, 2\}$, be party i 's exogenous probability of victory. Party $i \in \{1, 2\}$ chooses its level of commitment to an IEA κ by maximizing the following

$$\Omega_i(\kappa) = \bar{\pi}_1 [\kappa v(\tau, \alpha_i) + (1 - \kappa)v(\alpha_1, \alpha_i)] + \bar{\pi}_2 v(\alpha_2, \alpha_i) + \bar{\pi}_i R \quad (3.12)$$

Here, we need to distinguish between the two parties. Indeed, the derivative with respect to κ of party 1's objective function (3.12) is

$$\frac{\partial \Omega_1(\kappa)}{\partial \kappa} = \bar{\pi}_1 [v(\tau, \alpha_1) - v(\alpha_1, \alpha_1)] \quad (3.13)$$

Given that party 1 strictly prefers α_1 to τ , it immediately follows that function (3.13) is lower than zero and, therefore, that (3.12) is strictly decreasing in κ . Consequently, the solution of the maximization problem for party 1 is $\kappa = 0$. This

means that with fixed probabilities of victory, party 1 never chooses to constrain future policy choice by joining an IEA.

The reverse holds for party 2: the derivative of its objective function is

$$\frac{\partial \Omega_2(\kappa)}{\partial \kappa} = \bar{\pi}_1 [v(\tau, \alpha_2) - v(\alpha_1, \alpha_2)] \quad (3.14)$$

Given that party 2 strictly prefers τ to α_1 , it immediately follows that the right-hand side of equation (3.14) is positive and, therefore, that (3.12) is strictly increasing in κ . As a consequence, the solution of the maximization problem for party 2 is $\kappa = 1$. This means that party 2 always chooses to join an IEA with probability one when the probabilities of victory are exogenous.

We record this as

Proposition 8 *If parties' probabilities of victory are exogenously fixed — and therefore independent of the period-1 decision — then:*

- (i) *Party 1 always chooses $\kappa = 0$; and*
- (ii) *party 2 always chooses $\kappa = 1$.*

3.3.2 The Probability of Victory Functions

The result stated in Proposition 8 is intuitive: only the party with a higher environmental concern chooses to join an IEA. However, the above analysis does not take into account the fact that voters' preferences over candidates may be affected by parties' behaviour, thus influencing the probabilities of victory. In what follows we will show that endogenizing these probabilities may impact our previous result. To this end, we first need to establish a key result on the probability of victory functions.

Henceforth, we will refer to citizens whose types α exceed τ as “green citizens”.

Let us define the green citizens as

$$\gamma \equiv \int_{\tau}^1 f(\alpha) d\alpha \quad (3.15)$$

with $\gamma \in (0, 1)$.

Lemma 9 *There exists $\bar{\gamma} \in (0, 1)$ such that the following is true if $\gamma > \bar{\gamma}$: party 1's probability of victory π_1 is strictly increasing in κ ; and party 2's probability of victory π_2 is strictly decreasing in κ .*

Proof: Brief inspection of (3.10) reveals that π_1 is strictly increasing whenever $P_1(\cdot, r)$ is strictly increasing for all $r \in [-\rho, \rho]$. To analyse the shape of this function, it is convenient to begin with the analysis of $p_1(\cdot, \alpha, r)$. Applying Leibniz Integral Rule to (3.9), we obtain:

$$\begin{aligned} \frac{\partial p_1(\kappa, \alpha, r)}{\partial \kappa} &= -\frac{\partial \Delta(\kappa, \alpha, r)}{\partial \kappa} g_{\alpha}(\Delta(\kappa, \alpha, r)) \\ &= [v(\tau, \alpha) - v(\alpha_1, \alpha)] g_{\alpha}(\Delta(\kappa, \alpha, r)) \end{aligned}$$

As $g_{\alpha}(\Delta(\kappa, \alpha, r)) > 0$, this derivative is non-negative if and only if $v(\tau, \alpha) \geq v(\alpha_1, \alpha)$. Therefore, $p_1(\cdot, \alpha, r)$ is increasing in κ if and only if the type- α citizens prefer τ to α_1 .

Now let

$$D^{-}(\kappa, r) \equiv \min_{\alpha \in [0, \tau]} \frac{\partial p_1(\kappa, \alpha, r)}{\partial \kappa} < 0$$

$$D^{+}(\kappa, r) \equiv \min_{\alpha \in [\tau, 1]} \frac{\partial p_1(\kappa, \alpha, r)}{\partial \kappa} > 0$$

We then have

$$\begin{aligned}
\frac{\partial P_1(\kappa, r)}{\partial \kappa} &\equiv \int_0^1 \frac{\partial p_1(\kappa, \alpha, r)}{\partial \kappa} f(\alpha) d\alpha \\
&= \int_0^\tau \frac{\partial p_1(\kappa, \alpha, r)}{\partial \kappa} f(\alpha) d\alpha + \int_\tau^1 \frac{\partial p_1(\kappa, \alpha, r)}{\partial \kappa} f(\alpha) d\alpha \\
&\geq \int_0^\tau D^-(\kappa, r) f(\alpha) d\alpha + \int_\tau^1 D^+(\kappa, r) f(\alpha) d\alpha \\
&= D^-(\kappa, r) \int_0^\tau f(\alpha) d\alpha + D^+(\kappa, r) \int_\tau^1 f(\alpha) d\alpha
\end{aligned}$$

By definition of γ , we consequently have

$$\frac{\partial P_1(\kappa, r)}{\partial \kappa} \geq D^-(\kappa, r)(1 - \gamma) + D^+(\kappa, r)\gamma > 0$$

if and only if

$$\gamma > \frac{-D^-(\kappa, r)}{D^+(\kappa, r) - D^-(\kappa, r)} \equiv \hat{\gamma}(\kappa, r) \in (0, 1)$$

(recall that $D^-(\kappa, r) < 0$, so that $-D^-(\kappa, r) > 0$).

Finally, we define $\bar{\gamma}$ as

$$\bar{\gamma} = \max \{ \hat{\gamma}(\kappa, r) : \kappa \in [0, 1] \text{ \& } r \in [-\rho, \rho] \}$$

Observe that, from Weierstrass' Theorem, $\bar{\gamma}$ is well-defined. Indeed, $\hat{\gamma}$ is a continuous function and $[0, 1] \times [-\rho, \rho]$ is compact in R_+^2 . We have thus proved that $P_1(\cdot, r)$ is strictly increasing for all r and, therefore, that π_1 is strictly increasing whenever $\gamma > \bar{\gamma}$.

As $\pi_2 \equiv 1 - \pi_1$, this in turn implies that π_2 is strictly decreasing whenever $\gamma > \bar{\gamma}$.

□

As previously discussed, the utility of a type- α citizen is determined by the winner of the elections. Recall that party 2 always implements its ideal policy α_2 if elected. Therefore, the utility obtained by type- α citizen if party 2 is in power, that is $V^2(\kappa, \alpha)$, is not affected by the level of commitment chosen by the incumbent in stage 1. However, switching from no commitment (i.e. $\kappa = 0$) to a positive level of κ does impact the type- α voter's utility if party 1 is in power, that is $V^1(\kappa, \alpha)$. In particular, $V^1(\kappa, \alpha)$ is increasing in κ for all $\alpha > \tau$ and decreasing in it for $\alpha < \alpha_1$. To see this, recall that citizens have single-peaked preferences, $v(\cdot, \alpha)$, with a peak at $t = \alpha$. As $\alpha_1 < \tau$, this implies that all types $\alpha \geq \tau$ strictly prefer policy τ to policy α_1 : $v(\tau, \alpha) > v(\alpha_1, \alpha)$. Put differently, an increase in the commitment variable κ makes the green citizens — namely those whose environmental concern α exceeds τ — better off in case of party 1's victory and, consequently, more likely to vote for it. Recall that the proportion of the population who shows such a high environmental concern has been defined in (3.15) as γ . When this proportion γ is sufficiently large — that is, higher than a certain threshold $\bar{\gamma}$ — party 1's probability of winning the election increases with the level of commitment κ . This result will have important implications when we turn to the analysis of the incumbent's choice of commitment level.

Henceforth, we make the following assumption:

A1: $\gamma > \bar{\gamma}$.

3.3.3 A Non-Green Incumbent May Commit to Protect the Environment

In this subsection we investigate under which conditions party 1 — the party with low environmental concerns — decides to commit to protect the environment. Suppose party 1 is the incumbent. Differentiating (3.11) with respect to κ when $i = 1$ reveals that a marginal increase in κ has two opposing effects on party 1's

expected payoff:

$$\begin{aligned} \frac{\partial \Omega_1(\kappa)}{\partial \kappa} = & \pi_1'(\kappa) [\kappa v(\tau, \alpha_1) + (1 - \kappa)v(\alpha_1, \alpha_1) - v(\alpha_2, \alpha_1) + R] - \\ & \pi_1(\kappa) [v(\alpha_1, \alpha_1) - v(\tau, \alpha_1)] \end{aligned}$$

The first term represents the positive effect; that is the electoral gain from increasing κ . As previously shown, this is due to the fact that, by raising its level of commitment κ , party 1 can increase its chances of re-election. This increase in its probability of victory is weighted by the utility gain from being in office. The second term is negative and shows the policy cost of committing to environmental protection in period 1. Indeed, when the incumbent chooses a positive level of commitment it constrains the period-2 government policy choice. Consequently, if party 1 is re-elected (i.e. with probability $\pi_1(\kappa)$), it will have to set a policy different from its ideal one, thus incurring a utility loss of $v(\alpha_1, \alpha_1) - v(\tau, \alpha_1)$. In equilibrium, party 1 chooses the level of commitment $\kappa \in [0, 1]$ that maximises its objective function (3.11). The expression above thus shows the trade-off between policy preferences and electoral incentives faced by party 1 in period 1.

From the above argument, in equilibrium party 1 commits to protect the environment — i.e. chooses $\kappa > 0$ — in period 2 if the (marginal) gains from increasing the probability of winning the elections exceed the (marginal) policy loss:

$$\pi_1'(0) [v(\alpha_1, \alpha_1) - v(\alpha_2, \alpha_1) + R] > \pi_1(0) [v(\alpha_1, \alpha_1) - v(\tau, \alpha_1)] \quad (3.16)$$

Inspection of the left-hand side of inequality (3.16) reveals that two factors are conducive to commitment. First, the polarization of parties' preferences (i.e. the difference between α_2 and α_1) increases the expected gain from re-election, as

$v(\cdot, \alpha_1)$ is strictly decreasing on the interval (α, α_1) . Second, an increase in the rent from holding office R similarly raises the gains from re-election.

Inspection of the right-hand side of inequality (3.16) reveals that two factors have a negative impact on the non-green party's commitment level. First, the higher the IEA requirements (i.e. the level of taxation τ the period-2 government will have to set in order to comply with the emissions reductions) the higher the distance between the tax τ and the party's ideal policy α_1 . Second, an increase in party 1's initial chances of re-election, $\pi_1(0)$, raises the probability of incurring the utility loss $v(\alpha_1, \alpha_1) - v(\tau, \alpha_1)$.

Proposition 10 *Suppose party 1 is the period-1 incumbent. It commits to protecting the environment if and only if condition (3.16) holds. Hence, party 1 is more inclined to commit to the IEA terms when:*

- (i) *polarization of policy preferences among the two parties increases;*
- (ii) *the rents from holding office increase; and*
- (iii) *the IEA's requirements decrease.*

Proposition 10 describes the factors that can make incumbent party 1 commit to protect the environment despite its low environmental concern. This stands in sharp contrast to the result stated in Proposition 8, where the probabilities of victory were exogenous. Introducing electoral concerns into the model has allowed us to identify factors that may drive a non-green government to commit to an IEA. In subsection 3.3.5, we will use numerical simulations to show that there exist parametric configurations of the model such that the non-green incumbent actually chooses positive commitment levels (i.e. $\kappa > 0$).

3.3.4 A Green Incumbent May Not Commit to Protect the Environment

Let us now turn to the case where the incumbent is party 2; that is the green party. In this subsection we want to analyse the impact of endogenizing the probabilities of victory on party 2's choice of the commitment level. In particular, we want to see whether, in contrast to the case without electoral concerns, this party may choose not to fully commit the future government to protect the environment. To this end, let us consider the impact of a marginal increase in κ on party 2's expected payoff by differentiating (3.11) when $i = 2$:

$$\begin{aligned} \frac{\partial \Omega_2(\kappa)}{\partial \kappa} = & \pi_1(\kappa) [v(\tau, \alpha_2) - v(\alpha_1, \alpha_2)] + \\ & \pi_2'(\kappa) [v(\alpha_2, \alpha_2) + R - \kappa v(\tau, \alpha_2) - (1 - \kappa)v(\alpha_1, \alpha_2)] \end{aligned}$$

As previously, this expression shows a trade-off between policy preferences and electoral incentives. The first term represents the expected benefit from constraining party 1 if the latter wins the elections. This term is positive due to the fact that party 1, if elected, will have to choose a policy $\tau \in [\alpha_1, \alpha_2]$ closer to party 2's ideal policy. The second term represents the electoral cost of committing party 1 to protect the environment. Indeed, as stated in Lemma 9, increasing the level of commitment κ reduces party 2's probability of victory (by $\pi_2'(\kappa)$) when $\gamma > \bar{\gamma}$. This effect is weighted by the utility gain from staying in office.

In equilibrium, party 2 chooses a positive level of commitment κ such that the objective function (3.11) is maximised. Hence, party 2 will not fully commit to protect the environment — i.e. will choose a value $\kappa < 1$ — if:

$$\pi_1(1) [v(\tau, \alpha_2) - v(\alpha_1, \alpha_2)] < -\pi_2'(1) [v(\alpha_2, \alpha_2) - v(\tau, \alpha_2) + R] \quad (3.17)$$

Inspection of the left-hand side of equation (3.17) shows that party 1's chances of re-election under full commitment, $\pi_1(1)$ have a negative impact on party 2's

likelihood of full commitment. Recall that $\pi_2(1) = 1 - \pi_1(1)$. Hence, party 2's probability of re-election under full commitment, $\pi_2(1)$ has a positive impact on its likelihood of full commitment.

Inspection of the right-hand side of equation (3.17) shows that two factors reduce party 2's optimal commitment level. First, party 2 is less likely to choose full commitment (i.e. $\kappa = 1$) the higher are the rents from holding office, R . Second, when party 1's consideration for the environment increases (i.e. α_1 becomes closer to α_2) its electoral gain also increases.

This leads to the following result:

Proposition 11 *Suppose party 2 is the period-1 incumbent. It does not fully commit to protecting the environment if and only if condition (3.17) holds. Hence, party 2 is less inclined to fully commit to the IEA terms when:*

- (i) *polarization of policy preferences among the two parties decreases; and*
- (ii) *the rents from holding office increase.*

The effect of the IEA's requirements is ambiguous.

Proposition 11 shows that when electoral motives are taken into account, party 2's choice of the level of commitment κ may differ from the result obtained when the probabilities of victory are exogenous. In the next subsection, we show that this can actually be the case in equilibrium.

3.3.5 Numerical Simulations

The previous subsections described how the various exogenous variables of the model affect incumbents' choices of κ . In this subsection we check that is actually possible for a non-green incumbent (resp. a green incumbent) to choose a value of κ greater than zero (resp. smaller than one) in period 1. To this end we

use a simple numerical example. We concentrate on one specific functional form, assuming the utility function takes the form:

$$u(x) = 10x - \frac{1}{2}x^2$$

The model is simulated assuming that $\beta = 3$ and $\rho = 5$ in (3.9) and (3.10), respectively, and then varying the values of our main variables: the policy preferences, α_1 and α_2 ; and the rents from being elected, R . We also assume that b and r are all uniformly distributed on their respective supports. The environmental concern $\alpha \in [0, 1]$ is distributed according to the following density function

$$f(\alpha) = \begin{cases} \phi & \text{if } 0 < \alpha < \tau \\ \frac{1-\tau\phi}{1-\tau} & \text{if } \tau < \alpha < 1 \end{cases} \quad (3.18)$$

where parameter ϕ allows us to control for $\bar{\gamma}$. From (3.15) and (3.18) it immediately follows that a large value of ϕ represents a small value of $\bar{\gamma}$. In this example, we will take $\phi = 0.9$ to show that the results can hold even when $\bar{\gamma}$ is small. (The condition on $\bar{\gamma}$ in the propositions is sufficient, but not necessary.)

Table 3.1 shows the level of commitment κ chosen by party 1 — the non-green incumbent — according to different levels of type- α_1 policy preferences and rents from being elected, R .

These results confirm that non-green incumbents can choose high levels of commitment to environmental protection. In addition, they confirm that when polarization between the policy preferences increases — that is when the distance between parties' policy preferences increases — the level of commitment chosen by party 1 also increases. Moreover, the level of commitment κ chosen by party 1 increases with the rents. This is consistent with our theoretical results.

α_1	α_2	R	κ
0.12	0.6	5.5	0.652 15
0.1	0.6	5.5	0.829 90
0.08	0.6	5.5	0.967 01
0.1	0.6	5.45	0.582 99
0.1	0.6	5.4	0.336 08
0.1	0.6	5.4	0.215 22
0.1	0.6	5.4	0.457 47

Table 3.1: Choice of level of commitment for non-green incumbent

α_1	α_2	R	κ
0.1	0.6	6.7	0.627 88
0.11	0.6	6.7	0.421 55
0.12	0.6	6.7	0.187 64
0.1	0.6	6.65	0.425 86
0.1	0.6	6.6	0.223 84

Table 3.2: Choice of level of commitment for green incumbent

We now test the predictions of the model regarding party 2 — the green incumbent — choice of level of commitment κ . Table 3.2 shows that the green incumbent may choose small levels of commitment. In addition, the level of commitment κ is chosen by party 2 according to different levels of α_2 and R . When the polarization between the policy preferences decreases — that is, when party 1's concerns for the environment increase — the level of commitment chosen by party 2 decreases. Moreover, when the rents from being elected, R , decrease, the level of commitment chosen by party 2 also decreases.

3.4 Conclusion

The starting point of our analysis was the increasing importance of IEAs in international politics and the subsequent necessity to identify the factors affecting domestic governments' choice of joining IEAs. To the best of our knowledge, very few papers have analysed the impact of domestic partisan politics on IEAs'

ratification choice. Moreover, they have mainly focussed on a limited set of issues, namely the impact of the degree of democracy and civil liberties, corruption and environmental lobbies' strength. In addition, the majority of papers have followed the traditional partisan theory, based on Downs (1957). Therefore, our model tries to fill this gap by applying to IEAs the framework that extends Downs' (1957) theory by introducing political parties' electoral concerns.

The aim of the chapter is to explain the reasons behind the choice of commitment to an IEA. Using a probabilistic framework à la Lindbeck and Weibull (1987), this chapter analyses how electoral concerns affect the choice of the level of commitment to an IEA in a framework where parties maximise their expected payoffs and choose the level of commitment to an IEA. Political parties' choices are driven by policy and electoral incentives. The former kind of incentive results from the utility obtained by the political party when a policy is implemented and depends on its policy preferences. The latter results from the ability the incumbent has to enhance its probability of winning the elections by increasing the commitment level to the IEA. We first derive the level of commitment chosen by the incumbents — non-green and green — when the probabilities of victory are exogenous. This eliminates the electoral incentive and the main findings are not surprising. On the one hand, a non-green incumbent never commits to an IEA; that is, the level of commitment chosen is always null. On the other hand, a green incumbent always commits to an IEA; that is, the level of commitment chosen is always equal to unity.

We then derive the level of commitment that maximises the incumbent's expected payoff when the probabilities of victory are endogenous. Endogenizing the probabilities of victory introduces electoral incentives into the framework. The main results interestingly differ from the predictions obtained in the previous case.

Indeed, they highlight that non-green parties may choose a strictly positive level of commitment if, by doing so, the electoral gain — i.e. the increase in the probability of victory — exceeds the policy loss — i.e. the fact that period-2 government is constrained in its policy choice. We also show that a green government's level of commitment to the IEA may be less than 1 if the electoral cost of commitment — i.e. the decrease in its probability of victory — exceeds the policy gain — i.e. constraining the non-green party.

Our model has enabled us to better understand the domestic-politics incentives that drive policymakers to join IEAs. Nonetheless, there are undoubtedly other factors that can affect such a decision. First, we have ignored that small countries might be obliged to sign the IEA in order to please important economic partners. Indeed, incumbent governments would gain from having a powerful ally supporting them. This would result in small countries having a higher level of commitment — i.e. high value of κ — independently of their governments' electoral incentives. For example, the candidate member states of the EU have to commit to the so-called *acquis communautaire*, that is the entire body of EU legislation published in the Official Journal of the European Union. Therefore, they are forced to commit to all the IEAs in place, regardless of policy and electoral incentives.

Second, the chapter does not account for the costs of not complying to the IEA. We can broadly identify two types of costs associated with non-compliance: explicit and reputational costs. The former regards actual expenditures to be incurred instead of cutting own emissions. For instance, the Clean Development Mechanism within the Kyoto Protocol (1997) allows signatories to fund emissions abatement projects in developing countries in order to earn certified emission reduction (CER) credits that will be equivalent to domestic emissions reductions

(UNFCCC, 2006). This flexibility mechanism is based on the assumption that abating in developing countries is less costly than in developed countries, but still costly. The latter is related to the cost due to the exclusion from future international treaties when a country is labelled as an unreliable partner. DeSombre's (2006) analysis focuses on the shipping industry and the incentives linked to exclusion. Her findings show that compliance with IEAs' requirements increases when the culprits of violating them are excluded from valuable services — i.e. club goods.

Third, we focussed on the individual country's decision without analysing the strategic interactions with other governments. Indeed, each country's choice of level of commitment will impact the levels of commitment chosen by the other signatories and therefore, the value of the IEA. For example, the Kyoto Protocol (1997) could only have a positive impact on environmental quality if at least 55 countries, representing at least 55 percent of the base-year carbon-dioxide emissions, would have ratified it. When the USA decided to withdraw from the treaty, the other signatories, especially the EU, had to engage in a series of negotiations with Russia in order to convince it to commit. Otherwise, the Kyoto Protocol (1997) would have been void. We leave these and other interesting issues, including an empirical test of the theory, for future research.

CHAPTER 4

SOCIAL INTERACTIONS IN CYPRUS: AN EVOLUTIONARY APPROACH

4.1 Introduction

The island of Cyprus has always been the centre of attention, not only for its beautiful natural landscape, but also for its strategic location. Indeed, Cyprus is located at the point where Europe, Middle East and Africa meet. This privileged position and the efforts of many countries to strategically control it has been the main cause of its problems. Since the Ottoman conquest the Cypriot population has been of two main ethnicities: an Orthodox majority of Greek descent and a Muslim minority of Turkish descent. They were living together with no major ethnic conflicts until the beginning of the nineteenth century. Since then, the situation has experienced an escalation of violence (in the 1970s) and then finally peace, but at the expense of a country now divided. The UN Buffer Zone (established in 1963 as a consequence of over a decade of interethnic conflict) divides the Republic of Cyprus area (in the Southern part of the island) from the Northern area, occupied by the Turkish army.

The Cyprus conflict is considered to be intractable, given that peacekeeping authorities (funded by international donors) have unsuccessfully been trying to find a solution since 1974. Nowadays, United Nations Development Programme - Action for Cooperation and Trust in Cyprus (UNDP-ACT) Survey data (covering the period 2007-2013) are the most reliable and long-term data available about the Cyprus issue. UNDP-ACT Surveys include several questions about the political,

economic and social situation in Cyprus, asked to a statistically representative sample of respondents from both ethnic communities. Those data show that Cypriots are stuck in an impasse, where more than 40% of the population is highly concerned about the situation of the island, but nonetheless the fraction of the population who thinks that a solution will be reached is quite low and the proportion of the population who supports peaceful co-living is stagnant.

The aim of the chapter is to give a theoretical explanation of this impasse and explain the reason why decades of international efforts miserably failed. We use a static model where there is a political issue of the dichotomous type, meaning that agents can either be in favour or against it (peaceful co-living with the members of the other ethnic community). Agents decide which idea to follow by maximizing their own utility. We assume that every agent has an opinion (no undecideds exist). They are randomly matched and meet in pairs at any time period. Agents occasionally compare their current payoffs with the expected payoff they would get if they decided to change their mind and adhere to the other idea.

We assume that there is a friction: agents pay a cost for switching opinion, which represents the psychological cost associated with behavior change. Indeed, a strand of literature has shown that behavioural changes are costly due to a number of agents' biases. This research has been applied to a number of products and suppliers' choices, adoption of innovations and can be successfully extended to opinion change. In particular, the endowment and the status quo biases are the most appropriate in our scenario. According to the "endowment effect", agents value their endowment more than goods or features that do not belong to them. For example, Thaler (1980) found that agents overvalue goods or features belonging to them by three times. According to the "status quo bias", agents tend to maintain their goods or actions even when faced with a more valuable alternative.

This bias has been pioneered by Samuelson and Zeckhauser (1988), who showed its existence through the use of experimental data. In our framework, individuals might overvalue their initial opinion and fail to switch even if the other idea yields a higher payoff. This irrational behaviour might be due to several factors. For example, Cyprus is a small island where family structure is still extremely powerful and hence, political ideas are usually inherited from other members of the family. As a consequence, in the event of a behavioural change, an individual will have to face within-family conflicts. Similar conflicts might arise with friends and work colleagues in extremely politicized areas. Therefore, agents are likely to change their opinion only if the prospective payoff is able to cover the psychological cost and still yield a payoff higher than the current one.

Our model shows that, within each ethnic community, the evolution over time of the idea depends on the fraction of the population supporting it. Indeed, if the proportion of the population supporting either idea is lower than a certain threshold (which is less than half of the population), then in the course of time the agents supporting it will change their opinion and switch to the other idea. If the population is fairly evenly split between both ideas, then all agents will stick with their initial opinion. We define this as area of inertia.

Using UNDP-ACT Survey data we show that the situation in Cyprus is consistent with the assumptions of our model, reinforcing the applicability of our model to this issue. Moreover, the prediction of the model is consistent with the behaviour of the two Cypriot Communities. We report descriptive statistics from the surveys to support our claim. Moreover, we state that the impasse in Cyprus is due to the fact that the proportion of the population supporting peaceful co-living is in the area of inertia.

The rest of the chapter is organized as follows. Section 4.2 gives an overview

of the relevant literature, paying particular attention to evolutionary models and wishful thinking. The model is described in Section 4.3. The empirical illustration using the situation in Cyprus is the focus of Section 4.4. Section 4.5 concludes.

4.2 Related Literature

This chapter is related to two strands of literature: the non-contractual social interactions literature and the wishful thinking literature.

According to the former, social interactions and the actions taken by the agents are based on their self-interest and not regulated by law (Bowles, 2004). Social interactions can be found in a context where agents' actions impact directly on other agents' choices. The economic literature assumes that the individuals' behavioural responses come from replicating the behaviour of successful agents. Agents are perceived as successful when they obtain a payoff higher than the one of some other individuals (Bowles, 2004).

According to this literature, social interactions may take the form of spillovers or social multipliers. If two paired agents are aware that their choices influence and are influenced by the other agent's choices, then this situation is defined as characterised by the existence of a social multiplier. Otherwise, the situation is defined as characterised by the existence of spillovers. Another difference relevant in literature is between active and passive interactions. Active interactions involve that all agents are affected by each other's choices; while passive interactions involve that some agents are not affected by other's choices. An important point stressed in this literature is that passive interactions cannot produce social multipliers.

From an economic point of view, the role played by social interactions is extremely important for policymakers, who could use them to spread certain be-

haviours in a faster and more effective way, rather than trying to directly affect every single individual's behaviour. Indeed, one of the most interesting findings of the literature on social interactions is that aggregate effects are not merely the sum of individual effects. Several studies found that when each individual follows self-interest motives, the aggregate outcome is not socially optimal (Schelling, 1971; Granovetter, 1973, 1978; Bowles, 2004). Indeed, evolutionary theory models agents' payoffs in such a way that they do not depend on aggregate outcomes. Therefore, there is no incentive for the individual to take socially optimal actions.

Bowles (2004) reports an extremely interesting example where self-interest generates aggregate unintended outcomes. In the US, individual preferences regarding mixed ethnicity neighbourhoods are not consistent with their actual racial composition. Indeed, according to Clark's (2011) survey, in Milwaukee, Cincinnati and Los Angeles, both whites and Afro-Americans would prefer to live in a fairly split neighbourhood. These preferences sharply contrast with the fact that, in reality, these big cities are mainly composed of segregated neighbourhoods. Therefore, the investigation of social interactions and their role in explaining the aggregate outcome is of primary interest for social scientists.

The seminal papers in this literature are Schelling (1971) and Granovetter (1973, 1978), who introduced threshold models of social interactions in order to explain certain social phenomena. Schelling (1971) focuses on neighbourhood segregation, Granovetter (1973) on social interactions between friends and Granovetter (1978) on riots. The main characteristic of those papers is that agents' marginal utility from choosing an action is increasing in the proportion of the population making the same choice. These models generate a "critical mass effect", that is, when the proportion of the population choosing a specific action is above a certain threshold, the only stable equilibria in the system are the ex-

tremes (i.e. one of the two actions completely disappears and all the agents will choose the same action). Indeed, in those models there is a first agent who chooses an action and then other agents will take the same action only if the number of agents already choosing it is higher than their individual-specific threshold. A critical assumption in this literature is that social interactions are of a sequential nature: individuals who choose to take an action are affected by the behaviour of individuals who chose the same action in the past, but the reverse is not true (Granovetter and Soong, 1983).

At its early stages, this literature mainly focused on testing if social interactions had a real impact on agents' behaviour. Then, it started growing in importance and a wide variety of issues are now being studied. Presenting an exhaustive literature review is beyond the scope of this chapter, therefore we shall limit our discussion to the most relevant papers. For example, Bernheim (1994), analyses agents with heterogeneous features and finds that the outcomes from a social point of view are usually either common behaviour or polarized behaviours. Economides and Himmelberg (1995) examine network effects in the American fax market. Their main result is that perfect competition does not generate first best outcome, due to the externalities coming from the existence of networks. Glaeser et al. (1995) study the variance of crime rates in different cities. A social interaction index is constructed and different types of crimes are empirically tested. Their main finding is that this variance is not due to geographical features, but to social interactions.

Dasgupta (1995), Kohler (1997), and Durlauf and Walker (1998) analyse fertility rates and the use of different types of birth control tools. Dasgupta (1995) links population growth, poverty and local environmental quality in order to study, from an economic point of view, the impact of high population growth. His main

finding is that there is dominant effect, but these three elements are interrelated and affect each other. The starting point of Kohler (1997) is the empirical evidence about across space and social classes' differences in birth control practices. He argues that word-of-mouth-type communication is the main factor responsible for these differences. Durlauf and Walker (1998) state that fertility transitions are due to the interconnection of both economic and cultural factors. In their book, they build up several models, able to shed light on selected specific issues.

An extensive literature review on economic social interactions has been provided by Manski (2000). He discusses both the theoretical and empirical advances and provides suggestions on how to proceed further. Topa (2001) studies the role of social interactions in unemployment. He models agents who interact within their own network by sharing valuable information about their local job market. He simulates his model and the results show that social interactions are significant and stronger in more deprived areas. Hong et al. (2004) empirically examine whether social interactions have an impact on stock-market participation by using data from the Health and Retirement Study. They define as "social households" the households who have a close connection with other agents within their neighbourhood, or go to their local church. Their main result is that those "social households" participate significantly more to the stock market than other households.

Christakis and Fowler (2007) empirically test the hypothesis that obesity is linked to social interactions. They use a dataset including data from a large social network over a period of time of 32 years. Their main finding is that obesity does spread through social networks. This result is challenged by Cohen-Cole and Fletcher (2008), who argue that Christakis and Fowler (2007) had incurred in a spurious result, due to the misspecification of their model. Cohen-Cole and

Fletcher (2008) apply Christakis and Fowler's (2007) empirical model to an alternative dataset in order to prove their claim.

A critical literature review of the progresses made in the empirical analysis of social interactions is provided by Blume et al. (2010). Moreover, they highlight some topics for future research. Ioannides (2013) provides an exhaustive literature review on social interactions, summarising all the main issues and models that have been used across time from both a theoretical and empirical point of view.

According to wishful thinking theory, agents' beliefs are affected by events or actions they want to happen or to be true. This means that an individual is more likely to believe that a utility enhancing event will happen. This extensive literature has identified in over-confidence, over-optimism, self-serving beliefs and cognitive-dissonance the most common biases source of wishful thinking. Three main wishful thinking theories have received the majority of attention within the literature: the universal theory, the ego-utility theory and the cognitive bias theory.

According to the first theory, wishful thinking has an impact on subjective judgments. This means that when an event increases agents' utility, they are more likely to believe that the event is true. Mayraz (2011) developed an experiment where agents were provided with a financial asset's historical price chart and were asked to predict the asset's future price. During the experiment, agents were given two bonuses. The former was an "accuracy bonus", whose size was proportional to the accurateness of the prediction. The latter bonus' size was proportional to the size of the predicted price. A fraction of the individuals was given bonuses increasing with the size of the predicted price and the other fraction was given bonuses decreasing with the size of the predicted price. The results showed that agents whose bonus was increasing with the size of the predicted price

made dramatically higher predictions compared to the other group. In addition, the bias' size was independent from the "accuracy bonus".

According to the ego-utility theory, wishful thinking has an impact only on subjective judgments related to the agent's skills and characteristics. For example, Koszegi (2006) introduces "ego utility" as a further component of agents' utility function. "Ego utility" is the idea that agents derive extra utility when they are perceived as talented in performing certain tasks. According to his findings, agents show overconfidence in the task choice when agent's skills might be inferred from the chosen task.

According to the cognitive bias theory, wishful-thinking is caused by the agent's systematic incapacity in processing information asymmetries. For example, Kataria (2012) performs an experiment where undergraduate students are asked whether they believe the Porter hypothesis to be true. The Porter hypothesis is extremely controversial and claims that strict environmental regulations have a positive impact on innovations and efficiency (Rubashkina, 2008). The main findings of the paper show that more environmentally concerned students are more likely to believe the Porter hypothesis to be true.

The existence of wishful thinking poses a number of issues of extreme importance in a policy decision making environment. Indeed, individual agents affected by wishful thinking face a distorted decision process, where risks are underestimated and uncertain rewards are overestimated. In strategic decision-making processes, agents' beliefs differ according to their interests. On the empirical side, a number of papers found evidence of wishful-thinking in many areas. For example, Babcock and Loewenstein (1997) in bargaining processes, Olsen (1997) in investment management, Camerer and Lovo (1999) in market entry, Malmendier and Tate (2008) in mergers and acquisitions, Mullainathan and Washington (2009)

in political economy.

4.3 Theoretical model and general solution

There is a society with a population of constant size where there is a political issue of dichotomous type: agents can have one of two opinions about this subject. For instance, people in Cyprus are either in favour or against reconciliation. In our model, the agents' payoffs are completely symmetric with regard to the two opinions. We shall use the subscripts i for one opinion and j for the other opinion. The share of agents of type i (j) in the population is x_i (x_j), with $x_i + x_j = 1$. We assume that there are many agents in the economy, such that each agent is infinitesimally small with respect to the total population and x_i can be treated as a continuous variable.

At any time t , each agent meets another agent. Matching is completely random: each agent of type i has the same probability of meeting any other agent in the population. The probability of meeting someone of the same type (the other type) is thus x_i ($1 - x_i$).

An agent of type i obtains positive utility u from meeting other agents of type i , such that $u > 0$. The utility to a type- i agent of meeting an agent of type j is normalized to zero.

Agent i and agent j expected payoffs, U^i and U^j respectively, are:

$$U^i = x_i u \quad (4.1)$$

$$U^j = (1 - x_i) u \quad (4.2)$$

We assume that when agents switch opinion, they have to pay a cost $0 < c < u$. This cost represents the psychological cost of changing a consolidated behavioural pattern. For example, in our specific framework, it could represent the cost of

distancing themselves from previous "friends", that is those who shared their former opinion.

Therefore, agent i 's expected utility after switching to opinion j is given by U^{ij} , defined as:

$$U^{ij} = (1 - x_i)u - c \quad (4.3)$$

When considering whether to change her opinion, agent i compares her payoff from keeping the present opinion, U^i , with the expected payoff from switching to the opposite one, U^{ij} . Therefore, she will decide to support idea j only if the expected utility from changing her opinion, (4.3), is higher than the one she is currently obtaining, (4.1), such that:

$$(1 - x_i)u - c > x_i u \quad (4.4)$$

By re-arranging expression (4.4) we obtain the population threshold needed for agent i to decide and support idea j , that is $\underline{x}$. Therefore, she will change her opinion if the probability x_i of meeting another individual of type i is below the threshold, such that:

$$x_i < \underline{x} \equiv \frac{u - c}{2u} \quad (4.5)$$

Lemma 12 $\underline{x} \in (0, \frac{1}{2})$ with $\underline{x}$ defined by (4.5).

Proof. From our assumptions $0 < c < u$ and $u > 0$, it immediately follows in (4.5) that $\underline{x} > 0$. Moreover, (4.5) can be re-written as

$$x_i < \underline{x} \equiv \frac{1}{2} - \frac{c}{2u}$$

Therefore, it immediately follows that $\underline{x} < \frac{1}{2}$. ■

Symmetrically, if agent j decides to change her mind, her expected utility after switching to idea i is given by U^{ji} , defined as:

$$U^{ji} = x_i u - c \quad (4.6)$$

When agent j considers switching to opinion i , she compares her payoff from keeping the present opinion, U^j , to the expected payoff she would obtain by switching, U^{ji} . Therefore, she will change her opinion if the probability x_i of meeting an individual of type i is above the threshold, such that:

$$x_i > 1 - \underline{x} \equiv \bar{x} \quad (4.7)$$

The intersection between U^i and U^{ij} represents the opinion change threshold for agent i . If the proportion of the population supporting type- i idea is lower than $\underline{x}$ then over time agents i will change their opinion and switch to idea j . Thus x_j rises and x_i falls. The intersection between U^j and U^{ji} represents the opinion change threshold for agent j . If the proportion of the population supporting type- i idea is higher than $\bar{x}$ then over time agents j will change their opinion and switch to idea i . Thus x_i rises and x_j falls. If the proportion of the population supporting type- i idea is included between the two thresholds, then both types of agents will stick with their initial opinion. Therefore, we define this as area of inertia.

Thus we have:

Proposition 13 *The evolution over time of the opinion path depends on the proportion x_i of the population supporting type- i idea such that:*

- (i) *If $x_i < \underline{x}$ as defined by (4.5) then x_i falls and x_j rises over time;*
- (ii) *If $x_i > \bar{x}$ as defined by (4.5) then x_i rises and x_j falls over time;*
- (iii) *If $\underline{x} < x_i < \bar{x}$, then x_i and x_j remain constant over time.*

The model shows different time paths for the spread of idea i , according to where the initial proportion of the population supporting it is located. We shall now discuss the several possible cases.

Initial fraction of the population supporting idea i higher than the threshold. At time t_0 the initial fraction of the population supporting idea i is $x_0 > \bar{x}$. This means that agent i 's current utility is higher than her expected utility from switching to opinion j . Therefore, agents i will keep on supporting idea i . On the other hand, agent j 's current utility U^j is lower than her expected utility U^{ji} from switching to opinion i . Therefore, over time agents j will switch to supporting idea i . As a consequence, x_i will increase, thus further increasing U^i and U^{ij} , while decreasing U^j . Therefore, this process will go on over time, until the fraction of the population supporting idea i will reach $x_i = 1$, that is the stable equilibrium in this case. A value of $x_i = 1$ means that every agent will end up supporting idea i and idea j will disappear.

Initial fraction of the population supporting idea i lower than the threshold. At time t_0 the initial fraction of the population supporting idea i is $x_0 < \bar{x}$. This means that agent j 's current utility is higher than her expected utility from switching to opinion i . Therefore, agents j will keep on supporting idea j . On the other hand, agent i 's current utility U^i is lower than her expected utility U^{ij} from switching to opinion j . Therefore, over time agents i will switch to supporting idea j . As a consequence, x_i will decrease, thus further increasing U_0^j and U_0^{ji} , while decreasing U^i . Therefore, this process will go on over time, until the fraction of the population supporting idea i will reach $x_0 = 0$, that is the stable equilibrium in this case. A value of $x_0 = 0$ means that every agent will end up supporting idea j and idea i will disappear.

Initial fraction of the population supporting idea i within the area of inertia. If the initial fraction of the population supporting idea i is $\underline{x} < x_0 < \bar{x}$, agent i 's current utility is higher than her expected utility from switching to opinion j and agent j 's current utility is higher than her expected utility from switching to opinion i . Therefore, both agents will keep on supporting their initial idea. As a consequence, x_0 will remain unchanged. Therefore, every value of $\underline{x} < x_0 < \bar{x}$ represents a stable equilibrium in this case.

4.4 Empirical illustration

In this section we shall apply our theoretical framework to the Cyprus issue in order to give an economic explanation of the impasse in which the island has been trapped. The next subsection shall introduce the historic roots of the Cyprus issue. Then, we will introduce the data we shall use in our empirical illustration and provide several descriptive statistics useful to that end. The final subsection shall provide an illustration of the data and the Cyprus issue in the light of our model. We shall see that our model is able to shed new light on the causes of the current situation in Cyprus.

4.4.1 The Cyprus Issue: historical overview

A complete and detailed historical analysis of the Cypriot history is beyond the scope of this chapter and we refer the interested reader to the extensive literature on the subject (e. g. Hakki, 2007). Nonetheless, a brief historical overview of the roots of the Cyprus issue and its development until the Annan Plan (2004) is useful for the sake of our chapter.

Cyprus has been ruled by foreign conquerers for centuries. The Ottomans conquered Cyprus in 1571 and then brought twenty thousands Turkish settlers to

the island: that was the beginning of the Cyprus issue (Drevet, 2000). At the beginning, the settlers and the native Cypriot community of Greek descendance were living together peacefully (Drevet, 2000). Aimilianides (1938) highlights that during the nineteenth century inter-religious marriages were quite common and even conversion from one religion to the other one was not a taboo (as it is nowadays). According to Pollis (1973), during this period Cypriots used to distinguish themselves according to their religion (e.g. Orthodox vs Muslims) and not to their nationality (e.g. Greeks vs Turks).

Under the Ottomans, from the seventeenth century, economic conditions in Cyprus worsened dramatically, generating discontent amongst the population. Moreover, during the Greek War of Independence from the Ottomans (1821-1827), the Turkish Governor in Cyprus decided to kill hundreds of Greek Cypriots (including the Archbishop of the Orthodox Church), in order to scare them and avoid their uprising. These killings stopped the peaceful co-living of the two ethnic communities (Darrell, 1957).

In 1878 the British obtained control of Cyprus from the Berlin Congress and a new colonization era started (Pollis, 1973). The British ruled following the "divide et impera" of Roman memory (Jacovides, 2011) and they started categorising the inhabitants by their descent, i.e. Greeks vs Turks (Pollis, 1973). "Divide et impera" was based on dividing the two ethnic communities and pitting them against each other in order to avoid them to jointly fight against the colonizer. Some authors argue that Cypriots were completely unaware of nationalistic ideology (Pollis, 1973). Other authors, such as Peristianis (2008), support the argument that Cypriots were not extraneous to the concept of nationality, but there is wide consensus about the idea that ethno-nationalism in Cyprus became so relevant

only as a consequence of the British colonial policy.

As foreseeable, this policy resulted in Cyprus becoming a powder keg ready to explode. Moreover, the British soon after the acquisition of the island realised that massive investments would be needed in order to make use of it, by transforming it into a naval base (Varnava, 2012). Therefore, the plans they had about Cyprus soon vanished and they never helped the island to fully develop its potential (Varnava, 2012).

In the '30s the first riots took place against the British Empire and the Governor's House was burned down by the protesters. The riots were led by Greek Cypriots, who wanted the British to leave the island and, based on their cultural and linguistic affinities with Greece, were claiming their "enosis" (e. g. union) to it (Holland, 1998). The riots worried the Turkish Cypriots, who were afraid of unification with Greece. Indeed, they were a minority (at that time they were around 20% of the total population), but first under the Turkish Governor and then the British, they always felt "protected". Enosis, on the other hand, would mean being completely left unprotected in their own homecountry (Drevet, 2000).

In 1923 the Greek minority living in Turkey and the Turkish minority living in Greece were forced to migrate to their original countries. Faulkenberry (2012) argues that this forced exchange, even if violated individual human rights and displaced millions of people, actually avoided a potential genocide of the Greek Orthodox Christians living in Turkey.

In the '50s both Cypriot communities organised themselves into secret paramilitary groups fighting each others and the British (Drevet, 2000). Cyprus finally reached its independence from the British in 1960. The Cypriot Constitution regarded the two ethnic communities as peers, but Turkish Cypriots (being only less than 20% of the whole population) failed to occupy their institutional seats, thus

making institutions unable to work (Pollis, 1973). Therefore, in 1963 the Cypriot President Archbishop Makarios, in order to overcome the institutional deadlock, tried to modify the Turkish Cypriots' status into national minority (Drevet, 2000). This scared the Turkish Cypriot Community and ethno-nationalism on the island had gone so far that inter-communal conflict started again and lasted for all the '60s. Indeed, a UN Buffer Zone separating the two communities in Nicosia was established in 1964 (Sözen, 2013), following inter-communal violence the preceding winter.

The decade of violence ended in 1974, when Turkey invaded Cyprus (twice in the same year) with the official reason of protecting the Turkish Cypriot minority from the "enosis" with Greece attempted by the Greek Cypriot military coup d'état in that same year (Henn, 2004). Archbishop Makarios (the Greek Cypriot leader in power) was destituted after publicly showing disagreement with the Greek military Junta (Mallinson, 2005). Moreover, Turkey illegally started bringing Turkish settlers from the mainland with the intention of modifying the island's ethnic composition. Greek Cypriots were expelled from the Northern area and Turkish Cypriots from the South, leaving 215,000 displaced, that is a third of the overall Greek Cypriot Community and half of the overall Turkish Cypriot Community (Prio, 2011). The UN Buffer Zone was then extended to stretch across the island, completely dividing the island and separating the two communities from each other. The first crossing point across the Buffer Zone, allowing Cypriots to reach the "other side" was only opened in 2003 (Broome, 2005). Before that, only limited physical interaction had taken place, in the form of groups of citizens taking part in inter-communal conflict resolution workshops and other activities in the Buffer Zone (Broome, 2005).

At the beginning of 1975 the Northern area auto-declared itself "Turkish Fed-

erated State of Cyprus". In this way the Turkish Cypriots tried to lead the way towards the creation of a Federal Republic of Cyprus, strongly disapproved by the Greek Cypriot community. Since then, a number of political and diplomatic bodies have tried to intervene and thousands of negotiations have taken place in order to settle the Cyprus issue and reunite the island. It goes without saying that the Cyprus issue is still unsolved.

An extremely important event took place in 1983, when the "Turkish Federated State of Cyprus" became "Turkish Republic of Northern Cyprus", an allegedly independent and sovereign state only recognised by Turkey (Mallinson, 2005). In 1996 Greece and Turkey almost declared war on each other, due to the dispute over the possession of two small Aegean islands (the so-called Imia incident). US diplomatic intervention avoided a war, but the dispute over the islands is yet to be solved.

In the meantime, the peace negotiations to reunite Cyprus continued under the UN first and then the EU flag, with no positive results. In 2002 the process leading to the drafting of the Annan Plan (2004) started and it took two years of work and five different versions of the Plan before the UN decided to put it on a referendum. It contained a solution to the Cyprus issue that was supposed to be agreed by both communities through a referendum. The Turkish Cypriot community voted in its favor, whilst the Greek Cypriot community rejected it. Therefore, it never entered into force and the UN dismissed it.

In 2004 the Republic of Cyprus joined the European Union and the Greek Cypriots thought they had now the EU on their side and hence, increased bargaining power whilst negotiating with the Turkish Cypriots (Kaymak, 2009). Several sources consider this as one of the causes of the rejection of the Annan Plan (2004) by the Greek Cypriot majority (Tocci, 2004; Theophanous, 2004; Kaymak, 2009).

Unfortunately, their hopes once again vanished, given that the EU efforts have not been able to generate any real effects.

In 2008 the newly elected President Dimitris Christofias announced in his initial speech that finding a solution to the Cyprus issue was the main goal of its government. The Turkish Cypriot leader Mehmet Ali Talat expressed optimism and availability to discuss a solution. Unsurprisingly, after the initial openings, the negotiations went on a wrong track, generating tensions instead of an agreed solution. Indeed, the Turkish Cypriot side tried to support the creation of a confederation, thus shocking the Greek Cypriot side.

The following year the European Court of Justice sentenced the Orams, a British family who had bought a piece of land in the Northern area of Cyprus, to give it back to its original owner. Indeed, that land was originally owned by Mr. Apostolides, a Greek Cypriot displaced in 1974 due to the Turkish invasion. After the opening of the crossing points (i.e. in 2003), he visited the Northern area and realised that his property had been sold without his consent to the Orams' family. In an attempt to win his property back, Mr. Apostolides took the case first to the Nicosia Court, obtaining a legal victory in 2004 and then to Her Majesty's High Court of Justice in England, where he lost the case. In 2009, after Mr. Apostolides' appeal, the European Court of Justice decided against the Orams, thus giving the property back to its legal owner, Mr. Apostolides. This sentence had a strong impact on the relations between Greek and Turkish Cypriots, especially due to the fact that it made impracticable for foreigners to buy property in the Northern area, with consequent negative economic effects on the Turkish Cypriot community.

The 2009 economic crisis had a strong negative impact on the island, increasing unemployment and reducing economic growth. In the aftermath, the negative

effects on the real economy summed to a big financial crisis that exploded in 2012. The Cypriot Government received an emergency loan from Russia in 2012 and then a bailout loan from the European institutions and the International Monetary Fund.

The next subsection shall show the data and descriptive statistics relevant for our analysis.

4.4.2 Descriptive Statistics

The data used in this chapter come from the UNDP-ACT Trust Surveys (UNDP-ACT), commissioned by the UNDP Action for Cooperation and Trust (UNDP-ACT) and conducted in Cyprus during the period 2007-2013 on an annual basis, by the research companies Prologue Consulting (in the Turkish Cypriot Community) and CYMAR Market Research (in the Greek Cypriot community). These two agencies collaborated on the compilation of the survey results. The survey is composed of a representative sample of 1,000 Cypriots over eighteen years old, 500 from each ethnic community. The method of contact was face-to-face interviews at the residence of respondents, with the help of a structured questionnaire. The study covered the entire island of Cyprus, and the sample distribution by region within each community was statistically significant, that is it represented the distribution of the true population. Data in the Greek Cypriot Community (GCC) were not weighted, but data in the Turkish Cypriot Community (TCC) were weighted by age and sex. The respondents were asked a number of questions about the situation in Cyprus.

For the sake of our analysis we are interested in the importance the respondents give to the Cyprus issue and their opinion about the feasibility of peaceful co-living for the two communities.

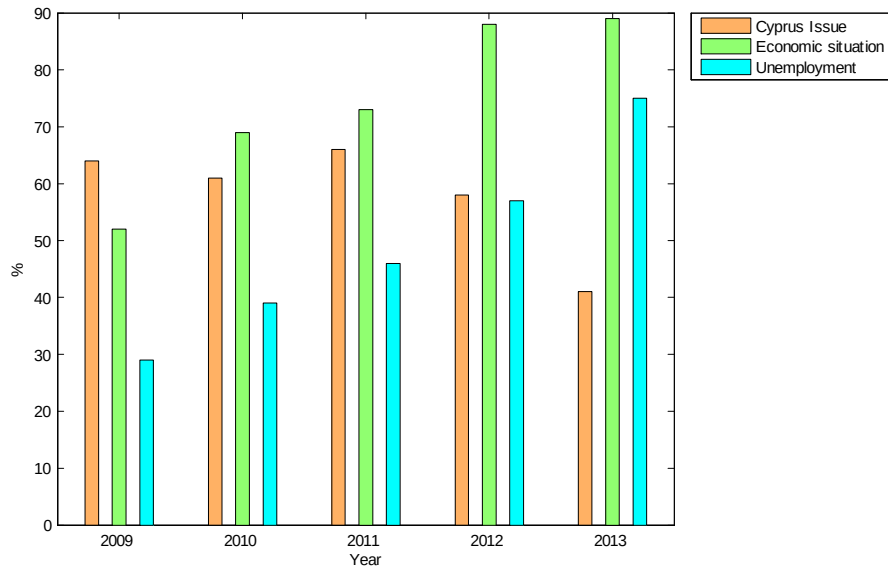


Figure 4.1: Major issues: Greek Cypriot Community (UNDP-ACT, 2013)

In the first question we are interested in, the respondents were asked to list the "major issues the two societies face at present" (p. 26, UNDP-ACT, 2013). Multiple answers were possible and we focus on the three that obtained the highest ranking. Figures 4.1 and 4.2 show the three answers that obtained the highest importance, by ethnic community for the period from 2007 to 2013.

It is clear from Figures 4.1 and 4.2 that the situation in Cyprus represents a major concern for both communities. Over the years it has always been mentioned by at least 40% of the respondents. The slight reduction of its importance in the last couple of years is probably due to the financial crisis that in 2012-2013 struck down the Cypriot banking system. Indeed, we can see that the economic situation in that same period became a major source of concern, especially for the Greek Cypriot Community.

The question we focus on in order to analyse peaceful co-living willingness reads "I believe that Greek Cypriots (GCs) and Turkish Cypriots (TCs) can live

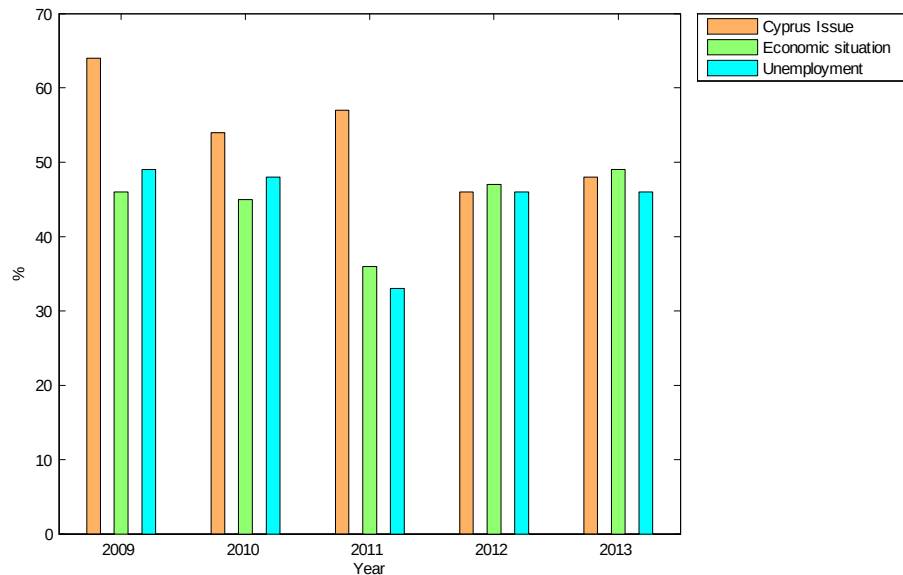


Figure 4.2: Major issues: Turkish Cypriot Community (UNDP-ACT, 2013)

together peacefully" (p. 53, UNDP-ACT, 2013). The respondents were given five possible answers to choose from, that is: do not know, totally agree, agree, disagree and totally disagree with the question statement. Figures 4.3 and 4.4 show the respondents' answers by ethnic community for the period from 2007 to 2013. For the sake of readability, the categories agree and totally agree have been aggregated, as have the categories disagree and totally disagree. Figures 4.3 and 4.4 show that the Greek Cypriot Community appears to be more open to reconciliation than the Turkish Cypriot one. Indeed, the percentage of respondents within the GCC who answered agree or totally agree is always around 50%. It must be noticed that the 2007 survey was based on a different sampling method compared to the following one and the major discrepancy between the 2007 percentage and the other ones might be attributed to this. The 2008 big drop in support for reconciliation within the GCC might depend on the fact that the new rounds of peace talks between the newly elected President Dimitris Christofias and the

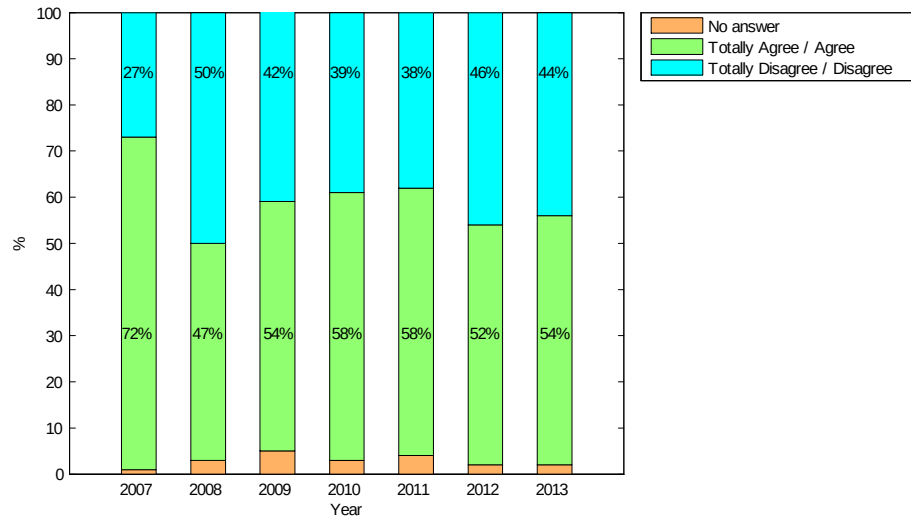


Figure 4.3: Peaceful co-living: Greek Cypriot Community (UNDP-ACT, 2013)

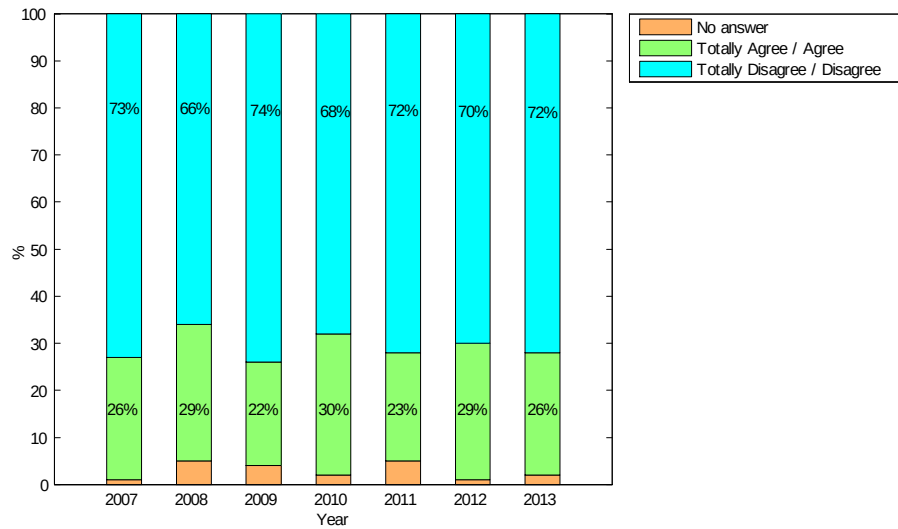


Figure 4.4: Peaceful co-living: Turkish Cypriot Community (UNDP-ACT, 2013)

Turkish Cypriot leader Mehmet Ali Talat generated tensions instead of a solution. Indeed, the Turkish Cypriot side supported the creation of a confederation: an idea absolutely unacceptable for the Greek Cypriot side. For the rest of the time period, the percentages remain quite stable.

On the other hand, the percentage of respondents within the TCC who answered agree or totally agree is always below 30%. On the contrary, Turkish Cypriots in 2008 increased their support for reconciliation due to the hope of obtaining the creation of a confederation. This hope faded and that explains the drop in the following year. Moreover, in 2009 the Grand Chamber of the European Court of Justice in Luxembourg decided in favour of a Greek Cypriot architect, Mr. Apostolides, on an extremely important case, *Apostolides v Orams*. An in-depth explanation of this landmark legal case is beyond the scope of this chapter. Here, we shall only highlight that Mr. Apostolides' legal win had an enormous impact on the peace talks, because since then the purchase of lands and estates vacated by their Greek Cypriot owners in the northern part of Cyprus has been de facto prevented, with negative consequences on the TCC.

The last relevant question for the sake of this chapter is about the expectation that a solution to the Cyprus problem will be reached. The question (p. 51, UNDP-ACT, 2013) asks the respondents to which extent they agree or disagree to the following statement "I believe that there will be a solution to the Cyprus problem". The possible answers are totally agree, agree, disagree, totally disagree or the respondents may decide not to give an answer. Figures 4.5 and 4.6 show the respondents' answers by ethnic community for the period from 2009 to 2013. It must be noticed that this question has been asked starting from the 2009 survey, hence the different time horizon compared to the previous data. As previously mentioned, for the sake of readability the categories agree and totally agree have

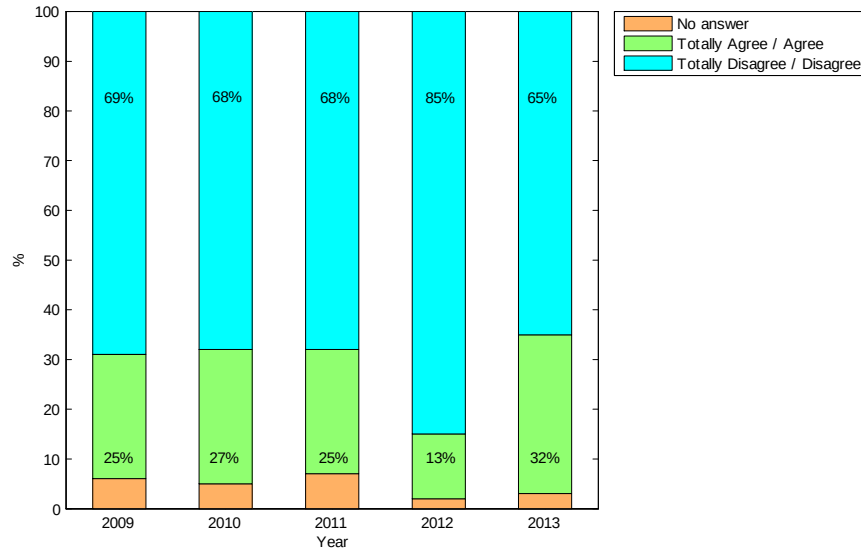


Figure 4.5: Expectation of a solution: Greek Cypriot Community (UNDP-ACT, 2013)

been aggregated, as have the categories disagree and totally disagree. It is not surprising that, after more than 30 years from the beginning of the Cyprus issue, few individuals from both ethnic communities still believe in the possibility of a solution. For the GCC, around a quarter of the respondents believes that a solution is possible. That percentage sees a dramatic reduction in 2012, probably due to the fact that the failure of the 5th UN-held peace meeting had a big echo on the news and even the Special Advisor of the Secretary-General Alexander Downer admitted the UN could not do more if the parties stubbornly kept their on sides. For the TCC, the percentages are not stable and change dramatically from one year to another. This could be due to the fact that the new rounds of peace talks started from 2008 have been a rollercoaster, with more than a hundred negotiations and different news coming quite frequently.

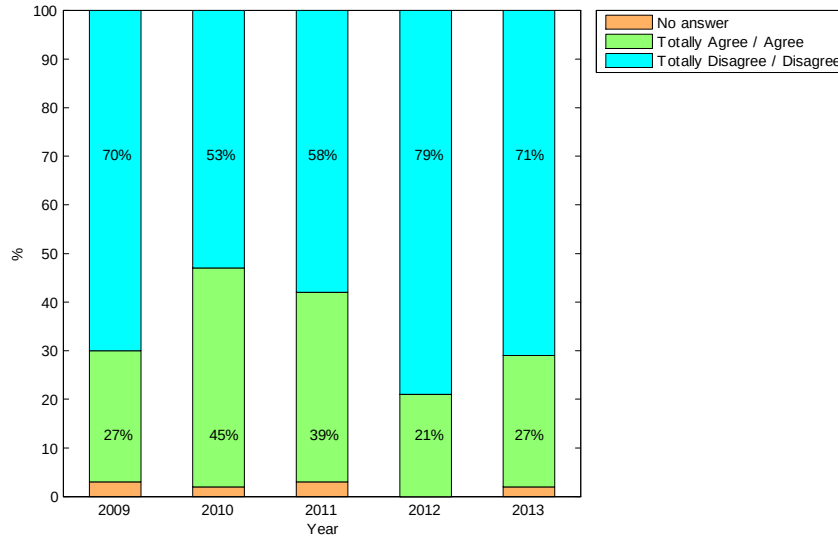


Figure 4.6: Expectation of a solution: Turkish Cypriot Community (UNDP-ACT, 2013)

4.4.3 Interpretation of results

This subsection shall provide an interpretation of the survey results in the light of our theoretical results. First of all, it must be noticed that Figures 4.1, 4.2, 4.3 and 4.4 show the applicability of our theoretical model to the situation in Cyprus. Indeed, from Figures 4.1 and 4.2 we can see that the Cyprus issue is extremely important for Cypriots and this is coherent with our theoretical assumption of an economy where individuals have an opinion over an issue of a dichotomous type. Moreover, Figures 4.3 and 4.4 are consistent with our assumption of an economy where no undecideds exist, given that the percentage of the respondents who decided not to answer (the category closest to the undecideds) is never above 5%. As we can see from Figures 4.3 and 4.4, the percentages of individuals supporting reconciliation are quite stable over time, apart from years 2007 and 2008 for which an explanation has already been provided in the previous subsection. The percentages of individuals in favour of reconciliation do move a bit, but this could

be due to the fact that the surveys do not represent a panel. The theoretical model assumes all agents have the same utility functions: in the applied context this assumption can be considered as representing a population-wide average. In the region of inertia, the fact that occasionally individuals change their opinion can be considered as “noise” that cancels out on aggregate. We argue that this stability over time is due to the fact that the percentages of individuals in favour of reconciliation lie in the area of inertia. Therefore, deviations from the initial equilibrium due to small exogenous shocks, lead the society to another equilibrium still within the area of inertia and are not able to move the system far from that area. In order for the system to move away from the area of inertia a strong positive exogenous shock is needed, e.g. some kind of incentive able to induce the parts to compromise. Indeed, after years of failed peace talks, it is quite obvious that they are not providing the right incentive for the two communities.

4.5 Conclusion

The international community has attempted to solve the Cyprus issue since 1974. Hundreds of meetings and several rounds of peace talks have been organised and funded by the UN and international donors and they all miserably failed. One of the most popular efforts has been done through the Annan Plan (2004), submitted to referendum to the two ethnic communities: a shattering 76% of the Greek Cypriot Community rejected it, thus causing the whole Plan to fail.

Why have 40 years of international efforts not been able to settle this issue? The aim of this chapter is to give a theoretical explanation to this well-known and internationally relevant question. We use a static framework to model an economy where agents differ only in the opinion about a political issue of dichotomous type. They are randomly matched and meet in pairs at any time period. In this

situation, agents occasionally compare their current payoffs with the expected payoff they would get if they decided to change their mind and adhere to the other idea. One of our most important assumptions has been introduced to make the model particularly adherent to the situation in Cyprus: a small island where people know each other very well (especially in the small villages and rural areas), where family is still a very powerful institution and opinions are handed down from parents to children. To this end, we assume that if agents change their opinion, they have to bear a psychological cost. Indeed, usually political ideas are inherited from the family environment and if one of the members decides to modify their opinion, it is likely that some conflicts within the family will be generated.

Our model shows that the evolution over time of the idea depends on the fraction of the population supporting it. Indeed, if the proportion of the population supporting the peaceful co-living idea is lower than a certain threshold, then the agents supporting it will change their opinion and switch to the other idea. On the other hand, if the proportion of the population believing that peaceful co-living is possible is higher than a certain threshold, the agents supporting the opposite idea will change their opinion and switch to supporting peaceful co-living. If the proportion of the population supporting peaceful co-living is included between the two thresholds, then all agents will stick with their initial opinion. We define this as area of inertia.

We use UNDP-ACT Survey data for the period 2007-2013 to test the predictions of our model and its applicability within each Cypriot ethnic community. Our results show that the prediction of the model is consistent with the situation in Cyprus, as highlighted by the respondents' answers to some selected survey questions. The main finding of the chapter is that all the international efforts to solve the Cyprus issue failed because the proportion of the population supporting

peaceful co-living is within the area of inertia. Therefore, these efforts have not been able to move the system far from the area of inertia.

One of the limitations of the theoretical model is its specificity, but it could be extended in order to make it more general. For example, some assumptions could be dropped, such as the symmetry of the agents' payoffs or random matching. Indeed, in reality individuals have different preferences, reflected in different payoffs. Moreover, even if random matching is a relatively painless assumption for an island as small as Cyprus (it takes more or less two hours to drive from one side to the opposite one), it does not generally hold in a much more general context.

In this chapter we applied this theoretical model to the Cyprus issue, but it might well be applied to any situation where there are two competing issues that oppose citizens and that have the capability of spreading through their social interaction. For example, the apartheid issue, the abolitionist or the women's suffrage movements.

CHAPTER 5

CONCLUSION

Externalities play such an important role in our lives that their study and the understanding of how they work is of a primary interest for economists. More specifically, environmental externalities have been at the centre of attention in the last 40 years, especially due to the negative effects caused by pollution. Indeed, scientists nowadays agree about how dangerous pollution is and on the anthropogenic source of climate change. Scientists agree about the dangerousness of climate change as well and the need to stop it in order to save the planet. As a consequence, measures to reduce pollution emissions have attracted a great deal of attention, both from civil society organizations and policymakers. Therefore, a number of international environmental agreements (IEAs) have been ratified with the clear intent of reducing pollution and putting a stop on its negative effects. Unfortunately and unsurprisingly, greenhouse gases (GHGs) emissions in developing countries increased over the period from 2000 to 2010 according to final draft of IPCC (chapter 5, p. 394, 2014). Indeed, there is still a lot to be done from a policy point of view, especially because the free riding incentive applies to IEAs as well. The aim of this thesis is to give a theoretical contribution to the understanding of environmental externalities in selected contexts. We have analysed an international environmental agreement with partial coverage, the democratic choice of environmental taxes and social interactions.

The second chapter has focused on an international environmental agreement with partial coverage. We have analysed three cases: full agreement, non-cooperative policy and partial agreement. The full agreement is characterised by

complete cooperation within the whole high-income bloc, in both deciding the amount of allowed emissions and setting the ad valorem tax on abatement. With non-cooperative policy, each high-income country sets both the emission level and the abatement tax noncooperatively. The partial agreement is characterised by emissions chosen cooperatively within the high-income bloc and the abatement tax set non-cooperatively. Our results show that carbon leakage is negative under full agreement and positive under the other two scenarios. Moreover, we show that leakage arises due to the design of the IEA. Indeed, individual countries have an incentive to set their abatement tax in a way that does not internalise the externality. Hence, we suggest that the most effective way to avoid carbon leakage is to include the choice of the domestic policy instrument within the terms of the IEA. If all the policy instruments are chosen in a cooperative fashion, carbon leakage shall be negative.

Suggestions for further research include using more general functional forms for the production, abatement and utility functions. For analytical purposes we found it expedient to work with the ad valorem tax on abatement as the domestic policy instrument. However, it remains to be seen whether our results hold for other instruments. The choice of instruments to be studied could be motivated by policies that governments have actually used to implement IEAs. It would also be interesting to investigate whether there has been any recognition in negotiations or in the IEAs themselves that the noncooperative choice of domestic policy instrument can undermine the agreement. Finally, the model could be simulated with Computable General Equilibrium (CGE) models. This would give an indication of the size of carbon leakage to be expected from partial agreements.

The third chapter has analysed the democratic choice of environmental taxes. We have used a two-period model of probabilistic voting à la Lindbeck and Weibull

(1987), where political parties care about both the environmental policy implemented in the country and the rents from being in office. There is an international environmental agreement in place and the incumbent government in the first period has to decide on the level of commitment to the IEA. The level of commitment is defined as the choice of the extent to which signatories decide to commit to the IEA (e.g. Mattes 2012). Two types of incentives play a role in our model: policy and electoral. Our results show that when the probability of victory is exogenous, both political parties choose to implement, if elected, their preferred policy. This is due to the fact that with an exogenous probability of victory only the policy incentive plays a role. On the other hand, when the probability of victory is endogenous, that is when parties can affect it with their actions, both incentives play a role. Indeed, our results show that in this case, when the proportion of green citizens is large enough, both parties choose a policy to be implemented, if elected, different from their preferred ones. The non-green party chooses a strictly positive level of commitment and the green one chooses a level of commitment strictly lower than one. Therefore, we have uncovered a domestic-politics incentive for policymakers to join IEAs.

One of the limitations of the model is that there might be other factors that have an impact on this decision. Indeed, we have ignored that small countries might be obliged to sign the IEA in order to please important economic partners, that is small countries might have a high level of commitment, independent from domestic-politics incentives. Moreover, not complying to the IEA might bear some costs: explicit and reputational. Indeed, a country might be asked to incur actual expenditures or it might be labelled as unreliable and excluded from future international treaties. Another limitation is that there could be some strategic interactions between governments. Indeed, each country's choice of level

of commitment will affect the levels of commitment chosen by the other signatories. Following Mattes (2012), this model could be easily empirically tested in order to analyse both the significance of domestic politics and of the predictions, but we leave it for future research.

The fourth chapter has analysed the impact of the externalities caused by social interactions in a society where agents are divided by their views on a salient issue. In our static model, an agent is randomly paired with agents of the same opinion and those of the opposite opinion. Agents occasionally consider changing their opinion. However, when agents change their opinion, they will incur in a psychological cost representing the difficulty of changing behaviour and adapting to new circumstances. The main result of the model is that if the proportion of the population supporting either idea is lower than a certain threshold (which is less than half of the population), then over time the agents supporting it will change their opinion and switch to the other idea. If the population is fairly evenly split between both ideas, then all agents will stick with their initial opinion. We define this as area of inertia.

We have applied our theoretical model to the Cyprus issue, as represented by the UNDP-ACT Survey data (2007-2013). We found that the assumptions of our model are coherent with the Cypriot environment. We verified that the behaviour of the two Cypriot Communities is coherent with the prediction of the model. We can then argue that the impasse in Cyprus is due to the fact that the proportion of the population supporting peaceful co-living is in the area of inertia.

One of the limitations of the theoretical model is its specificity, but it could be easily generalised. Agents' payoffs could be asymmetric, in order to represent the fact that agents might have different preferences. Moreover, the assumption of agents being paired through random matching does not generally hold and might

be replaced by taking into account agents' own network of social interactions. In future research, this theoretical model could be applied to situations where, as in Cyprus, an important issue causes a division in society between two opposing views that have the capability of spreading through social interactions.

BIBLIOGRAPHY

- [1] Abbott, K. W., Snidal, D., (2000) "Hard and Soft Law in International Governance", *International Organization* 54: 421–456

- [2] Aghion, P., Howitt, P., (1992) "A Model of Growth through Creative Destruction", *Econometrica* LX, 323–351

- [3] Aichele, R., Felbermayr, G., (2012) "Kyoto and the Carbon Footprint of Nations", *Journal of Environmental Economics and Management* 63: 336–354

- [4] Aimilianides, A. C., (1938) "The Evolution of the Law Concerning Mixed Marriages in Cyprus", *Cypriote Studies* II: 197–236

- [5] Alesina, A., Tabellini, G., (1990) "A Positive Theory of Fiscal Deficits and Government Debt", *Review of Economic Studies* 57: 403–414

- [6] Anesi, V., (2006) "Earmarked Taxation and Political Competition", *Journal of Public Economics* 90: 679–701

- [7] Ansolabehere, J., Snyder, J. M. Jr., (2000) "Valence Politics and Equilibrium in Spatial Election Models", *Public Choice* 103: 327–336
- [8] Aragonès, E., Palfrey, T. R., (2002) "Mixed Equilibrium in a Downsian Model with a Favored Candidate", *Journal of Economic Theory* 103: 131–161
- [9] Ashworth, S., Bueno de Mesquita, E., (2008) "Elections with Platform and Valence Competition", *Games and Economic Behavior* 67: 191–216
- [10] Babcock, L., Loewenstein, G., (1997) "Explaining Bargaining Impasse: The Role of Self-Serving Biases", *The Journal of Economic Perspectives* 11: 109–126
- [11] Babiker, M. H., (2005) "Climate Change Policy, Market Structure and Carbon Leakage", *Journal of International Economics* 65: 421–445
- [12] Bac, M., (2014) "Opinion Expressions under Social Sanctions", *International Review of Law and Economics* 38: 58–71
- [13] Baylis, K., Fullerton, D., Karney, D., (2014) "Negative Leakage", *Journal of the Association of Environmental and Resource Economists* 1: 51–73
- [14] Bass, F. M., (1969) "A new Product Growth for Model Consumer Durables", *Management Science* 15: 215–227

- [15] Bednar-Friedl, B., Schinko, T., Steininger, K. W., (2012) "The Relevance of Process Emissions for Carbon Leakage: A Comparison of Unilateral Climate Policy Options with and without Border Carbon Adjustment", *Energy Economics* 34: 168–180

- [16] Belderbos, R., Cassiman, B., Faems, D., Leten B., Van Looy, B., (2014) "Co-ownership of intellectual property: Exploring the value-appropriation and value-creation implications of co-patenting with different partners", *Research Policy* 43: 841–852

- [17] Bell, D., Song S., (2007) "Neighborhood Effects and Trial on the Internet: Evidence from Online Grocery Retailing", *Quantitative Marketing and Economics* 5: 361–400

- [18] Bernhard, W., Broz, L., Clark, W. R., (2002) "The Political Economy of Monetary Institutions", *International Organization* 56: 693–723

- [19] Bernheim, B. D., (1994) "A Theory of Conformity", *Journal of Political Economy* 102: 841–877

- [20] Beron, K. J., Murdoch, J. C., Vijverberg, W. P. M., (2003) "Why Cooperate? Public Goods, Economic Power and the Montreal Protocol", *Review of Economics and Statistics* 85: 286–297

- [21] Bisin, A., Verdier, T., (2000) "Beyond the Melting Pot: Cultural Transmis-

- sion, Marriage, and the Evolution of Ethnic and Religious Traits", *Quarterly Journal of Economics* 115: 955–988
- [22] Bisin, A., Verdier, T., (2001) "The Economics of Cultural Transmission and the Dynamics of Preferences", *Journal of Economic Theory* 97: 298–319
- [23] Blume, L. E., Brock, W. A., Durlauf, S. N., Ioannides, Y. M., (2010) "Identification of Social Interactions", *Reihe Ökonomie / Economics Series*, Institut für Höhere Studien (IHS), No. 260
- [24] Böhm, P., (1993) "Incomplete International Cooperation to Reduce CO₂ Emissions: Alternative Policies", *Journal of Environmental Economics and Management* 24: 258–271
- [25] Böhringer, C., Carbone, J. C., Rutherford, T. F., (2012) "Unilateral Climate Policy Design: Efficiency and Equity Implications of Alternative Instruments to Reduce Carbon Leakage", *Energy Economics* 34: 208–217
- [26] Böhringer, C., Lange, A., Rutherford, T. F., (2014) "Optimal Emission Pricing in the Presence of International Spillovers: Decomposing Leakage and Terms-of-trade Motives", *Journal of Public Economics* 110: 101–111
- [27] Bowles, S., (2004) "Microeconomics: Behavior, Institutions, and Evolution", Princeton, N.J. ; Oxford : Princeton University Press

- [28] Brauning, T., (2005) "A Partisan Model of Government Expenditure", *Public Choice* 125: 409–429
- [29] Brett, C., Keen M., (2000) "Political Uncertainty and the Earmarking of Environmental Taxes", *Journal of Public Economics* 75: 315–340
- [30] Brock, W. A., Durlauf S. N., (2001) "Discrete choice with social interactions", *Review of Economic Studies* 68: 235–260
- [31] Broome, B.J., (2005) "Building Bridges across the Green Line", UNDP
- [32] Bruter, M., Erikson, R. S., Strauss, A. B., (2010) "Uncertain Candidates, Valence, and the Dynamics of Candidate Position-taking", *Public Choice* 144: 153–168
- [33] Bulte, E., Horan R. D., (2010) "Identities in the Commons: The Dynamics of Norms and Social Capital", *The BE Journal of Economic Analysis and Policy*: 10(1) Topics, Article 13
- [34] Burniaux, J. M., Oliveira Martins, J., (2012) "Carbon Leakage: A General Equilibrium View", *Economic Theory* 49: 473–495
- [35] Burniaux, J. M., Chateau, J., Duval, R., (2013) "Is there a Case for Carbon-based Border Tax Adjustment? An Applied General Equilibrium Analysis", *Applied Economics* 45: 2231–2240

- [36] Burt, R. S., (1987) "Social Contagion and Innovation: Cohesion versus Structural Equivalence", *American Journal of Sociology* 92: 1287–1335

- [37] Calvert, R., (1986) "Models of Imperfect Information in Politics", Washington University, St. Louis

- [38] Camerer, C., Lovo, D., (1999) "Overconfidence and Excess Entry: An Experimental Approach", *The American Economic Review* 89: 306–318

- [39] Carrillo, J. D., Castanheira, M., (2008) "Information and Strategic Political Polarisation", *The Economic Journal* 118: 845–874

- [40] Chiang, A. C., (2005) "Fundamental Methods in Mathematical Economics", New York, McGraw-Hill

- [41] Christakis, N. A., Fowler, J. H., (2007) "The Spread of Obesity in a Large Social Network over 32 Years", *New England Journal of Medicine* 357: 370–379

- [42] Clark, W. R., (2002) "Partisan and Electoral Motivations and the Choice of Monetary Institutions Under Fully Mobile Capital", *International Organization* 56: 725–749

- [43] Clark, W. A. V., (2011) "Residential Preferences and Neighborhood Racial

- Segregation: A test of the Schelling Segregation Model", *Demography* 28: 1–19
- [44] Cohen-Cole E., Fletcher, J. M., (2008) "Is Obesity contagious? Social Networks vs. Environmental Factors in the obesity Epidemic", *Journal of Health Economics* 27: 1382–1387
- [45] Cole, M. A., Elliott, R. J. R., (2005) "FDI and the Capital Intensity of Dirty Sectors: A Missing Piece of the Pollution Haven Puzzle", *Review of Development Economics* 9: 530–548
- [46] Coleman, J. S., Katz E., Menzel H., (1966) "Medical Innovation", New York: Boobs-Merrill
- [47] Comaner, W., (1976) "The Median Voter Rule and the Theory of Political Choice", *Journal of Public Economics* 5: 169–177
- [48] Conconi, P., (2002) "Green and Producer Lobbies: Competition or Alliance?" In Murshed, S. M. (Ed.), *Issues in Positive Political Economy*, London: Routledge
- [49] Conconi, P., (2003) "Green Lobbies and transboundary Pollution in large open Economies", *Journal of International Economics* 59: 399–422
- [50] Conconi, P., Perroni, C., (2009) "Do Credible Domestic Institutions Pro-

- mote Credible International Agreements?", *Journal of International Economics* 79: 160–170
- [51] Congleton, R. D., (1992) "Political Institutions and Pollution Control", *Review of Economics and Statistics* 74: 412–421
- [52] Congleton, R. D., (2001) "Governing the Global Environmental Commons: the Political Economy of International Environmental Treaties and Institutions", In Schulze, G. G., Ursprung, H. (Eds.), *International Environmental Economics: a Survey of the Issues* (pp. 241–263), Oxford: Oxford University Press
- [53] Copeland, B. R., Taylor, M. S., (2003) "Trade and the Environment: Theory and Evidence", Princeton University Press, Princeton and Oxford
- [54] Copeland, B. R., Taylor, M. S., (2009) "Trade, Tragedy, and the Commons", *American Economic Review* 99: 725–49
- [55] Darrell, L., (2005) "Bitter lemons of Cyprus", Faber & Faber, New Edition, London
- [56] Dasgupta, P., (1995) "The Population Problem: Theory and Evidence", *Journal of Economic Literature* 32: 1879–1982
- [57] Di Maria, C., van der Werf, E., (2008) "Carbon Leakage Revisited: Unilat-

- eral Climate Policy with Directed Technical Change", *Environmental Resource Economics* 39: 55–74
- [58] DeSombre, E. R., (2006) "Flagging Standards: Globalization and Environmental, Safety, and Labor Regulations at Sea", Cambridge, Mass.: MIT Press
- [59] Downs, A., (1957) "An Economic Theory of Democracy", New York: Harper and Brothers
- [60] Drevet, J. F., (2000) "Chypre en Europe", L'Harmattan, Paris
- [61] Durlauf, S., Walker, J., (1998) "Social Interactions and Fertility Transitions", Mimeo, University of Wisconsin at Madison
- [62] Duso, T., Seldeslachts, J., (2010) "The Political Economy of Mobile Telecommunications Liberalization: evidence from the OECD Countries", *Journal of Comparative Economics* 38: 199–216
- [63] Economides, N., Himmelberg C., (1995) "Critical Mass and Network Size with Application to the US FAX Market", Working Paper, New York University
- [64] Eichner, T., Pethig, R., (2011) "Carbon Leakage, the Green Paradox and Perfect Future Markets", *International Economic Review* 52: 767–805

- [65] Eichner, T., Runkel, M., (2010) "Subsidizing Renewable Energy under Capital Mobility", CESifo Working Paper No. 3185

- [66] Eichner, T., Runkel, M., (2012) "Interjurisdictional Spillovers, Decentralised Policymaking and the Elasticity of Capital Supply", *American Economic Review* 102: 2349–2357

- [67] Elliott, J., Fullerton, D., (2014) "Can a Unilateral Carbon Tax Reduce Emissions Elsewhere?", *Resource and Energy Economics* 36: 6–21

- [68] Enelow, J. M., Hinich M. J., (1984) "Probabilistic Voting and the Importance of Centrist Ideologies in Democratic Elections", *The Journal of Politics* 46: 459–478

- [69] Enelow, J. M., Hinich, M. J., Mendell, N. R., (1986) "An Empirical Evaluation of Alternative Spatial Models of Elections", *The Journal of Politics* 48: 675–693

- [70] Fæhn, T., Bruvoll, A., (2009) "Richer and Cleaner - At Other's Expense?", *Resource and Energy Economics* 31: 103–122

- [71] Faulkenberry, J. B., (2012) "The 1923 Greco-Turkish Population Exchange: Successful Prevention of Genocide and Mass Atrocities", Master thesis, Faculty of the U.S. Army Command and General Staff College

- [72] Fell, H., Kaffine, D. T., (2014) "Can Decentralized Planning really Achieve First-best in the Presence of Environmental Spillovers?", *Journal of Environmental Economics and Management* 68: 46–53

- [73] Fiorina, M. P., (1981) "Some Problems in Studying the Effects of Resource Allocation in Congressional Elections", *American Journal of Political Science* 25: 543–567

- [74] Francois, J. F., Strutt, A., (1999) "Post Uruguay Round Tariff Vectors for GTAP Version 4", mimeo

- [75] Fredriksson, P., (1997) "Environmental Policy Choice: Pollution Abatement Subsidies", *Resource and Energy Economics* 20: 51–63

- [76] Fredriksson, P. G., Gaston, N., (2000) "Ratification of the 1992 Climate Change Convention: What determines Legislative delay?", *Public Choice* 104: 345–368

- [77] Fredriksson, P. G., Neumayer, E., Ujhelyi, G., (2007) "Kyoto Protocol Cooperation: Does Government Corruption facilitate Environmental Lobbying?", *Public Choice* 133: 231–251

- [78] Fredriksson, P. G., Svensson, J., (2003) "Political Instability, Corruption and Policy formation: the Case of Environmental Policy", *Journal of Public Economics* 87: 1383–1405

- [79] Fredriksson, P. G., Ujhelyi, G., (2006) "Political Institutions, Interest Groups and the Ratification of International Environmental Agreements", Unpublished Manuscript

- [80] Gerlagh, R., Kuik, O., (2007) "Carbon Leakage with International Technology Spillovers", Nota di Lavoro 33.2007, Fondazione Eni Enrico Mattei, Milano

- [81] Geys, B., Nuscheler, R., (2010) "Public Health Care Spending in the OECD: the Role of Partisan Cycles and Campaign Promises", Unpublished Manuscript, Wissenschaftszentrum Berlin

- [82] Ghertner, D. A., Fripp, M., (2007) "Trading Away Damage: Quantifying Environmental Leakage through Consumption-based, Life-cycle Analysis", *Ecological Economics* 63: 563–577

- [83] Glaeser, E. L., Sacerdote, B., Scheinkman J. A., "Crime and Social Interactions", NBER Working Paper No. 5026

- [84] Golombek, R., Hoel, M., (2004) "Unilateral Emission Reductions and Cross-Country Technology Spillovers", *Advances in Economic Analysis and Policy* 4

- [85] Granovetter, M., (1973) "The Strength of Weak Ties", *American Journal of Sociology* 78: 1360–1380

- [86] Granovetter, M., (1978) "Threshold Models of Collective Behavior", *American Journal of Sociology* 83: 1420–1443
- [87] Granovetter, M., Soong, R., (1983) "Threshold Models of Diffusion and Collective Behavior", *Journal of Mathematical Sociology* 9: 165–179
- [88] Groseclose, T., (2001) "A Model of Candidate Location When One Candidate Has a Valence Advantage", *American Journal of Political Science*, 45: 862–886
- [89] Grossman, G. M., Helpman, E., (1991) "Trade, Knowledge Spillovers, and Growth", *European Economic Review* 35: 517–526
- [90] Grossman, G. M., Krueger, A. B., (1993) "Environmental Impacts of a North American Free Trade Agreement", in *The U. S.– Mexico Free Trade Agreement*, P. Garber, ed. Cambridge, MA: MIT Press
- [91] Gürtzgen, N., Rauscher, M., (2000) "Environmental Policy, Intra-Industry Trade and Transfrontier Pollution", *Environmental and Resource Economics* 17: 59–71
- [92] Hafner-Burton, E. M., Helfer, L. R., Fariss, C. J., (2011) "Emergency and Escape: Explaining Derogations from Human Rights Treaties", *International Organization* 65: 673–707

- [93] Hakki, M. M., (2007) "The Cyprus Issue: A Documentary History, 1878-2006", I.B.Tauris, London

- [94] Harstad, B., (2012) "Buy Coal! A Case for Supply-Side Environmental Policy", *Journal of Political Economy* 120: 77–115

- [95] Henn, F., (2004) "A Business of Some Heat: The United Nations Force in Cyprus Before and During the 1974 Turkish Invasion", Pen and Sword Books Ltd, South Yorkshire

- [96] Hinich, M. J., (1977) "Equilibrium in Spatial Voting: The Median Voter Result is an Artifact", *Journal of Economic Theory* 16: 208–219

- [97] Hinich, M. J., (1978) "The Mean versus the Median in Spatial Voting Games", P. Ordeshook (Ed.), *Game theory and political science*, New York University Press

- [98] Hoel, M., (2005) "The Triple Inefficiency of Uncoordinated Environmental Policies", *Scandinavian Journal of Economics* 107: 157–173

- [99] Holland, R., (1998) "Britain and the Revolt in Cyprus, 1954-1959", Oxford University Press, Oxford

- [100] Hong, H., Kubik, J. D., Stein J. C., (2005) "Social interaction and stock-

- market participation", *The journal of finance* 59: 137–163
- [101] Imbeau, L. M., (2009) "Do They Walk Like They Talk? Speech and Action in Policy Processes", Springer, Heidelberg
- [102] Ioannides, Y. M., (2013) "From Neighborhoods to Nations: The Economics of Social Interactions", Princeton University Press, Oxford
- [103] IPCC (2014) "Climate Change 2014: Mitigation of Climate Change", Cambridge University Press, Cambridge and New York
- [104] Jacovides, A., (2011) "Turkey's Cyprus Problem", *Foreign Affairs* 90: 172–173
- [105] Jahn, D., (1998) "Environmental Performance and Policy Regimes: explaining Variations in 18 OECD Countries", *Policy Sciences* 31: 107–131
- [106] Jakob, M., Marschinski, R., Hübler, M., (2013) "Between a Rock and a Hard Place: A Trade-Theory Analysis of Leakage under Production- and Consumption-Based Policies", *Environmental and Resource Economics* 56: 47–72
- [107] Jensen, C., Spoon, J., (2011) "Testing the "Party Matters" Thesis: Explaining Progress towards Kyoto Protocol Targets", *Political Studies* 59: 99–115

- [108] Johns, L., Rosendorff, B. P., (2009) "Dispute Settlement, Compliance, and Domestic Politics, In Trade Disputes and the Dispute Settlement Understanding of the WTO: An Interdisciplinary Assessment", *Frontiers of Economics and Globalization*, Vol. 6, edited by James C. Hartigan, 139–64. Bingley, UK: Emerald Group
- [109] Karp, L., (2011) "The Environment and Trade", *Annual Review of Resource Economics*, 3: 397–417
- [110] Karp, L., Zhao, J., (2008) "A Proposal for the Design of the Successor of the Kyoto Protocol", CUDARE Working Papers
- [111] Kataria, M., (2012) "The role of Preferences in Disagreements over Scientific Hypothesis: Evidence on Cognitive Bias in Formation of Beliefs", *The Journal of Socio-Economics* 41: 364–369
- [112] Knill, C., Debus, M., Heichel, S., (2010) "Do Parties Matter in Internationalised Policy Areas? The Impact of Political Parties on Environmental Policy Outputs in 18 OECD Countries", 1970–2000, *European Journal of Political Research* 49: 301–336
- [113] Kohler, H. P., (1997) "Learning in Social Networks and Contraceptive Choice", *Demography* 34: 369–383
- [114] Koremenos, B., (2005) "Contracting Around International Uncertainty",

American Political Science Review 99: 549–565

- [115] Koszegi, B., (2006) "Ego Utility, Overconfidence, and Task Choice", Journal of the European Economic Association 4: 673–707

- [116] Kucik, J., Reinhardt, E., (2008) "Does Flexibility Promote Cooperation? An Application to the Global Trade Regime", International Organization 62: 477–505

- [117] Kuik, O., Gerlagh, R., (2003) "Trade Liberalisation and Carbon Leakage", The Energy Journal 24: 97–120

- [118] Kuik, O., Hofkes, M., (2010) "Border Adjustment for European Emissions Trading: Competitiveness and Carbon Leakage", Energy Policy 38: 1741–1748

- [119] Kuran, T., Sandholm, W. (2008) "Cultural integration and its discontents", Review of Economic Studies 75: 201–228

- [120] Laffont, J. J., (2008) "Externalities", The New Palgrave Dictionary of Economics, 2nd Ed.

- [121] Lazear, E.P., (1991) "Culture and Language", Journal of Political Economy 107: S95–S126

- [122] Levinson, A., (2010) "Offshoring Pollution: Is the United States Increasingly Importing Polluting Goods?", *Review of Environmental Economics and Policy* 4: 63–83

- [123] Lindbeck, A., Weibull, J. W., (1987) "Balanced-Budget Redistribution as the Outcome of Political Competition", *Public Choice* 52: 273–297

- [124] Lipson, C., (1991) "Why are Some International Agreements Informal?", *International Organization* 45: 495–538

- [125] List, J. A., Sturm, D. M., (2006) "How Elections Matter: Theory and Evidence from Environmental Policy", *The Quarterly Journal of Economics* 121: 1249–1281

- [126] Lohmann, S., (1992) "Optimal Commitment in Monetary Policy: Credibility versus Flexibility", *The American Economic Review* 82: 273–286

- [127] Maestad, O., (2007) "Allocation of Emission Permits with Leakage through Capital Markets", *Resource and Energy Economics* 29: 40–57

- [128] Mallinson, B., (2005) "Cyprus: a Modern History", I. B. Tauris & Co. Ltd, London

- [129] Malmendier, U., Tate, G., (2008) "Who Makes Acquisitions? CEO Over-

- confidence and the Market's Reaction", *Journal of Financial Economics* 89: 20–43
- [130] Mansfield, E. D., Pevehouse, J. C., (2006) "Democratization and International Organizations", *International Organization* 60: 137–167
- [131] Mansfield, E. D., Pevehouse, J. C., (2008) "Democratization and the Varieties of International Organizations", *The Journal of Conflict Resolution* 52: 269–294
- [132] Manski, C. F., (2000) "Economic Analysis of Social Interactions", NBER Working Paper 7580
- [133] Manski, C. F., (2013) "Identification of Treatment Response with Social Interactions", *The Econometrics Journal* 16: 1–23
- [134] Markusen, J. R., (1975) "International Externalities and Optimal Tax Structures", *Journal of International Economics* 5: 15–29
- [135] Mattes, M., (2012) "Reputation, Symmetry, and Alliance Design", *International Organization* 66: 679–707
- [136] Mayraz, G., (2011) "Wishful Thinking", CEP Discussion Paper No 1092

- [137] Merrill, S., Grofman, B., (1999) "A Unified Theory of Voting: Directional and Proximity Spatial Models", Cambridge University Press, Cambridge

- [138] Montgomery, J., (2010) "Intergenerational Cultural Transmission as an Evolutionary Game," *American Economic Journal: Microeconomics* 2: 115–136

- [139] Moravcsik, A., (2000) "The Origins of Human Rights Regimes: Democratic Delegation in Postwar Europe", *International Organization* 54: 217–252

- [140] Mullainathan, S., Washington, E., (2009) "Sticking with your vote: Cognitive dissonance and political attitudes", *American Economic Journal: Applied Economics* 1: 86–111

- [141] Murdoch, J. C., Sandler, T., (1997) "A voluntary Provision of a Pure Public Good: the Case of reduced CFC Emissions and the Montreal Protocol", *Journal of Public Economics* 63: 331–349

- [142] Neumayer, E., (2002) "Do Democracies exhibit stronger International Environmental Commitment? A cross-country Analysis", *Journal of Peace Research* 39: 139–164

- [143] Neumayer, E., (2003) "Are Left-wing Party Strength and Corporatism Good for the Environment? Evidence from Panel Analysis of Air Pollution in OECD Countries", *Ecological Economics* 45: 203–220

- [144] Neumayer, E., (2004) "The Environment, Left-wing Political Orientation and Ecological Economics. A Commentary", *Ecological Economics* 51: 167–175

- [145] North, D. C., Weingast, B. R., (1989) "Constitutions and Commitment: The Evolution of Institutions Governing Public Choice in Seventeenth-Century England", *The Journal of Economic History* 49: 803–832

- [146] Oates, W. E., Schwab, R. M., (1988) "Economic Competition amongst Jurisdictions: Efficiency Enhancing or Distortion Inducing?", *Journal of Public Economics* 35: 333–354

- [147] Ogawa, H., Wildasin, D. E., (2009) "Think Locally, Act Locally: Spillovers, Spillbacks, and Efficient Decentralised Policymaking", *American Economic Review* 99: 1206–1217

- [148] Olsen, R. A., (1997) "Investment Risk: The Experts' Perspective", *Financial Analysts Journal* 53

- [149] Ordeshook, P. C., (1986) "Game Theory and Political Theory: An Introduction", Cambridge University Press, Cambridge

- [150] Oses-Eraso, N., Viladrich-Grau, M., (2007) "On the sustainability of common property resources", *Journal of Environmental Economics and Management* 42: 393–410

- [151] Osterloh, S., Debus, M., (2012) "Partisan Politics in Corporate Taxation", *European Journal of Political Economy* 28: 192–207

- [152] Paltsev, S. V., (2001) "The Kyoto Protocol: Regional and Sectoral Contributions to the Carbon Leakage", *The Energy Journal* 22: 53–79

- [153] Pelc, K. J., (2009) "Seeking Escape: The Use of Escape Clauses", *International Studies Quarterly* 53: 349–368

- [154] Pellegrini, L., Gerlagh, R., (2006) "Corruption, Democracy, and Environmental Policy: an Empirical Contribution to the Debate", *The Journal of Environment and Development* 15: 332–354

- [155] Peristianis, N., (2008) "Between Nation and State: Nation, Nationalism, State, and National Identity in Cyprus", PhD thesis, Middlesex University Research Repository

- [156] Persson, T., Svensson, L. E. O., (1989) "Why a stubborn Conservative would run a Deficit: Policy with Time-Inconsistent Preferences", *The Quarterly Journal of Economics* 104: 325–345

- [157] Pollis, A., (1973) "Intergroup Conflict and British Colonial Policy: The Case of Cyprus", *Comparative Politics* 5: 575–599

- [158] Ritter, H., Schopf, M., (2013) "Unilateral Climate Policy: Harmful or even Disastrous?", *Environmental and Resource Economics* 58: 155–178

- [159] Rivera-Batiz, L. A., Romer, P. M., (1991) "Economic Integration and Endogenous Growth", NBER Working Paper No. 3528

- [160] Roemer J. E., (2000) "Political Competition. Theory and Applications", Harvard University Press

- [161] Rogoff, K., (1985) "Can International Monetary Policy Cooperation be Counterproductive?" *Journal of International Economics* 18: 199–217

- [162] Rogoff, K., Sibert, A., (1988) "Elections and Macroeconomic Policy Cycles", *The Review of Economic Studies* 55: 1–16

- [163] Rogoff, K., (1990) "Equilibrium Political Budget Cycles", NBER Working Paper No. 2428

- [164] Romer, P., (1990) "Endogenous technological change", *Journal of Political Economy*, 98: S71–S102

- [165] Rosendorff, B. P., Milner, H. V., (2001) "The Optimal Design of International Trade Institutions: Uncertainty and Escape", *International Organization* 55: 829–857

- [166] Rosendorff, B. P., (2005) "Stability and Rigidity: Politics and Design of the WTO's Dispute Settlement Procedure", *American Political Science Review* 99: 389–400
- [167] Rothman, D. S., (2000) "Measuring Environmental Values and Environmental Impacts: Going from the Local to the Global", *Climatic Change* 44: 351–376
- [168] Ryan, S., Tucker C., (2006) "Heterogeneity and the Dynamics of Technology Adoption", Working Paper, MIT
- [169] Samuelson, W., Zeckhauser, R., (1988) "Status Quo Bias in Decision Making", *Journal of Risk and Uncertainty* 1: 7–59
- [170] Schelling, T., (1971) "Dynamic Models of Segregation", *Journal of Mathematical Sociology*, 1: 143–186
- [171] Simm, H., (2008) "Public Policies against Global Warming: a Supply Side Approach", *International Tax and Public Finance* 15: 360–394
- [172] Snyder, J. M., Ting, M. M., (2002) "An informational Rationale for Political Parties", *American Journal of Political Science*, 46: 90–110
- [173] Sözen, A., (2013) "The Cyprus Challenge in Turkey-EU Relations: Heading towards the Defining Moment?", in Cengiz, F., Hoffmann, L., *Turkey and*

the European Union: Facing New Challenges and Opportunities, Routledge, New York

- [174] Stehlé, J., Barrat, A., Bianconi, G., (2010), "Dynamical and Bursty Interactions in Social Networks", *Physical review*
- [175] Tabellini, G., Alesina, A., (1990) "Voting on the Budget Deficit", *American Economic Review* 80: 37–39
- [176] Thaler, R., (1980) "Toward a Positive Theory of Consumer Choice", *Journal of Economic Behavior and Organization* 1: 39–60
- [177] Theophanous, A., (2004) "The Cyprus Question and the EU: the Challenge and the Promise", *Intercollege Press*
- [178] Tocci, N., (2004) "EU Accession Dynamics and Conflict Resolution: catalysing Peace or consolidating Partition in Cyprus?", Accessed on February 2014 at <<http://cadmus.eui.eu/handle/1814/3559>>
- [179] Topa, G., (2001) "Social Interactions, Local Spillovers and Unemployment", *The Review of Economic Studies* 68: 261–295
- [180] UNFCCC, (2006) "Report of the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol on its first session", held at Montreal from 28 November to 10 December 2005

- [181] UNEP, (2012) "Global Environment Outlook GEO4: Environment for Development", Accessed on February 2014 at http://www.unep.org/geo/GEO4/report/GEO4_Report_Full_en.pdf
- [182] Van der Werf, E., (2010) "Unilateral Climate Policy, Asymmetric Backstop Adoption and Carbon Leakage in a Two-Region Model", CESifo Working Paper No. 2907
- [183] Varnava, A., (2012) "British Imperialism in Cyprus, 1878-1915: the Inconsequential Possession", Manchester
- [184] Volkens, A., Lehmann, P., Merz, N., Regel, S., Werner, A., with Lacewell, O. P., Schultze, H., (2013) "The Manifesto Data Collection. Manifesto Project (MRG/CMP/MARPOR)", Berlin: Wissenschaftszentrum Berlin: Sozialforschung (WZB)
- [185] Weber C. L., Matthews, H. S., (2007) "Embodied Environmental Emissions in US International Trade, 1997-2004", *Environmental Science and Technology* 41: 4875–4881
- [186] Wittman, D. A., (1973) "Parties as Utility Maximizers", *The American Political Science Review* 67: 490–498
- [187] Yang, S., Narayan V., Assael H., (2006) "Estimating the Interdependence of

Television Program Viewership between Spouses: A Bayesian Simultaneous Equation Model", *Marketing Science* 3: 336–349

- [188] Zhang, J., (2004) "Residential Segregation in an all-integrationist World", *Journal of Economic Behavior and Organization* 54: 533-550