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ESSAYS ON THE POLITICAL ECONOMY OF LAND USE CHANGE

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Johanna Jussila Hammes

Till Klaus

ABSTRACT

This thesis consists of three articles. The two first ones construct theoretical models for land use change between agriculture and forestry in the presence of lobbies representing both sectors. The third article tests empirically the hypothesis forwarded in the first essay.

In the first essay we assume that agricultural land use causes a negative externality as compared to forestry. The government attempts to internalize this with the help of a land tax on agriculture. The tax affects the allocation of land between agriculture and forestry. We find that in social optimum the government imposes a land tax on agriculture because of the negative externality. In political optimum, if lobby groups organize in the agricultural and forestry sectors, their land demand elasticities determine whether land will be taxed or subsidized. Then, if land demand in agriculture is inelastic enough, land might be subsidized. This is contrary to the received public economics wisdom of taxing goods with low elasticities and constitutes a political economy avenue through which the elasticity of land demand affects the tax rate. We further show that if there is technological progress in agriculture, land demand by agriculture increases and land demand by forestry falls. Then, it would be socially optimal for the land tax to increase in technology, but in the political optimum, i.e., if the government is susceptible to lobbying, the tax rate will rather fall. This reallocates more than a socially optimal amount of land from agriculture to forestry.

In the second essay we examine the determination of domestic trade policy when the world market price of food changes and affects land demand by the agricultural and forestry sectors when forestland, besides producing private goods, also produces a positive externality. We find that an increase in the price of food raises the value of land, which redistributes land towards the agricultural sector. It further increases the agricultural lobby's clout and reduces that of the forestry lobby. The agricultural lobby's political contribution increases and that by the forestry lobby falls, which raises the relative tariff rate on agriculture. The resulting deforestation in the political equilibrium is excessive from a social point of view, and may be higher than would be the case if the relative world market prices prevailed also domestically. It further gives a country a perceived comparative advantage in agricultural production. These results are not changed by the inclusion of an exogenous land use subsidy to forestry, or if we consider an umbrella lobby group that solves the conflict between the two competing lobbies internally.

In the third essay we test the hypothesis that governments determine the taxation of agricultural land by taking into account both contributions by agricultural and forestry lobbies, and social welfare. We find empirical support to our hypothesis that a strengthening of the agricultural lobby lowers the land tax and that environmental concerns affect the tax, the effect being exponential rather than linear. We further find some evidence for the hypothesis that technological progress affects land taxation. The effect works through the effect of technology on the negative externality produced by the agricultural sector. Finally, we find some support for a hypothesis suggesting that richer farmers lobby more and consequently get a higher land subsidy.

ABSTRAKTI

Tämä kokoelma koostuu kolmesta artikkelista. Näistä kaksi ensimmäistä kehittävät teoreettisia malleja maan käytön selittämiseksi maa- ja metsätaloussektoreilla. Oletuksena on, että kummankin sektorin tuottajia voi edustaa eturyhmä. Kolmannessa artikkelissa testataan empiirisesti ensimmäisessä esseessä kehitettyä teoriaa.

Ensimmäisessä esseessä oletan että maatalousmaan käyttö aiheuttaa negatiivisia ulkoisia kustannuksia metsätaloussektoriin verrattuna. Poliitikot yrittävät sisäistää näitä kustannuksia maatalousmaasta maksetun maaveron avulla. Maavero vaikuttaa maankäyttöön sekä maa-, että metsätaloussektorilla. Malli näyttää kuinka yhteiskunnallisessa optimissa valtio verottaa maatalousmaata negatiivisten ulkoisten kustannusten sisäistämiseksi. Poliittisessa optimissa, jos eturyhmiä muodostuu sekä maa-, että metsätaloussektorille, maan kysyntäelastisiteetit määräävät josko maatalousmaan käyttöä verotetaan vai tuetaan. Jos maan kysyntäelastisiteetti maataloudessa on tarpeeksi matala, maatalousmaan käyttöä voidaan näin ollen tukea verottamisen sijaan. Tämä havainto on päinvastainen julkistalouden tutkimuksessa yleensä tehtyyn löytöön siitä, että niiden hyödykkeiden, joiden kysyntäelastisiteetti on matalin, verotus tulisi olla korkeinta. Esseessä tehty päinvastainen löydös muodostaa täten poliittis-taloustieteellisen mekanismin jonka kautta maan kysyntäelastisiteetti vaikuttaa maan verotukseen. Näytän myös esseessä kuinka teknillinen kehitys maataloudessa madaltaa maan kysyntäelastisiteettia tällä sektorilla ja kasvattaa sitä metsätaloudessa. Yhteiskunnan kannalta tässä tapauksessa olisi optimaalista jos maan verotus kiristyisi, mutta poliittisessa optimissa, eli kun poliitikot ovat vastaanottavaisia eturyhmien painostukselle, veroaste laskee. Tästä on seurauksena se, että enemmän maata kuin mikä olisi yhteiskunnallisesti optimaalista käytetään maatalouteen, ja vastaavasti metsätalouteen käytetyn maan määrä laskee yhteiskunnallisesta näkökulmasta liian alas.

Kokoelman toisessa esseessä tutkin sitä, kuinka pieni maa määrittää maa- ja metsätaloussektoreiden välisen suhteellisen tullin kun ruoan maailmanmarkkinahinta nousee, ja kun maan käyttö metsätalouteen aiheuttaa positiivisia ulkoisia kustannuksia. Tutkin myös sitä, kuinka tulli vaikuttaa maan käyttöön kummallakin sektorilla. Näytän kuinka ruoan hinnan nousu vaikuttaa maan arvoon, mikä uudelleenallokoi maata maataloussektorin suuntaan. Maataloussektorin eturyhmän intressit myös kasvavat, mikä nostaa sen poliitikoille antaman kampanja-avustuksen määrää, kun taas metsätaloussektorin eturyhmän avustus laskee. Seurauksena maatalousmaan osuus koko maankäytöstä on suurempi kuin mikä olisi yhteiskunnallisesti optimaalista. Seurauksena voi myös olla että kotimaa saa suuremman havaitun suhteellisen edun maataloustuotteiden tuotannossa kun mitä sillä oikeasti on. Tulokset eivät muutu vaikkai metsätalousmaan tuottama ulkoinen hyöty sisäistäistettäisiinkin maatuen avulla.

Kolmannessa esseessä testaan hypoteesia siitä, että poliitikot määrittävät maatalousmaan veroasteen ottaen huomioon niin maa- kuin metsätaloussektorien eturyhmien painostuksen, ja että myös yhteiskunnallinen hyöty vaikuttaa veroasteeseen. Löydän empiiristä tukea hypoteesille, että maatalouseturyhmän vahvistuminen madaltaa maan verotusta maataloudessa. Tukea löytyy myös hypoteesille ympäristötekijöiden vaikutuksesta veroasteeseen: tämä vaikutus on kuitenkin ei-lineaarinen ja, odotusten vastaisesti, se laskee veroastetta ympäristövaikutuksen ollessa alhainen. Jonkin verran tukea löydän myös hypoteesille teknillisen kehityksen vaikutuksesta maan verotukseen, joskin vaikutus toimii maan kysynnän kautta ennemmin kuin suorana vaikutuksena veroasteeseen. Lopulta löydän jonkin verran tukea hypoteesille, joka esittää että rikkaammat maanviljelijät kykenevät vaikuttamaan veroasteeseen enemmän kuin köyhät, näin ollen saaden enemmän maankäyttötukia.

Introduction

This dissertation consists of three articles studying the change in land use between the agricultural and the forestry sectors, given various changes in the environment that the sectors operate in. I construct political economy models based on Grossman and Helpman [27] for the determination of a land tax on agriculture and of trade tariffs on agriculture and forestry, respectively, in the presence of two lobby groups that attempt to influence the government's decision-making. The first two articles in the thesis are theoretical, and the third one tests empirically the theory presented in the first article.

The aim of this thesis is to add to our understanding of the process of land use change between agriculture and forestry. Often, this is seen as a process of deforestation. As can be seen from Table 1, between 1990 and 2000 the percentage share of forestland fell considerably in Africa and in Central and South America. At the same time, the arable land area increased in these regions, albeit not quite enough to alone explain the fall in forest area. On the other hand, over the 1990s, the forested area actually expanded in Europe and some other developed regions. At the same time, the arable land area has fallen somewhat in these regions.

	Forest area, %		**Arable land area, %**	
Region	1990	2000	1990	1999
Africa	29.51	27.27	5.884	6.504
Asia	22.26	22.06	19.08	17.40
Australia and Oceania	21.15	21.19	6.328	6.218
Caribbean	24.22	24.78	23.75	25.87
Central America	34.17	30.17	12.48	12.96
EU-15 and EFTA	34.04	35.02	22.11	21.13
Europe, non-EU + Russia	47.83	48.70	41.40	11.20
Middle East and North Africa	2.282	2.33	6.620	6.853
North America	25.39	25.60	12.60	12.11
South America	51.78	49.70	5.181	5.516

Table 1: Forest and arable land area in selected regions as percentages of total land area. Source: WDI 2002

The articles included in this thesis study events that tend to increase agriculture's share of total land, especially if the government is susceptible to lobbying by the agriculturalists. Nevertheless, because of the symmetry of the model, if the same factors that tend to increase agriculture's share of total land were applied to forestry, the forested share of land would increase. Furthermore, the models can easily be applied to other areas of economic activity where two sectors use a common factor of production that is in short supply.

In the thesis, I examine two different types of policy instruments, namely land taxes and trade taxes. The first type of taxation is rather unusual, although, as can be seen from Table 2, most of the OECD member countries collect revenue from "Recurrent tax on immovable property," of which land taxes are a part. Table 2 also gives figures on "Subsidy based on area planted/animal numbers," to give an idea of the subsidies paid to agricultural land use.

Trade taxes are much more common. In the second article included in this thesis, I examine how import tariffs or export subsidies (import subsidies or export taxes) on the agricultural and the forestry sector are affected by an increase in the world market price of food. This is a relevant question to study towards the background of the Doha round of trade talks, of which the liberalization of trade in agricultural goods is an integral part. Liberalization of trade in agricultural goods should lead to an increase in the world market price of food because of the removal of export subsidies by, especially, the European Union. These subsidies are presently depressing the price of food on the world market. In this study, however, we assume the foreign trade liberalization to be exogenous since we do not examine the negotiation process behind international trade agreements.

In the following I will give a brief review of the relevant literature. After this I will shortly present each essay entering this thesis.

0.1 Related literature

The theoretical background to the articles included in this dissertation is Grossman and Helpman's [27] seminal article, where, based on Bernheim and Whinston's [5] principle-agent theory, they study the determination of trade tariffs in a small economy in the presence of industry lobby groups that give campaign contributions to the agent, the government. Whereas Bernheim and Whinston's model sets the ground for the study of the principle-agent relationships and the resulting Nash-equilibrium, Grossman and Helpman popularize the approach and show how the equilibrium is affected by the fact that not all groups in a society are able to organize a lobby group.

Grossman and Helpman's article has by now spawned a huge literature examining as well the determination of tariffs from a theoretical point of view (see, e.g., Grossman and Helpman [28], Dixit [16] or many others), empirical examinations of tariff determination (e.g., Goldberg and Maggi [26], Gawande and Bandyopadhyay [24], Eicher and Osang [19] or Ederington and Minier [18]) as the determination of certain other policy areas, such as environmental policy (e.g., Fredriksson [22], [23], Aidt [1], Schleich [35] and so on). The articles in this collection can be considered to belong to this latter strand of literature. The innovation here is to study how the equilibrium changes when the sectors are no longer studied in

Country	Recurrent tax on immovable property, millions of USD		Subsidy based on area planted/animal numbers, millions of USD	
	1995	2001	1995	2001
Australia	5169,6	4933,2	0	19,3
Austria	626,4	486,3		
Belgium	34,4	36,6		
Canada	19024,6	20377,6	134,5	405,7
Czech Republic	143,1	120,1	12,8	181,5
Denmark	1843	1761,5		
European Union			31636,4	25034,5
Finland	600,9	540,2		
France	27788,8	22879,5		
Germany	9590,2	8103,6		
Greece	223,6	337,5		
Hungary	48,3	124,8	0	62,7
Iceland	85,5	83,5	0	0
Ireland	534,4	589,3		
Italy	8854,9	8658		
Japan	109185,6	86538,3	0	0
Korea	3554,8	2718,8	15,8	195,5
Luxembourg	23,9	19,3		
Mexico	631,2	1284,6	11,9	72,1
Netherlands	3232,3	3077,7		
New Zealand	1079,9	885,9	0	0
Norway	440,7	313,6	431,9	368,2
Poland	1413,2	2291,2	0	43,5
Portugal	411,3	478,9		
Slovak Republic	-	0	115,8	95,6
Spain	3768,6	3974,1		
Sweden	2139,7	2052		
Switzerland	511,6	424,2	830,1	534,6
Turkey	0	158,6	0	0
United Kingdom	35651,2	48001,5		
United States	203451	263773	2470	2043,4

Table 2: Recurrent taxes on immovable property (4120) and Subsidy based on area planted/animal numbers (C). Source: SourceOECD.

isolation from one another. I thus add a general equilibrium effect to the previous models.

The present essays, besides drawing heavily on the Grossman-Helpman model, are closely related to other strands of economic literature as well. In the first essay I examine the determination of a land tax on the agricultural sector in the presence of negative externalities arising from land use to agriculture. The literature on taxing land is both old and extensive, starting from Ricardo [34] and George [25], with more modern treatises including Feldstein [21], Calvo *et al.* [9], Lindholm [31] and Eaton [17]. A common feature to this literature, which the article in the present thesis does not share, is that they consider the effect of land taxation on general welfare when the motive for taxing land is to raise government revenue, and to spur economic growth. Here land is taxed because of the negative externalities arising from land use. Therefore, the two strands of literature are not directly comparable. Nevertheless, the article included in this dissertation is able to explain the rarity of land taxation by lobbying, an explanation missing from the previous literature on land taxation.

The second essay in this collection is closely related to the literature on declining industries (see, e.g., Hillman [29], Cassing and Hillman [10], Brainard and Verdier [7], [8] and Damania [12], [13]). Especially the four latter articles are of interest since they, too, take the Grossman-Helpman model as their point of departure. These models are partial equilibrium models, however, and therefore they fail to consider the effect present in the essay included in this collection, where a boom in one sector leads to a decline in another because of changes in the factor markets. This feature connects the article to the literature on the Dutch disease (e.g., Corden and Neary [11], Barbier [2]), which examines the coexistence within the traded goods sector of progressing and declining sub-sectors. Most often it further assumes that the booming sector is of an extractive kind, and the boom places the traditional manufacturing sector under pressure. This has a tendency to result in "de-industrialization." In the article included here, the booming sector is the agricultural one, and the declining industry is the forestry sector. The analysis here is somewhat lacking, however, since I do not consider the effects on a sector that is not open for international competition, which is the case with much of the Dutch disease literature.

Finally, there are several interesting strands of literature which the present studies do not touch upon explicitly. The first of these is the question of lobby organization. The literature examining the organization of lobbies within the general framework of the Grossman-Helpman model is rather new, but is growing fast. It was pioneered by Mitra [33], who studies both endogenous lobby formation and endogenous trade policies. He assumes that a lobby forms if the rents it generates are sufficient to cover fixed costs of lobby formation. Damania and Fredriksson [14] show that more collusive industries, which have greater collusive profits, have a greater incentive to lobby. The lobby organization is determined by whether the firms contribute to an industry lobby or not in the first stage of the game. The aim of the lobby is then to influence the determination of an environmentally motivated tax. In Magee [32], the author develops a model where an industry bargains with a government policymaker over the campaign contributions it must offer in exchange for each level of tariff protection received. "Taking the tariff schedule as given, individual firms decide whether to cooperate with the other firms in the industry lobbying effort or to defect from the effort" (Magee [32]). Le Breton and Salanie [30] for their part examine lobby organization when the type of politician is not known. Finally, Damania and Fredriksson [15] study the effects of trade liberalization on environmental policy outcomes when collective action is endogenous.

Another interesting strand of literature is that examining the strategies taken by lobby groups. Thus, Sloof and van Winden [36] examine the choice that an interest group makes between using lobbying (or "words") and pressure (or "actions") in order to influence the policymaker. The approach is game-theoretic, and the analysis comes to the conclusion that it may make sense for the lobby groups first to establish their credibility by taking action. Not until then will the policymaker take their words seriously. Bennedsen [3] for his part makes a survey of how the relationship between interest groups and decision makers can be analyzed. Bennedsen and Feldmann [4] show how campaign contributions crowd out lobbying that uses information provision as the chosen instrument for influence.

0.2 Essay I: Land taxation, lobbies and technological change: internalizing environmental externalities

In the first article of the thesis I examine the determination of land taxation on agriculture in the presence of negative externalities arising from land use by that sector, and when at most two lobbies organize to influence the government's decision-making about the tax rate. The two lobbies that may organize represent the two sectors that are directly affected by the tax, namely agriculture and forestry. Since the tax affects the cost of land both for agriculture and for forestry, it has an impact on the profits of both sectors. Consequently, both sectors have an incentive to organize a lobby group to influence the government's decision-making. The effect of lobbying on the land tax rate depends, however, on how susceptible the government is to lobbying. I end the paper by considering the effect that technological change in agriculture has both on the land tax rate and on the ensuing allocation of land between agriculture and forestry.

As for the results, I find that in the social optimum, i.e., when the government only considers social welfare in its decision-making, it will impose a land tax on agriculture because of the negative externality arising from this sector. However, in the political optimum, i.e., when the government considers both contributions given by the lobby groups and the social welfare when making its decision, given that two lobby groups organize, the land demand elasticities determine whether land will be taxed or subsidized. Consequently, if land demand in agriculture is inelastic enough, land may be subsidized. This is to the contrary of the received public economics wisdom of taxing goods with low elasticities of demand, and constitutes therefore a political economy avenue through which the elasticity of land demand affects the land tax in a negative direction. The effect makes sense, however, since the more inelastic land demand is in a sector, the more that sector will bear of the tax burden. It then has great incentives to see to the lowering of the tax rate.

I further show how land augmenting technological change in agriculture strengthens the agricultural lobby by making the sector's land demand more inelastic. At the same time, technological change has the effect of making land demand by forestry more elastic, which will affect the power balance between the two lobby groups. I show how technological change by itself will reallocate land from forestry towards agriculture. Because of the negative externality arising from land use to agriculture, it would then be socially optimal for the government to raise the land tax rate. However, because of its effect on relative lobby strength, technological progress will lower land taxation on agriculture in the political equilibrium. Political economy considerations consequently lead to excessive deforestation in small economies where the government is susceptible to lobbying in the face of exogenous technological progress in agriculture.

0.3 Essay II: Agricultural trade liberalization and deforestation: Political economy connections?

In the second article I study how an increase in the world market price of food affects the relative tariff rate between agriculture and forestry when both sectors use land in production and where land demand is variable. I further assume that the forestry sector's land use produces a positive external effect in the form of, for instance, watershed and/or biodiversity protection and carbon sequestration.

Because of the positive externality produced by the forestry sector, that sector gets a relatively higher import tariff or export subsidy (import subsidy/export tax) than the agricultural sector in the social optimum. An increase in the world market price of food has the effect of increasing the marginal benefit from forests, which leads the government to mitigate the effect of an increase in the price of food by lowering the relative tariff rate on agriculture further. Hillman [29] shows that the domestic price of goods moves in the same direction as the world market price, however. Consequently, an increase in the world market price of food leads to an increase in the relative output price of food to logs, but by a lesser amount than the increase in the world market price. This mitigates the effect that the increase in the world market price of food has on land allocation, so that land will be reallocated from forestry to agriculture, but to a lesser degree than would be dictated by the change in the world market price.

In the political optimum things change, however. Then it is possible for the agricultural sector to get a higher relative tariff rate than that given to forestry, despite the positive externality. This may be the case if the value of production in agriculture is sufficiently high. Furthermore, in the political optimum the relative tariff rate on agriculture increases in the world market price of food. The output price of food increases by more than the world market price, and more than the socially optimal amount of land will be reallocated from forestry to agriculture. Besides, the country gets a perceived, rather than real, comparative advantage in agricultural goods because its domestic output price seems to be higher than the world market price because of the political distortion in its relative tariffs.

I further relate the analysis to the literature on the Dutch disease. The Dutch disease literature, as was explained above, examines changes in production in the traded goods sector when the world market price of one good increases. This leads to a decline in some sectors, because a booming sector draws more factors of production to itself from these sectors. The Dutch disease type of analysis has typically been used to study the decline of the manufacturing sector in countries that start exploiting energy resources. In the present context, we study a boom in agriculture. Then, in the social optimum, the government mitigates the effects of the boom by lowering the trade taxation of the agricultural sector. In the political optimum, however, the changes in the government's policies, due to changes in lobbying, actually multiply the effect of the international price movements. Therefore, we show how political economy considerations may aggravate the Dutch disease and actually help make it a real disease if some sector declines more than would be dictated by its relative world market price.

I end the paper by considering an exogenous subsidy to the forestry sector's land use. Except that in this case some (or all) of the positive externality from forestry will be internalized by the subsidy, the above results do not change. Thus, regardless of the presence of the externality, a resource boom in agriculture will lead to excessive trade protection given to that sector and to deforestation that is excessive from a social optimum point of view.

0.4 Essay III: An empirical examination of land taxation in EU-15

In the last paper of the collection I empirically test the hypothesis forwarded in Essay I. The data used comes mainly from the EU Commission's FADN database [20], and from Eurostat, and covers the 15 "old" European Union member countries[1] for the years 1990-2002, with some exceptions.

According to the theory, lobby strength is inversely proportional to the elasticity of land demand in each respective sector. Lobby strength in turn affects the land tax rate so that a strengthening of the agricultural lobby lowers the tax, and a strengthening of the forestry lobby raises the tax. The elasticities of land demand used to calculate a measure of lobby strength are estimated in the article by using the weighted average cost of capital, r_{WACC}, as a proxy for the value of land. The reason for this choice of proxy for land value, rather than using the bookkeeping value or calculating a market value for land, is that the value of land is dependent on the land tax and, consequently, endogenous. Since the market rate of interest measures the cost of borrowing for investment in land, but also applies to other forms of capital, it is less likely that changes in the land tax rate influence it. Therefore, this is taken to be an exogenous measure of the cost of land.

I further include a measure for the negative externalities arising from agriculture by including a measure of the expenditure on fertilizers and crop protection, $fertilizer_{ik}$. According to the theory, the effect from the externality is not linear, however. For this reason I include the measure $fertilizer_{ik}$ both in levels and squared. According to the theory, the externality raises the land tax rate. Furthermore, the effect increases in land use for agriculture.

Finally, I attempt to test the hypothesis that technological change affects the land tax rate by including interactions of various variables with a measure of technological progress in agriculture. According to the theoretical specification of the estimating equation, technology does not affect the land tax rate directly but

[1] Belgium, Denmark, Germany, Greece, Spain, France, Ireland, Italy, Luxembourg, the Netherlands, Austria, Portugal, Finland, Sweden and the UK.

through its impact on land demand and the land price. Therefore, I include the technology variable both to the land demand elasticity estimating equation and as interactions into the land tax estimating equation.

I find empirical support to the hypothesis that a strengthening of the agricultural lobby, by lowering its land demand elasticity, lowers the land tax rate. There is, however, scant support to the hypothesis that the forestry lobby, when it organizes, has any effect on the land tax rate. Furthermore, expenditure on fertilizers and crop protection affect the tax rate. The effect is not quite the same as hypothesized, however, but serves to lower the land tax rate at low levels of expenditure, and only raises the land tax rate at high levels of expenditure. Finally, I find some support for the hypothesis about the effect of technology. The effect seems to work through the interaction with the negative externality. Furthermore, the level of technology in agriculture affects land demand by the forestry sector negatively.

I end the essay by running a short test of a hypothesis forwarded by Bombardini [6] that richer farmers lobby more and get consequently a lower land tax rate. I find some support for the hypothesis, although the results are not entirely conclusive.

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Chapter 1

Land Taxation, Lobbies and Technological Change: Internalizing Environmental Externalities

Johanna Jussila Hammes[1]

Abstract: We study the determination of a land tax on agriculture in the presence of two lobbies, when agricultural land use causes a negative externality as compared to forestry. The tax affects the allocation of land between agriculture and forestry. We find that in social optimum the government imposes a land tax on agriculture because of the negative externality. In political optimum, if lobby groups organize in the agricultural and forestry sectors, their land demand elasticities determine whether land will be taxed or subsidized. Then, if land demand in agriculture is inelastic enough, land might be subsidized. This is contrary to the received public economics wisdom of taxing goods with low elasticities and constitutes a political economy avenue through which the elasticity of land demand affects the tax rate. We further show that if there is technological progress in agriculture, land demand by agriculture increases and land demand by forestry falls. Then, it would be socially optimal for the land tax to increase in technology, but in the political optimum, i.e., if the government is susceptible to lobbying, the tax rate will rather fall. This reallocates more than a socially optimal amount of land from agriculture to forestry.

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1.1 Introduction

Optimal land allocation between agriculture and forestry has been mainly studied as a dynamic resource use problem (e.g., Ehui and Hertel [8], Ehui *et al.* [9], Barbier and Damania [2]). These analyses yield the optimal steady-state forest stock, and examine also the effect of other factors, such as technology, fertilizer use or social discount rates. Barbier and Damania [2] further derive the optimal deforestation rate in the presence of lobbies and given that the government is corruptible. They find that government corruptibility has an impact on the rate at which agricultural land increases.

The aim of this paper is to contribute to our understanding of land use change between agriculture and forestry by analyzing two factors that can influence such a process. Thus, we start by considering the effects of lobbying and of government susceptibility to lobbying on the level of policy instruments that aim at internalizing negative externalities arising from agriculture, and how this affects land allocation between agriculture and forestry. Secondly, we study how improvements in agricultural technology impact on the optimal share of agricultural land. In a closed economy with a stable population, an improvement in agricultural technology that increases the marginal productivity of land should lead to land reallocation away from agriculture since it leads to a fall in the price of agricultural goods. It is perceivable, however, that if a small country is able to export at a given price, then an improvement in agricultural technologies, by increasing the productivity of land in agriculture, increases demand for agricultural land and thereby leads to deforestation.

This paper studies the latter case. Thus, we assume that a small open economy attempts to internalize a negative externality arising from agricultural land use with the help of a first-best policy instrument, namely a land tax on agriculture.[2] The question naturally arises as to why the expansion of agricultural land, at the expense of forests, is bad. The answer lies in the externalities that the two land uses produce. Thus, agricultural land use causes loss of watershed protection, loss

[2] Another oft-used policy instrument to influence land use is zoning. The literature on zoning, which is often also concerned with property taxes, examines questions such as land value change due to zoning, and its implications to, for instance, income distribution (see, e.g., Henneberry and Barrows, [17], who examine the effect of zoning of agricultural land on land value). The emphasis is often on land use for agriculture on one hand and residential, industrial and commercial use on the other.

The emphasis here is on the land at the margin between agriculture and forestry; i.e., the land that in the case of a land use change between the two sectors either gets deforested or afforested. We are not aware of the existense of zoning to determine this land use boundary, with the possible exception of natural parks. We therefore deem zoning not to be a relevant policy instrument for our case. For the determination of zoning versus taxes we refer the reader to Netzer [22], which is a volume investigating the impact of various tax mechanisms on regulating land use, or to Pogodzinski and Sass [24] for a political theory of zoning.

of biodiversity, increased erosion, pesticide, herbicide and fertilizer run-off, etc. However, it is perceivable that the agricultural sector also produces some positive externalities, for instance in the form of an open landscape. For this reason, we consider a negative *net* externality arising from agriculture.

Land taxes have been studied extensively in the past, although the research has concentrated on the effect of land taxation on economic growth.[3] Land taxes as an instrument for environmental policy is largely missing from the literature. This might be partly due to the fact that land taxes rarely exist in reality (Lindholm [19]).[4] Lindholm's explanation to the rarity of land taxation derives from the analysis of these taxes as an instrument for economic growth, and is based on the difference between efficiency and economic justice, where in decision-making the latter tends to weigh in more than the former.

By way of including lobby groups that attempt to influence the government's policy, this paper offers an alternative explanation to the rarity of land taxation or to why land use in agriculture is sometimes subsidized rather than taxed. We formulate a political economy model of the determination of a land tax on the agricultural sector in a world where two sectors, agriculture and forestry, use land in production. The model is based on Bernheim and Whinston's [3] principle-agent model with menu auctions, which Grossman and Helpman [15] extend to trade policy formation. Unlike the "traditional" land tax literature, the tax here does not arise from a revenue motive for taxation but rather from the need to internalize a negative externality.

Grossman and Helpman's model has by now spawned a large literature examining environmental policy determination.[5] The contribution of the present paper to this literature is twofold. Firstly, we introduce a general equilibrium effect arising from competition for, and a change in factor use arising from the introduction of the policy instrument. Thus, we assume that both the agricultural and the forestry sectors use land in production and compete for it, and that land use by neither sector is fixed.[6] A common feature to all the other political

[3]The case for taxing land in order to spur economic growth is strong. For instance, George [14], Feldstein [11], Calvo *et al.* [4] and Eaton [7] all argue in its favor, mainly because land taxation is seen to encourage capital formation and therefore, to benefit economic growth.

[4]Nevertheless, out of the OECD member countries Austria, Denmark, France, Greece, Hungary, Italy, Japan, Korea, Luxembourg, the Netherlands, New Zealand, Poland, and the UK report revenue from a "land tax."

[5]See, e.g., Fredriksson [12] and [13], Aidt [1], Schleich [27], Eliste and Fredriksson [10], and Conconi [5].

[6]Of the previous studies examining the political economy of environmental policy the one that is closest to this one is by Aidt [1]. Aidt includes three factors of production: labor, sector-specific capital and raw materials (e.g., oil or environmental goods such as clean water). The use of raw materials causes an externality and the imposition of an environmental tax changes the use of these. There is, however, no competition for the raw materials in Aidt's model, and consequently, no price changes, as there is competition for and change in the price of land in

economy models based on Grossman and Helpman is that they assume that the (industrial) lobbies organize around a fixed sector-specific input factor. Assuming sector specific capital insulates the rest of the economy from the policy considered.

We further examine the effect of technological change in agriculture on policy-making.[7] Technological change in agriculture raises the productivity of land thereby leading to an increase in its value, and resulting in land reallocation from the less towards the more productive sector. This is in line with Ehui and Hertel [8], who show that technological progress in agriculture lowers the optimal steady-state forest stock. What we add is the effect of technological change on the land tax rate. We show that technological progress in agriculture increases land demand by that sector and lowers land demand by forestry. This has the effect of making land demand by agriculture more inelastic, and making it more elastic in forestry, consequently strengthening the agricultural lobby and weakening the forestry lobby. This leads to a lowering of the land tax rate in the political optimum, i.e., given that the government is susceptible to lobbing. It would nevertheless be socially optimal for the tax rate to actually increase in technological change. The fall in the land tax leads to excessive land allocation towards agriculture from a social point of view, and consequently, causes deforestation. This effect might further explain the rarity of land taxation, and its falling popularity as agricultural technologies have improved.

The paper is organized as follows. Section 1.2 presents the formal model. In Section 1.3 we use the characterization of the government's maximization problem to solve for the politically optimal land tax rate. In that section we further study how lobby strength affects the possibility of land use in agriculture being subsidized instead of being taxed. In Section 1.4 we examine the effect of technological progress in agriculture on the land tax rate and on land allocation. Section 1.5 concludes.

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the present model.

[7]Technological change in agriculture has arisen from several sources. It is the result of breeding over thousands of years, advances in fertilizer, pesticide and herbicide production and use, increased use of machines, and the use of genetically modified organisms. Technological change in forestry for its part seems to have arisen from the increased use of machines in forestry and from the selection of tree species to be planted (although, whether this is technological progress can be contested). Nowadays also GM techniques seem to be becoming important in raising productivity in forestry (see, e.g., The Economist [28]). Historically, however, it seems that productivity in agriculture has risen faster than that in forestry; increases in forest production arise rather from the inclusion of new areas to wood production.

Therefore, considering that it is rather difficult to get a tree to grow faster whereas increasing agricultural yields seems to be easier, we deem it justified to assume that over history, agricultural technologies have progressed relative to technology in forestry. This justifies our study of technological change in agriculture rather than in forestry. Nevertheless, the set-up of the model is such that the case for technological change in forestry would be symmetric to that in agriculture.

1.2 The Model

Consider a small open economy consisting of N individuals with identical, additively separable preferences. We normalize $N = 1$ without loss of generality. Each individual maximizes a utility function of the form $U^h = x_O + \sum_{i=A,\ F} u_i(x_i) - \phi(T_A)$, where x_O denotes consumption of a numeraire good O and x_i consumption of food and logs, which will be indexed by $i,\ j \in \{A,\ F\}$, $i \neq j$. The sub-utility functions $u_i(x_i)$ are differentiable, increasing and strictly concave. The net damages from land use for agriculture, $\phi(T_A)$, where T_A is land use by the agricultural sector, are differentiable, increasing and strictly convex. Land use in sector F, T_F, is assumed not to cause any (net) externalities.

The numeraire good O has a domestic and world market price equal to one. The domestic and world market price of food and logs equals p_i. With these preferences each consumer demands $d_i(p_i)$ units of good i, where $d_i(p_i)$ is the inverse of the marginal utility function $u_i'(x_i)$. The remainder of a consumer's income E is devoted to the numeraire good. The consumer thus attains indirect utility given by $v(\mathbf{p},\ E) = E + S(\mathbf{p}) - \phi(T_A)$, where $\mathbf{p} \equiv (p_A,\ p_F)$ is the vector of output prices of the non-numeraire goods and $S(\mathbf{p}) = \sum_{i\in\{A,\ F\}} u_i[d_i(p_i)] - \sum_{i\in\{A,\ F\}} p_i d_i(p_i)$ is the consumer surplus from goods A and F. Consumption of the numeraire good produces no consumer surplus.

The numeraire good O is produced using labor alone, with constant returns to scale and an input-output coefficient equal to one. We assume that the aggregate labor supply, l, is sufficiently large to ensure a positive output of this good. It is then possible to normalize the wage rate to one ($w = 1$). Goods A and F are produced using labor and land, also with constant returns to scale. The aggregate rent accruing to land in sector $i = \{A,\ F\}$ is denoted by $\Pi_i(p_i,\ z_i,\ H_i)$. Hotelling's lemma gives the industry's land demand curve $\frac{\partial \Pi_i}{\partial z_i} = -T_i$.[8]

Allocation of land between the sectors is not fixed but land demand T_i is a function $T_i(p_i,\ z_i,\ H_i)$. H_i is a technology parameter on land use (see Romer [26]) and z_i is the cost of land.[9] For simplicity, we assume land demand to be falling but linear in land price, so that $\frac{\partial T_i}{\partial z_i} = T_{i2} < 0$, $T_{i22} = 0$ and $T_{i23} = 0$. The production function of good i is given by $y_i \equiv y_i(H_i T_i,\ L_i)$, where L_i is labor demand.[10]

The government has only one policy instrument at its disposal, namely a land tax or subsidy on the agricultural sector. Since the tax is used to internalize a

[8] Because a change in land price, and consequently, land demand, also affects sector j, we further obtain a general equilibrium effect on that sector's land demand: $\frac{\partial \Pi_j}{\partial z_i} = -T_j \frac{\partial z_j}{\partial z_i}$.

[9] H_i is assumed to be exogenous since, as we study a small open economy, the country imports technological innovations from abroad.

[10] The "technology" or the "effectiveness of land use" parameter H_i used here is of the same form as that used in the Solow growth model. We thus refer to $H_i T_i$ as effective land use.

negative externality arising from land use, it is the first-best policy instrument. Revenue from the tax (cost of the subsidy) is distributed (collected) in a lump-sum fashion to the consumers.[11]

The ad-valorem land tax drives a wedge between the value of land z and the cost of land to the agricultural sector, z_A. The tax (subsidy) is denoted by the parameter t_A, such that $z_A \equiv (1 + t_A) z$. The cost of land to sector F equals the value of land, z. $t_A > 0$ denotes a land tax and $-1 < t_A < 0$ a land subsidy.[12] The land tax (subsidy) generates the per capita government revenue (expenditure) of

$$R(t_A,\ z) = t_A z T_A. \tag{1.1}$$

Individuals collect income from several sources. Firstly, they supply their labor endowment, l_h, where $\sum_h l_h = l$ is the aggregate labor supply, inelastically to the competitive labor market and receive the wage income $wl_h = l_h$. Secondly, each individual receives (pays) an equal share of any government revenue, $R(t_A,\ z)$. Thirdly, the farmers and foresters use a share α_h^i of land in sector i and obtain the rent from land. It is perceivable that a person uses land both for agriculture and forestry. We allow for this possibility and assume that a share α_A of the population uses agricultural land in production, a share α_F uses land under forests and a share $\alpha_{AF} = \alpha_A \cap \alpha_F$ uses land for both uses. We further assume the existence of a group of workers that constitute a share $\alpha_W = 1 - (\alpha_A + \alpha_F - \alpha_{AF}) > 0$ of the population, who own no land. Finally, land owners get income from land, given by $z(T_A + T_F)$.

The users of land in use i are assumed to have similar interests in the land tax and to form a lobby group to influence the government's tax policy. The formation of lobby groups is not modeled here; the reader is referred to Olson [23], or for models of lobby organization based on Grossman and Helpman [15] to Mitra [21], Magee [20] and Le Breton and Salanie [18]. We assume that at most two groups, the agricultural and the forestry lobby, overcome the free riding problem inherent to interest group organization and organize, following Aidt [1], functionally specialized lobby groups that offer a menu of contributions to the government depending on its choice of land tax policy. That a lobby group is

[11] The political economy models often assume that besides for normative reasons, such as the internalization of externalities, taxes are also raised in order to influence the income distribution (see, e.g., Grossman and Helpman [15]), which provides a reason for the government to need to raise tax revenue. The argument cannot reasonably be used here, however, since farmers usually are rather in the receiving end of income transfers. Therefore, the only justification for a land tax on agriculture here is the negative externality arising from agricultural land use. Alternatively we could argue for some non-modeled government sector of the economy needing tax revenue.

[12] The lower restriction arises from an assumption that the cost of land for the agricultural sector is always positive.

functionally organized means that it only cares about profits to the sector it represents, and does not consider other sources of income, for instance government transfers or income from labor and land to its members. The organized land users coordinate their political activities so as to maximize the respective lobby's welfare. The lobby representing industry i thus submits a contribution schedule $C_i(t_A)$ that maximizes

$$v_i = \hat{W}_i(t_A,\ z) - C_i(t_A), \tag{1.2}$$

where

$$\hat{W}_i(t_A,\ z) \equiv \alpha_i \Pi_i[p_i,\ z_i,\ H_i] \tag{1.3}$$

gives the gross of contribution profits (welfare) of the members of lobby group i.

Facing the contribution schedules offered by the various lobbies the incumbent government sets the land tax (subsidy). The government's objective is to maximize its own welfare. We assume that the government cares about the contributions paid by the lobbies and possibly also about social welfare. The government's objective function is assumed to be linear and is given by

$$G = \sum_{i\in B} C_i(t_A) + a\hat{W}(t_A,\ z),\ \ a \geq 0 \tag{1.4}$$

where B is the set of organized industries, and

$$\hat{W}(t_A,\ z) \equiv l + \sum_{i=A,\ F} \Pi_i[p_i,\ z_i,\ H_i] + R(t_A,\ z) + S(\mathbf{p}) + z - \phi(T_A) \tag{1.5}$$

measures the average (gross) welfare. Parameter a represents the government's weighing of a unit of social welfare compared to a unit of contributions and is taken to measure the government's non-susceptibility to lobbying (the higher the a, the less susceptible the government is to lobbying).

The total amount of land available is normalized to one so that

$$T_A[p_A,\ (1+t_A)z,\ H_A] + T_F[p_F,\ z,\ H_F] = 1. \tag{1.6}$$

We can use this to solve for the equilibrium value of land as a function of the output prices, the land tax rate and the technologies available. We denote this functional relationship by $z(\mathbf{p},\ t_A,\ \mathbf{H})$, where $\mathbf{H}$ is the vector of technologies.

According to Ricardo [25] and Calvo *et al.* [4], a tax on land rents gets fully capitalized in the value of land. This was refuted by Feldstein [11], who nevertheless allows for a fall in land price as a land tax is introduced. We obtain the change in the value of land when a land tax is introduced by differentiating equation (1.6) with respect to t_A to obtain[13, 14]

$$\frac{\partial z/\partial t_A}{z} = -\frac{T_{A2}}{(1+t_A)\,T_{A2}+T_{F2}} < 0; \tag{1.7}$$

Figure 1.1 exemplifies the situation. Thus, due to the increased land demand by the forestry sector as land in agricultural use is being taxed, the tax will not necessarily be wholly capitalized in the value of land.

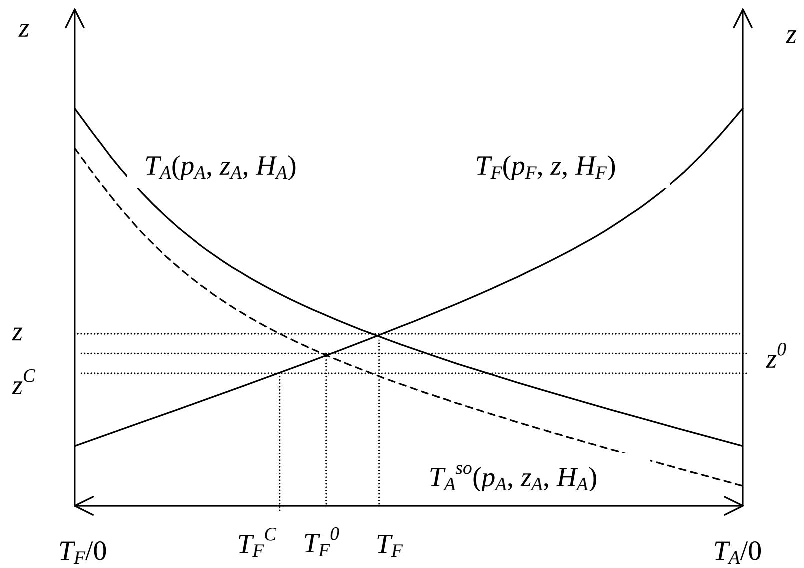

Figure 1.1: Land demand by agriculture is given by the $T_A\,(p_A,\ z_A,\ H_A)$ curve from the left and land demand by forestry by the $T_F\,(p_F,\ z,\ H_F)$ curve from the right. The socially optimal land demand by agriculture is given by the dotted line $T_A^{so}\,(p_A,\ z_A,\ H_A)$. Starting from the equilibrium land allocation indicated by T_F, the government imposes a land tax. If the tax is capitalized entirely in the value of land, this falls to z^C. At z^C the forestry sector demands T_F^C of land, whereas land demand by agriculture is still $1-T_F$. Land demand exceeds supply, which will drive up the value of land. The new equilibrium is found at the land allocation given by T_F^0 at which the equilibrium value of land is z^0.

Changes in the taxation of land thus affect the allocation of land between the two land using sectors. We formulate the following lemma to elaborate on the changes in land demand:

Lemma 1.1 *An increase in the land tax leads to a decrease in land demand by agriculture and to an increase in land demand by forestry.*

[13] It is further easy to verify that $-1 \leq \frac{dz/dt_A}{z} < 0$ given that $t_A \geq -\frac{T_{F2}}{T_{A2}}$, where the RHS is negative.

[14] The second order condition of the land price function with respect to the land tax is given by $\frac{\partial^2 z/\partial t_A^2}{z} = \frac{2T_{A2}^2}{[(1+t_A)T_{A2}+T_{F2}]^2} > 0$.

Proof. Totally differentiating land demand in each sector with respect to t_A and substituting in (3.14) yields for agriculture $\frac{dT_A}{dt_A} = \frac{\partial T_A}{\partial z_A}\frac{\partial z_A}{\partial t_A} = \frac{zT_{A2}T_{F2}}{(1+t_A)T_{A2}+T_{F2}} < 0$ and for forestry $\frac{dT_F}{dt_A} = \frac{\partial T_F}{\partial z}\frac{\partial z}{\partial t_A} = -\frac{zT_{A2}T_{F2}}{(1+t_A)T_{A2}+T_{F2}} > 0$. ■

The derivation of the equilibrium in differentiable strategies follows Grossman and Helpman [15], Dixit [6] and Fredriksson [12] and is reproduced in Appendix 1.A. To summarize, we model policy making under lobby influence as a two-stage common agency game. In the first stage, lobbies confront politicians with their contribution schedules, which are assumed to be globally truthful, continuous, and differentiable at least in the neighborhood of an equilibrium. In the second stage, policy makers unilaterally or cooperatively set environmental policies and receive the corresponding political contributions. The assumption of global truthfulness implies that the politically optimal policy vector can be characterized by the following equation:

$$\sum_{i=A,\ F} \bigtriangledown W_i\left(t_A\right) + a \bigtriangledown W\left(t_A\right) = 0. \tag{1.8}$$

1.3 The Politically Optimal Tax Rate

We differentiate the lobbies' welfare functions given by equation (3.7) and the general welfare function given by (3.12) with respect to t_A and enter the obtained derivatives into (3.15) to find the equilibrium characterization of the government's policy choice given by

$$\begin{aligned} &- I_A\alpha_A T_A\left[z + (1+t_A)\frac{\partial z}{\partial t_A}\right] - I_F\alpha_F T_F\frac{\partial z}{\partial t_A} \\ &+ a\left\{t_A z T_{A2}\left[z + (1+t_A)\frac{\partial z}{\partial t_A}\right] - \phi'\left(T_A\right)T_{A2}\left[z + (1+t_A)\frac{\partial z}{\partial t_A}\right]\right\} = 0. \end{aligned} \tag{1.9}$$

The second order condition of equation (1.9) is discussed in Appendix 1.B.

I_i is an indicator variable taking a value of one if lobby i organizes and zero otherwise. Substituting in the partial of z given by (3.14) we can simplify this and solve for the equilibrium ad valorem land tax given implicitly by $t_A = \frac{z_A - z}{z}$, namely

$$t_A^0 = \delta^0\left[-\frac{I_A\alpha_A}{\varepsilon^A_{T,\ z}} + \frac{I_F\alpha_F}{\varepsilon^F_{T,\ z}} + \frac{a\phi'\left(T_A^0\right)}{z^0}\right]. \tag{1.10}$$

$\varepsilon^i_{T,\ z} = -\frac{\partial T_i}{\partial z_i}\frac{z_i}{T_i} > 0$ denotes the price elasticity of land demand in sector i. The multiplicand $\delta^0 = \frac{\varepsilon^A_{T,\ z}}{a\varepsilon^A_{T,\ z}+I_A\alpha_A}$ is positive. The maximization problem thus yields a modified Ramsey rule. The superscript 0 denotes the politically optimal values of the variables. Appendix 1.C solves for the tax equation using specified functional forms for the land demand and the externality equations. We also demonstrate an example of the circumstances under which the second order condition of the equilibrium characterization is satisfied.

Equation (1.10) gives the ad valorem land tax rate as a sum of three components. The first two arise from lobbying by the respective lobby, where lobby A lobbies for a lower tax rate (the first term is negative), whereas lobby F lobbies for a higher tax rate (the positive second term). The lobbying effects arise from the impact of the land tax on profits in the respective sector. Thus, the tax raises the cost of land to agriculture but lowers the value of land (see (3.14)), and thereby lowers the cost of land to forestry. A higher tax therefore lowers profits in agriculture and increases them in forestry. Each lobby's strength is inversely proportional to its elasticity of land demand: the more elastic the land demand, the lower the lobby strength. The third term represents the marginal damages from agricultural land use and serves to raise the tax rate.

We start by establishing a benchmark by examining the social optimum:

Proposition 1.1 *In social optimum, the government imposes a land tax on agriculture.*

Proof. In social optimum the government is not susceptible to lobbying, i.e., $a \to \infty$. The tax equation simplifies to $t^{so}_A = \frac{\phi'(T^0_A)}{z^0}$, which is unambiguously positive. ■

Therefore, in the social optimum the government imposes a land tax on agriculture that is equal to the marginal damage from agricultural land use.

Turning to lobbying, we note that it is lobbying by the agricultural land-owners that creates an ambiguity to the tax.[15] If this lobby is strong enough, we might even observe a subsidy to land use in agriculture.

Proposition 1.2 *Land use in agriculture can be subsidized given that 1) the agricultural lobby organizes, 2) the government is susceptible to lobbying, and 3) land demand in the agricultural sector is sufficiently inelastic.*

Proof. Land use in agriculture is subsidized if equation (1.10) is negative. Solving

[15] As is obvious from equation 1.10, lobbying draws the tax in opposite directions. Thus, it is also possible that the socially optimal tax rate is achieved in the presence of lobbying. This will be the case if the elasticity of land demand in agriculture is equal to the elasticity of land demand in forestry, weighted by the strength of the respective lobby: $\varepsilon^A_{T,\ z} = \frac{I_A\alpha_A}{I_F\alpha_F}\varepsilon^F_{T,\ z}$.

for the elasticity of land demand in agriculture yields the following condition:

$$0 < \varepsilon^{A}_{T,\ z} < \frac{I_A \alpha_A z \varepsilon^{F}_{T,\ z}}{I_F \alpha_F z + a\phi'(T_A)\,\varepsilon^{F}_{T,\ z}}.$$

If the agricultural lobby does not organize, the RHS is equal to zero and it is impossible for the agricultural sector to negotiate a subsidy for itself. However, if the agricultural lobby organizes and if its land demand is sufficiently inelastic, it is possible for that sector to get a land subsidy instead of a tax. If, however, the government is not susceptible to lobbying (i.e., if $a \to \infty$), the RHS approaches zero and the case where land use in agriculture is subsidized becomes increasingly unlikely. ■

If land demand in agriculture is inelastic, even a small tax increases the cost of land to agriculture considerably. Therefore, the sector has a lot at stake in the tax, which gives it an incentive to lobby more vehemently for a lower tax/greater subsidy. On the other hand, if the sector has a very elastic land demand, the cost increase from a land tax will be small and the sector will not have a great incentive to lobby for a lower tax.

In a similar manner, the forestry lobby's incentives to lobby depend on the elasticity of land demand in that sector. The more inelastic its land demand, the more it will lobby for a higher land tax on agriculture.[16] The rationale for this is similar to that for the agricultural sector.

These results contrast to the usual public economics findings about taxes. In that literature it is usually found that the government, in order to raise tax revenue, should tax most heavily those sectors where the demand for, in this case, land is the most inelastic. This is, for instance, the case in the above-mentioned literature on land taxes as an instrument for economic growth (see, e.g., George [14], Feldstein [11] or Calvo *et al.* [4]). Here, the more inelastic the land demand in agriculture, the lower the tax will be. What we have found is thus a political economy channel of influence from the agricultural lobby, where that sector will be taxed less, not more, as its elasticity of land demand falls. This effect is nevertheless counterweighted by the fact that the forestry sector gains more from a high tax on agriculture the more inelastic its own land demand is, and that sector will lobby for a higher tax. Even this motivation for high taxes on the agricultural

[16] The land tax t_A is unambiguously positive in the presence of both lobbies if 1) the elasticity of land demand in agriculture is low: $0 < \varepsilon^{A}_{T,\ z} < \frac{I_A \alpha_A z}{a\phi'(T_A)}$, given that $0 < \varepsilon^{F}_{T,\ z} < \frac{I_F \alpha_F z \varepsilon^{A}_{T,\ z}}{I_A \alpha_A z - a\phi'(T_A)\varepsilon^{A}_{T,\ z}}$, i.e., if land demand in forestry is inelastic also, or if 2) land demand in agriculture is elastic: $\frac{I_A \alpha_A z}{a\phi'(T_A)} < \varepsilon^{A}_{T,\ z}$, given that $\frac{I_F \alpha_F z \varepsilon^{A}_{T,\ z}}{I_A \alpha_A z - a\phi'(T_A)\varepsilon^{A}_{T,\ z}} < \varepsilon^{F}_{T,\ z}$, where the LHS is negative. Therefore, if land demand in agriculture is elastic, land in agriculture will always be taxed since the sufficient condition for this is that land demand elasticity for forestry is positive, which always holds.

sector differs from the "normal" public economics explanation, however.

Finally, it is clear from equation (1.10) that as $a \to \infty$, i.e., as the government's susceptibility to lobbying decreases, the tariff rate approaches social optimum. This is regardless of which lobby has originally been stronger.

1.4 Technological Change

In this section we analyze the effect of technological change on the equilibrium land tax rate. Technological change is taken to be exogenous.

From equation (1.6), using the envelope theorem, we find the derivative of the land value function with respect to H_A: $\frac{\partial z}{\partial H_A} = -\frac{T_{A3}}{(1+t_A)T_{A2}+T_{F2}} \geq 0$, where $\frac{\partial T_A}{\partial H_A} = T_{A3} \geq 0$ (see Appendix 1.D) is the partial of the land demand function in agriculture to the technology parameter. From (1.6) we further obtain the change in land demand as agricultural technologies improve:

Lemma 1.2 *As better technologies become available to agriculture (H_A increases), the agricultural sector's net demand for land increases and the forestry sector's demand for land falls.*

Proof. Total land use in the model is constant, so that $\frac{dT_A}{dH_A} + \frac{dT_F}{dH_A} = 0$. Since $\frac{dT_F}{dH_A} = T_{F2}\frac{\partial z}{\partial H_A} < 0$, it must be that $\frac{dT_A}{dH_A} > 0$. ■

Turning to the effect of technological change on the land tax rate, we differentiate the equilibrium tax equation (1.10) totally with respect to H_A and rearrange to yield

$$\frac{dt_A}{dH_A} = \frac{I_A\alpha_A(1+t_A)\left[\varepsilon_{z,\ H_A} - \varepsilon_{T_A,\ H_A}\right]}{aH_A\varepsilon^A_{T,\ z}} - \frac{I_F\alpha_F\left[\varepsilon_{z,\ H_A} + \varepsilon_{T_F,\ H_A}\right]}{aH_A\varepsilon^F_{T,\ z}} + \frac{\phi''(T_A)\,T_A\varepsilon_{T_A,\ H_A} - \phi'(T_A)\,\varepsilon_{z,\ H_A}}{zH_A}. \quad (1.11)$$

We denote the elasticity of land demand to technological change by $\varepsilon_{T_A,\ H_A} = \frac{dT_i}{dH_A}\frac{H_A}{T_i} > 0$ and by $\varepsilon_{T_F,\ H_A} = -\frac{dT_F}{dH_A}\frac{H_A}{T_F} > 0$ for the agricultural and the forestry sector, respectively. The elasticity of land price to technology is given by $\varepsilon_{z,\ H_A} = \frac{dz}{dH_A}\frac{H_A}{z} > 0$. The derivatives of the price elasticities of land demand are given by

$$\frac{\partial\varepsilon^A_{T,\ z}}{\partial H_A} = \frac{\varepsilon^A_{T,\ z}\left[\varepsilon_{z,\ H_A} - \varepsilon_{T_A,\ H_A} + \varepsilon_{t_A,\ H_A}\right]}{H_A} \leq 0 \quad (1.12a)$$

$$\frac{\partial\varepsilon^F_{T,\ z}}{\partial H_A} = \frac{\varepsilon^F_{T,\ z}\left[\varepsilon_{z,\ H_A} + \varepsilon_{T_F,\ H_A}\right]}{H_A} > 0. \quad (1.12b)$$

$\varepsilon_{t_A,\ H_A} = \frac{dt_A}{dH_A}\frac{H_A}{t_A} \gtrless 0$ is the elasticity of the land tax to technology. We sum the effect of technological change on lobby strength in the following proposition:

Proposition 1.3 *Land demand by agriculture becomes more inelastic in agricultural technology thus strengthening the agricultural lobby. Land demand by forestry becomes more elastic thus weakening the forestry lobby.*

Proof. As for the agricultural lobby, there are two forces in play determining whether its elasticity of land demand falls or increases. We prove the direction of change by contradiction. Thus, were the land value effect, $\varepsilon_{z,\ H_A}$, in (1.12a) to dominate the land demand effect, $\varepsilon_{T_A,\ H_A}$, then technological change would lead to a fall in land demand by agriculture. From lemma 1.2 this is clearly not the case, thus showing that the land demand effect dominates the land value effect, and consequently rendering the change in the elasticity of land demand negative. Land demand by agriculture thus becomes more inelastic in technological change in agriculture.

Further, from equation (1.12b) it is clear that land demand becomes more elastic in the forestry sector as the agricultural technologies improve. Thus, both the land price ($\varepsilon_{z,\ H_A}$) and the land demand ($\varepsilon_{T_F,\ H_A}$) effects work in the same direction for the forestry sector. The consequence of technological change in agriculture is then to weaken the forestry lobby. ■

In Appendix 1.E we show how the technology effect works using defined land demand and externality functions.

The effect of technological change on the land tax rate is therefore a sum of several influences. The first term in (2.15) arises from the change in the strength of the agricultural lobby, which was shown to increase in proposition 1.3. The term is thus negative, and the agricultural lobby attempts to lower the land tax rate more the better the technologies it has access to.

The second term in (2.15) arises from the change in the strength of the forestry lobby. In proposition 1.3 we showed that the forestry lobby is weakened by technological progress in agriculture. The effect is due to the increase in the value of land, which is reinforced by the ensuing fall in land demand by forestry. A fall in the strength of the forestry lobby has the effect of lowering the land tax. Finally, the term on the second line of (2.15) arises from the second and the first order changes in the damages function, respectively. This term is of an ambiguous sign, but we will discuss its likely sign below.

In order to set a benchmark, we start the analysis of (2.15) from the social optimum.

Proposition 1.4 *In the social optimum the land tax increases in technological change.*

Proof. In social optimum, equation (2.15) simplifies to

$$\frac{dt_A}{dH_A} = \frac{\phi''(T_A) T_A \varepsilon_{T_A,\ H_A} - \phi'(T_A) \varepsilon_{z,\ H_A}}{zH_A}.$$

This expression is positive iff

$$\phi''(T_A) T_A \varepsilon_{T_A,\ H_A} > \phi'(T_A) \varepsilon_{z,\ H_A}. \tag{13}$$

The term on the LHS of (13) arises from the effect that technological change has on land demand by agriculture, and how this affects the damage function. The term on the RHS arises from the effect that technological change has on the value of land. From lemma 1.2 land demand in agriculture increases in technological change. Therefore, the LHS is greater than the RHS, and the land tax increases in technological change in the social optimum. ■

The two opposing effects shown in proposition 1.4 thus arise from the two effects that technological change has on agricultural land use. The negative term $(-\frac{\phi'(T_A)\varepsilon_{z,\ H_A}}{zH_A})$ arises from the fact that technological change raises the value of land, and therefore lowers land demand by agriculture. This mitigates the negative externality arising from agricultural land use. The positive $(\frac{\phi''(T_A)T_A\varepsilon_{T_A,\ H_A}}{zH_A})$ effect arises from the direct land demand effect found in lemma 1.2. Thus, technological progress increases land demand by agriculture thereby aggravating the negative externality.

Changes in lobbying, induced by technological change, complicate the analysis. We summarize the effect in the following proposition:

Proposition 1.5 *In the political optimum the land tax falls in technological change.*

Proof. Solving (2.15) for a when it is positive ($\frac{dt_A}{dH_A} \geq 0$) yields

$$a \geq -\frac{z\left\{I_A\alpha_A(1+t_A)\left[\varepsilon_{z,\ H_A} - \varepsilon_{T_A,\ H_A}\right]\varepsilon^F_{T,\ z} - I_F\alpha_F\left[\varepsilon_{z,\ H_A} + \varepsilon_{T_F,\ H_A}\right]\varepsilon^A_{T,\ z}\right\}}{\varepsilon^A_{T,\ z}\varepsilon^F_{T,\ z}\left[\phi''(T_A)T_A\varepsilon_{T_A,\ H_A} - \phi'(T_A)\varepsilon_{z,\ H_A}\right]}. \tag{14}$$

We showed in proposition 1.4 why equation (13) has to hold. Consequently, the denominator of (14) is positive, with the sign of the RHS being determined by the numerator. If no lobbies organize ($I_A = I_F = 0$), we have the socially optimal solution and the land tax increases in technology. If only the forestry lobby organizes, the numerator is positive rendering the whole RHS positive, and land tax increases in technological progress only at high enough values of a, i.e., given that the government is not susceptible to lobbying. If only the agricultural lobby organizes, the numerator is likewise positive and the land tax increases in technology only if the government is sufficiently non-susceptible to lobbying. At low values of a, then, the land tax falls in technological change regardless of which or whether both of the lobbies organize. ■

The finding in proposition 1.5 is due to two factors. The first is the increase in the strength of the agricultural lobby, and the second is the fall in the strength of the forestry lobby, which both serve to lower the land tax in the political optimum.

The findings in this section have consequences to what happens to the allocation of land between the agricultural and the forestry sectors. Regardless of which lobby is stronger in the initial situation, and consequently, regardless of whether the land tax is set above or below the socially optimal tax rate, if the government is susceptible to lobbying, once technological progress takes place in agriculture the land tax will fall. Over time, as agricultural technologies progress relative to technology in forestry, it becomes more and more likely that the agricultural sector will dominate the tax-setting game. Then, the land tax will be set at a level that is below the socially optimal level. This has the effect of reallocating land from forestry to agriculture to a greater degree than would be socially optimal. Thus, lobbying by the agricultural sector, coupled with technological progress in agriculture and the ensuing weakening in the strength of the forestry lobby, will lead to excessive deforestation from a social point of view.

1.5 Conclusions

The findings in this paper pertain to the inclusion of a political process in order to determine the land tax rate. We further consider the impact of technological change in agriculture on the equilibrium land tax rate and the allocation of land between agriculture and forestry.

Without including resource dynamics, we can explain a similar effect to that found by Barbier and Damania [2], namely that the relative share of agriculture of total land is bound to be higher in countries where the government is susceptible to lobbying. We have a different explanation to this, however. Thus, whereas Barbier and Damania's finding is based on lobbying for higher concessions to land conversion, in our model it is possible that an agricultural lobby is able to thwart the government's (assumed) attempts to internalize negative externalities arising from agriculture with the help of a land tax. If the agricultural lobby either manages to lower the land tax or to turn it into a land subsidy, this effect will reallocate land from forestry to agriculture more than would be socially optimal. It is, however, possible that a forestry lobby would be able to stop this fall in the land tax rate, in which case the opposite result would be obtained.

We further show how technological progress in agriculture affects the land tax rate and therefore nuances the picture given by Ehui and Hertel [8], who show that the steady-state forest stock falls in technological progress in agriculture. Thus, technological progress strengthens the agricultural lobby but weakens the forestry lobby. If the government is susceptible to lobbying, this will prompt a fall in the land tax rate (or an increase in the subsidy) in technological change. Then, over time, as the agricultural technologies have progressed, that lobby has become more and more powerful as compared to the forestry lobby, and more than the socially optimal amount of land has been allocated to agriculture.

We therefore offer two reasons for the low land taxes observed in the real world, the first being lobbying by the agricultural lobby, and the second being technological progress in agriculture. These explanations can be contrasted to the analysis by Lindholm [19], who explained the rarity of land taxation with considerations of equity versus efficiency. In order to further examine the political versus public economics motives for land taxation, we would have to construct a model of lobbying in a public economics setting. This is left for future research.

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1.A Appendix

In this appendix we show the derivation of the equilibrium characterization, equation (3.15). It is based on Grossman and Helpman [15], whose analysis in turn is based on Bernheim and Whinston [3].

Let Z denote the set of possible land taxes from which the government may choose. Z is bound so that land tax must lie between some minimum $\underline{t_A}$ and some maximum $\overline{t_A}$. Lemma 2 of Bernheim and Whinston [3] (Proposition 2 in Grossman and Helpman [15]) implies that an equilibrium to the tax-setting game can be characterized as follows:

Proposition 1.6 $\left(\{C_i^0\}_{i\in B}, t_A^0\right)$ *is a subgame-perfect Nash equilibrium of the land tax setting game if and only if:*

1. C_i^0 *is feasible for all* $i \in B$
2. t_A^0 *maximizes* $\sum_{i\in B} C_i^0(t_A) + aW(t_A)$ *on* Z
3. t_A^0 *maximizes* $W_j(t_A) - C_i^0(t_A) + \sum_{i\in B} C_i^0(t_A) + aW(t_A)$ *on* Z *for every* $j \in B$
4. *for every* $j \in B$ *there exists a* $t_A \in Z$ *that maximizes* $\sum_{i\in B} C_i^0(t_A) + aW(t_A)$ *on* Z *such that* $C_j^0(t_A) = 0$.

Condition [1] restricts each lobby's contribution schedule to be among those that are feasible (i.e., contributions must be non-negative and no greater than the aggregate income available to the lobby's members). Condition [2] states that, given the contribution schedules offered by the lobbies, the government sets... policy to maximize its own welfare...

Condition [3] stipulates that, for each lobby j, the equilibrium price vector must maximize the joint welfare of that lobby and the government, given the contribution schedules offered by the other lobbies...

[Condition 4] requires that for every i there must exist a policy that elicits a contribution of zero from lobby i which the government finds equally attractive as the equilibrium policy $[t_A^0]$. (Grossman and Helpman [16]: 120, 128).

We assume that the lobbies set political-contribution functions that are differentiable, at least around the equilibrium point t_A^0. With contribution functions that are differentiable, the fact that t_A^0 maximizes $v_i + G$ (condition 3) implies that a first order condition is satisfied at t_A^0, namely,

$$\nabla W_j^0\left(t_A^0\right) - \nabla C_j^0\left(t_A^0\right) + \sum_{i\in B} \nabla C_i^0\left(t_A^0\right) + a\nabla W\left(t_A^0\right) = 0 \text{ for all } j \in B. \tag{15}$$

However, the government's maximization of G in condition 2 requires the following first-order condition:

$$\sum_{i\in B} \nabla C_i^0\left(t_A^0\right) + a\nabla W\left(t_A^0\right) = 0. \tag{16}$$

Substituting (16) into equation (15) implies

$$\nabla C_i^0\left(t_A^0\right) = \nabla W_i\left(t_A^0\right) \text{ for all } i \in B. \tag{17}$$

"Equation [17] establishes that the contribution schedules all are *locally truthful* around $[t_A^0]$; that is, each lobby sets its contribution schedule so that the marginal change in the contribution for a small change in policy matches the effect of the policy change on the lobby's gross welfare" (Grossman and Helpman [16]: 121). Turning next to truthfulness, we note that "this is a contribution schedule that everywhere reflects the true preferences of the lobby" (p. 122). A truthful contribution function takes the form

$$C_j^T\left(t_A,\ M_j\right) = \max\left[0,\ W_j\left(t_A\right) - M_j\right] \tag{18}$$

for some M_j. Truthful schedules are differentiable, except possibly where the contribution becomes nil. This is because the gross benefit functions are differentiable. Following from Bernheim and Whinston's [3] arguments (see p. 122-123 in Grossman and Helpman [16]), we note that the equilibrium strategies of the lobbies are truthful Nash equilibria. The equilibrium tax of any truthful Nash equilibrium satisfies

$$t_A^0 = \arg\max_{t_A \in Z} \left[\sum_{j \in B} W_j (t_A) + aW (t_A) \right]. \tag{19}$$

From equation (19) we know that truthful contribution schedules induce the government to behave as if it were maximizing a social-welfare function that weighs different members of the society differently. Thus, since we here consider functionally specialized lobbies, the organized lobby groups' profits receive a weight of $(1 + a)$ and those not so represented receive the smaller weight a. The externality also receives a weight a.

Summing finally both sides of equation (17) over i and substituting the result into equation (16) yields equation (3.15).

1.B Appendix

The maximization problem requires that the equilibrium characterization function has a negative second order condition for a maximum. The fact that the lobby groups are functionally specialized poses a bit of a challenge in this respect, however. Thus in the agricultural sector, welfare is actually falling in the land tax and reaches a minimum at some tax rate. This yields a positive second order condition. For the forestry sector, there are two opposing effects in play, and this sector's welfare function has a maximum given that $T_F > -\frac{zT_{F2}}{2}$, i.e., given that its land demand is high enough. The general welfare function has a negative second order condition given that $t_A < \frac{(1+t_A)T_{A2}+T_{F2}}{3T_{A2}} + \frac{2\phi'(T_A)-\phi''(T_A)zT_{F2}}{3z}$, i.e., that the land tax is lower than some positive figure. In the following, we will assume this to be the case.

The second order condition of the equilibrium characterization is given by

$$\frac{I_A \alpha_A z T_{A2} T_{F2} (2T_A - zT_{F2}) - I_F \alpha_F (zT_{F2} + 2T_F) zT_{A2}^2}{[(1 + t_A) T_{A2} + T_{F2}]^2} + a \frac{\{z (T_{A2} + T_{F2}) - [2t_A z - 2\phi' (T_A) + \phi'' (T_A) zT_{F2}] T_{A2}\} zT_{A2} T_{F2}}{[(1 + t_A) T_{A2} + T_{F2}]^2}$$

which is negative given that $a \geq -\frac{I_A \alpha_A z T_{F2}(2T_A - zT_{F2}) - I_F \alpha_F z T_{A2}(zT_{F2}+2T_F)}{\{z(T_{A2}+T_{F2})-[2t_A z - 2\phi'(T_A)+\phi''(T_A)zT_{F2}]T_{A2}\}zT_{F2}}$. The denominator (including the minus sign in front of the expression) is positive whereas the first term in the numerator is negative and, assuming that land demand in forestry is high enough for its welfare function to have a maximum, the second term is positive. If no lobbies organize ($I_A = I_F = 0$), it is sufficient that $a \geq 0$ for the second order condition to be non-positive. If the lobbies organize, however, it is straightforward to show that $T_F < \frac{I_A \alpha_A T_{F2}(2T_A - zT_{F2})}{2I_F \alpha_F T_{A2}} - \frac{zT_{F2}}{2}$ is a sufficient condition to ensure the negativity of the second order condition. If this condition does not hold, then a has to be strictly positive for the second order condition to hold.

1.C Appendix

In this appendix we derive the land tax equation and its properties using specified functional forms for land demand by respective sectors and the externality equation.

Land demand in agriculture is given by $T_A = H_A - (1 + t_A)\, z$, and land demand in forestry by $T_F = H_F - z$, where we will normalize $H_F = 1$ yielding $T_F = 1 - z$. The negative net externality from agricultural land use is given by $\phi\,(T_A) = \frac{b}{2} T_A^2$, with $b > 0$.

The first order derivatives of the land demand functions are given by $T_{A2} = T_{F2} = -1$. Solving further for the value of land from $T_A + T_F = 1$ yields $z = \frac{H_A}{2+t_A}$. This has the first order derivative $\frac{\partial z}{\partial t_A} = -\frac{H_A}{(2+t_A)^2} < 0$ and the second order derivative $\frac{\partial^2 z}{\partial t_A^2} = \frac{2H_A}{(2+t_A)^3} > 0$.

Substituting the land value function into the land demand functions yields land demand by agriculture, $T_A = \frac{H_A}{2+t_A}$, and by forestry, $T_F = \frac{(2+t_A)-H_A}{2+t_A}$. Thus, at a sufficiently high level of technology in agriculture, i.e., if $H_A \geq 2 + t_A$, land demand by forestry is zero. Substituting these into equation (1.9) yields

$$- I_A \alpha_A \frac{H_A}{2+t_A}\left[\frac{H_A}{2+t_A} - (1+t_A)\frac{H_A}{(2+t_A)^2}\right] + I_F \alpha_F \frac{(2+t_A) - H_A}{2+t_A}\frac{H_A}{(2+t_A)^2}$$
$$+ a\left\{-t_A \frac{H_A}{2+t_A}\left[\frac{H_A}{2+t_A} - (1+t_A)\frac{H_A}{(2+t_A)^2}\right] + b\frac{H_A}{2+t_A}\left[\frac{H_A}{2+t_A} - (1+t_A)\frac{H_A}{(2+t_A)^2}\right]\right\}$$
$$= 0. \quad (20)$$

The elasticities of land demand in equation (1.10) are given by $\varepsilon^A_{T,\,z} = 1$ and $\varepsilon^F_{T,\,z} = \frac{H_A}{(2+t_A)-H_A}$. Simplifying (20) yields

$$t_A = \frac{-I_A \alpha_A H_A + I_F \alpha_F (2 - H_A) + abH_A}{aH_A - I_F \alpha_F}. \quad (21)$$

Furthermore, in the social optimum we have $t_A = b$.

The second order condition of the equilibrium characterization, (20), simplifies into $\frac{3I_A\alpha_A\left(\frac{H_A}{2+t_A}\right)^2-I_F\alpha_F\left(\frac{(2+t_A)-2H_A}{2+t_A}\right)+a(2t_A-3b-2)\left(\frac{H_A}{2+t_A}\right)^2}{(2+t_A)^2}$, which is negative if $b>\frac{I_A\alpha_A}{a}-\frac{I_F\alpha_F\left(1-\frac{2H_A}{2+t_A}\right)}{3a\left(\frac{H_A}{2+t_A}\right)^2}+\frac{2(2+t_A)}{3}$. If no lobbies organize, the second order condition is negative if $b>\frac{2(2+t_A)}{3}$. If $a\to 0$, b will have to be arbitrarily large for the condition to hold.

The land tax given by equation (2.2) is negative given that the denominator is positive iff $I_A\alpha_A>\frac{I_F\alpha_F(2-H_A)}{H_A}+ab$, and if the denominator is negative iff $I_A\alpha_A<\frac{I_F\alpha_F(2-H_A)}{H_A}+ab$.

1.D Appendix

In this appendix we prove the sign taken by the first order derivative of the land demand function with respect to H_i. We start by solving for the marginal product of land as

$$y_T^i=\frac{p_j\left(1+t_i\right)H_jy_T^j}{p_i\left(1+t_j\right)H_i}. \tag{22}$$

Totally differentiating equation (22) with respect to H_i yields

$$\begin{aligned}\frac{dy_T^i}{dH_i}=y_{TT}^i\left(\frac{\partial T_i}{\partial H_i}+\frac{\partial T_i}{\partial z_i}\frac{\partial z_i}{\partial H_i}\right)+y_{TL}^i\left(\frac{\partial L_i}{\partial H_i}+\frac{\partial L_i}{\partial z_i}\frac{\partial z_i}{\partial H_i}\right)\\ =\frac{p_j\left(1+t_i\right)H_j}{p_i\left(1+t_j\right)H_i}\left(\frac{1}{p_jH_j}\frac{\partial z_j}{\partial H_i}-\frac{y_T^j}{H_i}\right).\end{aligned} \tag{23}$$

Substituting in the first order condition of the marginal product of the labor -function with respect to H_i: $\frac{dy_L^i}{dH_i}=y_{LT}^i\left(\frac{\partial T_i}{\partial H_i}+\frac{\partial T_i}{\partial z_i}\frac{\partial z_i}{\partial H_i}\right)+y_{LL}^i\left(\frac{\partial L_i}{\partial H_i}+\frac{\partial L_i}{\partial z_i}\frac{\partial z_i}{\partial H_i}\right)=0$ and $\frac{\partial z_j}{\partial H_i}=\left(1+t_j\right)\frac{\partial z}{\partial H_i}$ and simplifying yields

$$T_{i3}=\frac{\partial T_i}{\partial H_i}=-\frac{y_{LL}^iy_T^i}{H_i\Upsilon_i}, \tag{24}$$

where $y_T^i>0$ is the marginal productivity of land. Since we assume that the production function y_i is increasing in T_i and L_i but at a falling rate, we have $y_{TT}^i<0$ and $y_{LL}^i<0$. $\Upsilon_i=y_{TT}^iy_{LL}^i-\left(y_{TL}^i\right)^2>0$. This completes the proof.

1.E Appendix

In this appendix we continue with the same functional forms as those used in Appendix 1.C. In that appendix we solved for the value of land as $z=\frac{H_A}{2+t_A}$, and for land demand functions $T_A = \frac{H_A}{2+t_A}$ and $T_F = \frac{(2+t_A)-H_A}{2+t_A}$. Differentiating land value with respect to technology yields $\frac{dz}{dH_A} = \frac{1}{2+t_A} - \frac{H_A}{(2+t_A)^2}\frac{dt_A}{dH_A} > 0$ from lemma 1.2. Taking the cross derivative of land value with respect to the land tax and technology yields $\frac{\partial^2 z}{\partial t_A \partial H_A} = -\frac{1}{(2+t_A)^2} + \frac{H_A}{(2+t_A)^2}\frac{\partial t_A}{\partial H_A}$.

Examining the elasticities entering into equation (2.15), $\varepsilon^A_{T,\ z} = 1$ and $\varepsilon^F_{T,\ z} = \frac{H_A}{(2+t_A)-H_A}$. Furthermore, $\varepsilon_{z,\ H_A} = 1 - \frac{H_A}{2+t_A}\frac{dt_A}{dH_A}$, $\varepsilon_{T_A,\ H_A} = 1 - \frac{H_A}{2+t_A}\frac{dt_A}{dH_A}$ and $\varepsilon_{T_F,\ H_A} = -\frac{H_A\left(2+t_A+H_A\frac{dt_A}{dH_A}\right)}{[(2+t_A)-H_A](2+t_A)}$. Substituting these into equation (2.15) and simplifying yields

$$\frac{dt_A}{dH_A} = -\frac{I_F \alpha_F\left[(2+t_A) - 2H_A\right]}{H_A\left(aH_A - 1\right)}. \tag{25}$$

Equation (25) is positive if $a > 1 - H_A$ and $t_A < 2\left(H_A - 1\right)$, i.e., if $H_A < 1$, given that the government is not very susceptible to lobbying and given that the land tax rate is sufficiently low. Otherwise the land tax will fall in technological progress. Furthermore, in social optimum (25) simplifies into $\frac{dt_A}{dH_A} = 0$. Consequently, the change in lobbying by the forestry lobby is the only thing affecting the change in the land tax as agricultural technologies improve under the present specification. The direction of the change in the land tax, however, depends on the level of technology in the agricultural sector and the government's susceptibility to lobbying.

Chapter 2

Agricultural Trade Liberalization and Deforestation: Political Economy Connections?

Johanna Jussila Hammes[1]

Abstract: This paper examines the determination of domestic trade policy when the world market price of food changes and affects land demand by the agricultural and forestry sectors when forestland, besides producing private goods, also produces a positive externality. We find that an increase in the price of food raises the value of land, which redistributes land towards the agricultural sector. It further increases the agricultural lobby's clout and reduces that of the forestry lobby. The agricultural lobby's political contribution increases and that by the forestry lobby falls, which raises the relative tariff rate on agriculture. The resulting deforestation in the political equilibrium is excessive from a social point of view, and may be higher than would be the case if the relative world market prices prevailed also domestically. It further gives a country a perceived comparative advantage in agricultural production. These results are not changed by the inclusion of an exogenous land use subsidy to forestry.

JEL Classification: D72, F18, Q17

Keywords: Agricultural trade liberalization, Doha round, Dutch disease, deforestation, perceived comparative advantage.

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2.1 Introduction

Export subsidies paid by the industrialized countries to agricultural exports depress the price of food on the world market.[2] Since removing these barriers to trade is part of the Doha round of trade negotiations, success in these talks is likely to lead to an increase in the world market price of food. It is therefore possible that the trade negotiations could lead to a boom in agriculture in some countries.[3] A boom in agriculture has consequences to other sectors, most notably by increasing the demand for agricultural land as the value of agricultural produce increases. The value of land increases, which in turn might lead to the so called Dutch-disease (see, e.g., Corden and Neary [11]), i.e., to a decline in other industries, e.g., in forestry. Barbier [3] discusses the possibility of resource booms of this type having dwarfed economic growth in Latin America.

The two most frequently cited connections between international trade liberalization and renewable resource management deal with overexploitation of the resources in the presence of poorly defined property rights (see, e.g., Chichilnisky [10]; Brander and Taylor [7], [8]), and with trade sanctions that may be linked to resource management practices. Barbier and Damania [4], using the framework proposed by Grossman and Helpman [16], further study the effect of government corruptibility on land conversion rates, and how changes in the terms of trade affect government policy towards resource conversion. They find evidence supporting the hypothesis that land conversion rates are higher in countries with corruptible governments and that an improvement in the terms of trade increases deforestation. Important cross-effects exist that may mitigate the resource conversion rates, however.

The aim of this paper is to contribute to our understanding of how an increase in the world market price of food impacts land allocation between agriculture and forestry in the presence of lobbies, and of when the government is susceptible to lobby contributions. We construct a principle-agent menu auctions model based on Grossman and Helpman [16], borrowing also from Brainard and Verdier [5] and Damania [12]. We assume that foreign trade liberalization increases the price of food on the world market exogenously. This raises the value of marginal product in agriculture, which leads to an increase in land demand by the agricultural sector in a small open economy. The effect is similar to that found in the Dutch

[2] Agricultural subsidies, including export subsidies, are widely used by the industrialized countries, especially by the European Union (EU). As the EU is a large actor in the world market, by standard trade theory, export subsidies paid by it depress the world market price of the subsidized goods.

[3] For instance, Brazil and Argentina have been mentioned as likely "winners" from the Doha talks in this respect. Generally, the so-called Cairns group should gain from the liberalization of agricultural trade.

disease literature where there exist both booming and lagging sub-sectors within the traded goods sector, which is explained by the fact that capital moves from the declining (manufacturing) sector towards the booming (energy) sector thus resulting in "de-industrialization" (see Corden and Neary [11]).[4] Thus, in the present model land will be reallocated from the sector with the lower value of marginal product to the sector with the higher value, until these are again equalized. Furthermore, by including lobbies for each respective land-using sector, we are able to study the effect of a change in lobby strength and of government susceptibility to lobbying on land allocation. This is new to the Dutch disease literature, which to our knowledge has so far not incorporated the effect of government policies formally into the model. Thus, a change in the relative output price and the ensuing change in land allocation affect the strength of the lobbies in the two land-using sectors. This, too, has consequences for the trade tariffs (export subsidies), output prices and finally, land allocation. We compare the outcome of the lobbying game to the situation as it would be if the government was not susceptible to lobbying, i.e., the social optimum.

The paper is closely related not only to the political economy, principle-agent literature (Grossman and Helpman [16], Barbier and Damania [4]), but also to the literature on declining industries and on the Dutch disease.[5] Brainard and Verdier [5], [6] study the question of declining industries within the framework proposed by Grossman and Helpman and show, among other things, that because of lobbying, the equilibrium tariff rate, albeit declining in industry decline, converges to a higher level than would be the case in the absence of lobbying. However, their model is a partial equilibrium one and examines industry decline solely due to a decline in the international price of one good. Damania [12] shows in a two period model where lobbying takes place only during the first period, that an industry that is assumed to decline gives a higher contribution than an industry that is assumed to expand. His result is based on the proposition that an industry in decline is constrained in its ability to raise revenue through production and has therefore a greater incentive to protect profits by lobbying for more favorable treatment. Damania [13] shows how underinvestment in technology, combined with a threat of declining contributions, leads both to underinvestment and to

[4] The Dutch disease should be seen as a benign phenomenon since an increase in the world market price of a traded good increases incomes for a country that produces that good. Most of the Dutch disease literature is, however, concerned with industry decline due to booms in resources, which are considered to hinder industrialization (see, besides Corden and Neary [11], also Barbier [3]).

[5] The literature on declining industries aims at explaining how persistent protection emerges. Once protection has been instituted, it tends to persist, even if the industry is declining in the sense that it is getting less competitive vis-à-vis foreign competitors and its production is declining. Early political economy explanations to the phenomenon are Hillman [19] and Cassing and Hillman [9].

excessive protection.

Within the Dutch disease literature, Barbier [3] discusses agricultural land use expansion and deforestation in Latin America, showing how agricultural land use expansion may actually have reduced welfare in these countries and hindered their industrial development. Sunderlin and Wunder [27] find preliminary support for a hypothesis that a boom in the oil sector may actually reduce deforestation. Love [21] and Richards [25] both note that the effect that the Dutch disease has on the sectorial composition of output not only depends on changes in relative prices, but that the government policies also have an impact on the outcome. Neither constructs a formal model to explain how exactly the government influences the result, however.

The present model includes the government explicitly. Also, it differs from the above-mentioned studies in several other respects. Unlike Brainard and Verdier [5], [6] and Damania [12], [13], it does not consider a declining industry and an expanding industry separately, but both at the same time within a general equilibrium model. The modeling of an explicit connection between two sectors also distinguishes the present study from the literature examining the determination of optimal tariffs in the presence of environmental externalities (see, e.g., Fredriksson [14], [15], Aidt [1] or Schleich [26]), which do not consider the effect of trade protection in one sector on other sectors. Further, whereas Barbier and Damania [4] study the effects of government corruptibility and changes in the terms of trade on deforestation, the emphasis here is more on changes in lobby strength. The model is able to explain both industry decline and expansion simultaneously because of the inclusion of two sectors using a common and variable input factor. The processes of industrial expansion and decline are thus endogenized, so that what determines production is the relative output price of the two land using sectors, i.e., the sectorial composition is determined by the country's terms of trade. This links the study to the Dutch disease literature, which studies how and why some sectors start to decline when others boom. In our model the effect works through the use of land in production, rather than through the labor market as in Corden and Neary [11]. Furthermore, our model of the Dutch disease is somewhat incomplete in that we do not consider the effects on manufacturing (a possible third industry that is open for international competition), or on a closed sector (services). We therefore examine how something reminiscent of the Dutch disease may lead to deforestation, not because of a boom in this sector like in the property rights literature (see Chichilnisky [10], Brander and Taylor [7], [8]) but because of a boom in agriculture.

Although the present paper considers the agricultural and forestry sectors, the analysis could easily be extended to other sectors using a common and adjustable factor of production. It could for instance be applied to two sectors using energy or capital in production when total energy production or the amount of available capital is restricted, but able to move between sectors.

Furthermore, we consider positive externalities arising from forested land. These can be thought of as public goods produced by forests, such as watershed protection, erosion control, carbon sequestration, biodiversity protection etc. It is also possible to imagine positive externalities from agriculture, for instance an open landscape. Therefore, the measure we include is one of a positive *net* externality from forested land.

The findings of the model are as follows: In the social optimum, the forestry sector gets a higher relative trade tariff or export subsidy than the agricultural sector, because of the positive externality that this sector's land use produces. Increases in the world market price of food then lead to a relative increase in the tariff (export subsidy) on forestry, thus partially offsetting the increase in the price of food. In the political optimum, however, an increase in the world market price of food leads to increased political contributions by the agricultural lobby, and to a decrease in the contributions by the forestry lobby. This has the consequence of increasing the relative trade protection given to agriculture as compared to forestry, which in turn yields a higher relative output price for food than would be socially optimal. Land demand by agriculture increases and land demand by forestry falls by more than would be socially optimal. In an extreme case, the agricultural sector may even get a higher output price relative to forestry than would be the case in the absence of trade protection altogether. The forestry sector declines, as is consistent with the Dutch disease hypothesis, due to a fall in its relative output price and the ensuing move of factors of production away from that sector. However, the presence of lobbies leads to a greater degree of contraction in forestry than would be the case were the lobbies absent from the model. Furthermore, the higher than socially optimal level of trade protection given to agriculture creates a perceived, as opposed to real, comparative advantage in the production of food.

We end the paper with short sections considering how the results change in the presence of an exogenous land use subsidy to forestry or when the two lobby groups unite under a common umbrella lobby group. Regardless of whether the (positive) subsidy is set at the socially optimal level or not, it makes it more likely that the agricultural sector gets a relatively higher tariff/subsidy than the forestry sector. Otherwise, the above results do not change. The same result applies to the presence of the umbrella lobby group, which determines its direction of lobbying from the relative value of production in the two sectors.

The paper is organized as follows: the next section delineates the basic structure of the model. In Sections 2.3.1 and 2.3.2 we solve the model backwards, showing how land use changes in the output price in agriculture and solving for the equations showing changes in tariff determination and lobbying. In Section 2.3.3 we consider the change in tariffs due to changes in contributions. Section 2.3.4 summarizes the findings and analyzes the effect on land demand. In Section 2.4 we examine some extensions to the model; in Section 2.4.1 we include an exogenously given land use subsidy to forestry, and in Section 2.4.2 we consider the effect of an umbrella lobby group. Finally, Section 2.5 concludes.

2.2 The Model

Consider a small open economy consisting of N individuals with identical, additively separable preferences. We normalize N to one without loss of generality. Each individual maximizes a utility function of the form $U_h = c_O + \sum_{i=A,\ F} u_i\left(c_i\right) + \phi\left(T_F\right)$, where c_O denotes consumption of the numeraire good and c_i consumption of good i, indexed by $A,\ F = \{i,\ j\}\,;\ i \neq j$, where A stands for agricultural goods (food) and F for forestry goods (logs). The sub-utility functions $u_i\left(c_i\right)$ are differentiable, increasing and strictly concave. $\phi\left(T_F\right)$ measures the positive net externalities arising from forest land, where T_i measures the use of land by sector i. The benefit function is assumed to be differentiable, increasing and strictly concave.

Good O serves as a numeraire with a domestic and world market price equal to one. The domestic price of good i equals p_i, and the world market price equals p_i^w. With these preferences, each consumer demands $d_i\left(p_i\right)$ units of good i, where $d_i\left(p_i\right)$ is the inverse of the marginal utility function $u_i'\left(c_i\right)$. The remainder of a consumer's income, E, is devoted to the numeraire good. The consumer thus attains an indirect utility level given by $v\left(\mathbf{p},\ E,\ T_F\right) = E + S\left(\mathbf{p}\right) + \phi\left(T_F\right)$, where $\mathbf{p} = \left(p_A,\ p_F\right)$ is the vector of domestic prices of the non-numeraire goods and $S\left(\mathbf{p}\right) = \sum_{i=A,\ F} u_i\left[d_i\left(p_i\right)\right] - \sum_{i=A,\ F} p_i d_i\left(p_i\right)$ is the consumer surplus arising from goods A and F. Consumption of the numeraire good creates no consumer surplus.

The numeraire good O is produced using labor only, with constant returns to scale and an input-output coefficient equal to one. We assume the aggregate labor supply, l, to be large enough to ensure a positive output of this good. It is then possible to normalize the wage rate to one, which means that we do not consider changes in wages. Food and logs are produced using both land and labor. Production exhibits constant returns to scale and all the goods are produced under perfect competition. The profit accruing to sector i is denoted by

$$\Pi_i(p_i,\ T_i) = p_i y_i(T_i,\ L_i) - zT_i - L_i - C_i(\mathbf{p},\ \mathbf{p}^w), \tag{2.1}$$

where $y_i(T_i,\ L_i)$ is the production function and $C_i(\mathbf{p},\ \mathbf{p}^w)$ is industry i's political contribution. Since we are mainly interested in changes in land use, T_i, and not in changes in labor, L_i, we will in the following suppress the notation on labor demand.

The total land area is normalized to one and consequently, the total land allocation is given by

$$T(p_A,\ z) + T(p_F,\ z) = 1. \tag{2.2}$$

This can be solved for the cost of land as a function of output price: $z(\mathbf{p})$. Differentiating (2.2) with respect to p_i, we find that the land price increases in output price: $\frac{\partial z}{\partial p_i} > 0$.[6]

The government has two policy instruments at its disposal, namely a trade tariff or a subsidy, θ_i, for each sector i. The domestic price is given by $p_i = (1+\theta_i)\,p_i^w$. A positive θ_i denotes an import tariff (export subsidy), and a negative θ_i denotes an import subsidy (export tax).[7] The revenue from the import tariffs or export taxes (cost of the subsidies) is distributed (collected) in a lump-sum fashion to (from) the consumers. The tariffs (subsidies) generate the following per capita government revenue (expenditure):

$$R(\mathbf{p}) = \sum_{i=A,\ F} \theta_i p_i^w \left\{d_i(p_i) - y_i\left[T_i(p_i,\ z)\right]\right\}. \tag{2.3}$$

Individuals collect income from several sources. They supply their labor endowment, l_h, where $\sum_h l_h = l$ is the aggregate labor supply, inelastically to the competitive labor market receiving wage income $wl_h = l_h$. Secondly, they receive (pay) an equal share of any government revenue $R(\mathbf{p})$. Thirdly, farmers and foresters use a share ω_{hi} of land in sector i and obtain the rent from land. We assume that a person can be both a farmer and a forester, and that if any changes in land use arise, they will take place within this group of persons so that the shares of land users in both uses remain constant throughout. Thus, the size of neither lobby, seen in terms of the number of its members, will change. A share ω_A of the population then uses agricultural land in production and a share ω_F uses forest land. A share $\omega_{AF} = \omega_A \cap \omega_F$ of the population uses land of both types. There is further a group of workers present that constitute $\omega_W = 1 - (\omega_A + \omega_F - \omega_{AF}) > 0$

[6] $\frac{\partial z}{\partial p_i} = -\frac{\frac{\partial T_i}{\partial p_i}}{\frac{\partial T_i}{\partial z} + \frac{\partial T_j}{\partial z}} > 0$, where $\frac{\partial T_i}{\partial p_i} > 0$ and $\frac{\partial T_i}{\partial z} < 0$.

[7] In order to guard ourselves against negative output prices, we further assume that $-1 < \theta_i$.

of the population. Workers own no land. Finally, those owning the land obtain income from land equal to $z\left(T_A + T_F\right) = z$.

Those using land in each respective sector have a common interest in the trade taxation of their sector. The formation of lobby groups is not modeled here; the reader is referred to Olson [24], or for formal models of endogenous lobby organization in the presence of trade taxation to Mitra [23], Magee [22] and Le Breton and Salanie [20]. We assume that at most two groups overcome the free riding problem inherent to interest group organization and organize, following Aidt [1], functionally specialized lobby groups making a menu of contribution offers to the government, depending on the latter's choice of trade policy. The lobby representing sector i thus submits a contribution schedule $C_i\left(\boldsymbol{\theta}\right)$ that maximizes

$$v_i = W_i\left(\boldsymbol{\theta},\ z\right) - C_i\left(\boldsymbol{\theta}\right), \tag{2.4}$$

where

$$W_i\left(\boldsymbol{\theta},\ z\right) = \Pi_i\left(p_i,\ T_i\right). \tag{2.5}$$

In order to study the effect of foreign agricultural trade liberalization we follow Brainard and Verdier [5], and Grossman and Helpman [16]. We examine a one period set-up with three stages where prior to the beginning of the game both the world market and the domestic prices have been constant. At the beginning of the game the international price of food rises so that $p_A^{w0} < p_A^w$, where the superscript 0 denotes values before the price change. The price remains constant thereafter. The world market price of logs will be constant throughout so that $p_F^{w0} = p_F^w$, and consequently, $\frac{p_A^{w0}}{p_F^{w0}} < \frac{p_A^w}{p_F^w}$. A price rise in agriculture affects forestry through the effect it has on the cost of land to both sectors.

Prior to the beginning of the game the economy is in equilibrium and the firms produce at a point where the price equals marginal cost. This determines the equilibrium output $y_i\left(T_i^0\right)$ and the equilibrium land demand T_i^0.

The timing structure of the lobbying game is such that the industry moves first, determining its menu of contributions, C_i, contingent on the chosen trade policy. In the second step, the government decides the level of trade taxation and consequently, the vector of domestic prices, taking the lobbies' contributions into consideration. In the third step, the lobbies adjust their land use, T_i, and produce their output using T_i of land. The model is solved backwards.

2.3 Determination of Equilibrium

2.3.1 Adjustment of land use

We start by examining the industries' land use adjustment decisions, i.e., the final outcome of the model. Industry i chooses its optimal land use taking the domestic price level and the political contributions as given. We obtain the change in land use from equation (2.2):

Lemma 2.1 *An increase in the output price of agricultural goods, p_A, leads to an increase in land demand by agriculture and to a fall in land demand by forestry.*

Proof. Totally differentiating land demand in forestry with respect to p_A yields $\frac{dT_F}{dp_A} = \frac{\partial T_F}{\partial z}\frac{\partial z}{\partial p_A} < 0$, because land demand falls in the price of land z, $\frac{\partial T_F}{\partial z} < 0$, and we showed above that the price of land increases in p_i. Totally differentiating land demand in agriculture yields $\frac{dT_A}{dp_A} = \left[\frac{\partial T_A}{\partial p_A} + \frac{\partial T_A}{\partial z}\frac{\partial z}{\partial p_A}\right] \gtrless 0$. However, from (2.2) we know that the total land use is fixed and we must have $\frac{dT_A}{dp_A} + \frac{dT_F}{dp_A} = 0$. Consequently, $\frac{dT_A}{dp_A^w} > 0$. ■

It is straightforward to show that T_F falls in both of the components of $p_A = (1 + \theta_A)\, p_A^w$ and that T_A increases in both of the components of p_A. It does therefore not matter whether the world market price of food increases, or whether the tariff/subsidy rate on agriculture increases; the effect on land allocation is the same. It is, however, possible that changes in p_A^w impact θ_A and have therefore a multiplicative effect on land allocation. Whether this is the case will be examined below.

We further note that lemma 2.1 shows how land will be reallocated towards a growing sector. This result is in line with the Dutch disease hypothesis (see, e.g., Corden and Neary [11]), which predicts that in an economy with two sectors sharing a common factor of production, a change in the terms of trade to the advantage of one sector leads to the contraction of the other sector due to changes in the factor markets. It further illustrates the importance of studying industry decline in a general equilibrium setting, and not in isolation from the rest of the economy as in Brainard and Verdier [5], [6]. Their model does not allow for effects such as the present one, where a boom in one industry negatively affects other industries and might lead to their decline

It remains to be shown how the tariff/subsidy rate on agriculture changes in the world market price of agricultural goods. We therefore turn to the political process determining the tariff rate.

2.3.2 Determination of the equilibrium tariff

Fully anticipating the industry's land adjustment and output response, the government chooses the vector of tariffs to maximize

$$\max_{p_i} \; G(\mathbf{p},\ \mathbf{T}) = \sum_{i=A,\ F} C_i(\mathbf{p},\ \mathbf{p}^w) + aW(\mathbf{p},\ \mathbf{T}), \tag{2.6}$$

where

$$W(\mathbf{p},\ \mathbf{T}) = l + \sum_{i=A,\ F} [p_i y_i(T_i) - zT_i] + R(\mathbf{p}) + S(\mathbf{p}) + z + \phi(T_F) \tag{2.7}$$

measures the average (gross) welfare. Starting our examination from the social optimum, we formulate the following proposition:

Proposition 2.1 *In the social optimum, the government gives relatively more protection (a higher tariff rate or a greater export subsidy) to the forestry sector than to agriculture.*

Proof. In social optimum, i.e., in a situation where the government gives no weight to the lobbies ($a \to \infty$), equation (2.6) simplifies to $\max_{p_i} \; G(\mathbf{p},\ \mathbf{T}) = W(\mathbf{p},\ \mathbf{T})$. Differentiating and solving, using the balanced trade condition yields[8]

$$\theta_A^{so} - \theta_F^{so} = -\frac{\phi'(T_F)\,\delta_A^{so}\varepsilon_{T_F,\ p_A}}{\varepsilon_{M_A,\ p_A}} < 0, \tag{2.8}$$

where $M_i(p_i,\ z) = d_i(p_i) - y_i[T_i(p_i,\ z)]$ is the import demand (export supply) function if positive (negative) and $\varepsilon_{M_i}(p_i) = -\frac{p_i}{M_i}\frac{dM_i}{dp_i}$ is the elasticity of import demand (export supply) if positive (negative). $\varepsilon_{T_F,\ p_A} = -\frac{p_A}{T_F}\frac{dT_F}{dp_A} > 0$ is the elasticity of land demand in forestry to the output price of agricultural goods and finally, $\delta_i^{so} = \frac{T_F^{so}}{p_i^w M_i^{so}}$ is the ratio of forest area to the value of imports or exports in sector i in the social optimum. $\frac{dM_i}{dp_i} = d_i'(p_i) - \frac{\partial y_i}{\partial T_i}\frac{\partial T_i}{\partial p_i} - \frac{\partial y_i}{\partial T_i}\frac{\partial T_i}{\partial z}\frac{\partial z}{\partial p_i} < 0$ and $\frac{dM_j}{dp_i} = -\frac{\partial y_j}{\partial T_j}\frac{\partial T_j}{\partial z}\frac{\partial z}{\partial p_i} > 0$.

If the numerator of (2.8) is negative, so is the denominator, and if the numerator is positive, so is the denominator, because δ_A^{so} and $\varepsilon_{M_A,\ p_A}$ always get the same sign. The rest of the terms in the numerator are positive. The negative sign in front of the expression then renders it negative. ■

The socially optimal tariff rate is driven by four terms. Its main component is the marginal change in the positive externality from forests: if this term is equal

[8] The balanced trade condition states that the value of imports must equal the value of exports: $M_O + p_i^w M_i + p_j^w M_j = 0$. Totally differentiating and rearranging yields $\frac{(\partial M_O/\partial p_i) + p_j^w(\partial M_j/\partial p_i)}{p_i^w(\partial M_i/\partial p_i)} = -1$. The change in M_O arises from the change in labor available to that sector. Assuming that the term is small, we set $\frac{\partial M_O}{\partial p_i} = 0$.

to zero, then it would be socially optimal to have the same tariff/subsidy rate on both sectors. Since our model gives the optimal *relative* tariff rate rather than the optimal tariff for each sector, it is not clear that free trade in this situation is optimal, but even that solution would belong to the set of optimal relative tariff rates.

However, assuming that the marginal benefits from forestland are positive, free trade in both sectors is no longer optimal; but in absence of other policy instruments to internalize the positive externality from forestland, the government uses trade taxation to obtain the socially optimal allocation of land between the two sectors. Then it is optimal to have a lower relative tariff/subsidy rate on agriculture than on forestry. It is, however, noteworthy that the trade policy is not the first-best policy instrument; this would be a subsidy to land use in forestry. Thus, rather than discouraging deforestation directly, the tariff/subsidy increases the output price and therefore production by the forestry sector, and consequently indirectly increases that sector's demand for land. We will study the determination of trade policy in the presence of an exogenously given subsidy to land use in forestry in Section 2.4.

The relative tariff rate is driven also by three other terms, the first one being the ratio of forestland to the world market value of imports/exports in the agricultural sector. The greater this term, i.e., the greater the forestland area, or the lower the world market value of imports/exports in the agricultural sector, the higher the difference between the relative tariff rates. Secondly, the greater the elasticity of demand for forestland, $\varepsilon_{T_F,\ p_A}$, and finally, the more inelastic the import/export demand in agriculture, $\varepsilon_{M_A,\ p_A}$, the greater the difference in the relative tariff rates.

Examining further how the socially optimal relative tariff rate changes in a rise in the world market price of food, totally differentiating (2.8) with respect to p_A^w yields

$$\frac{d\left(\theta_A^{so}-\theta_F^{so}\right)}{dp_A^w}=-\frac{\phi''\left(T_F\right)\left(\frac{dT_F}{dp_A}\right)^2\left(1+\theta_A\right)}{p_A^w\frac{dM_A}{dp_A}}+\frac{\phi'\left(T_F\right)\frac{dT_F}{dp_A}}{\left[p_A^w\frac{dM_A}{dp_A}\right]^2}\left[p_A\frac{d^2M_A}{dp_A^2}+\frac{dM_A}{dp_A}\right]. \tag{2.9}$$

The first term on the RHS of (2.9) is negative, the second term being of indeterminate sign because $\frac{d^2M_A}{dp_A^2}>0$ and $\frac{dM_A}{dp_A}<0$. Assuming that the change is driven by the effect on the externality, i.e., the first term on the RHS, we obtain that the relative tariff/subsidy rate falls in p_A^w in the social optimum. In other words, because more land will be allocated towards agriculture, the marginal benefits from the remaining forestland increase. This necessitates a fall in the tariff/subsidy rate on agriculture relative to that on forestry.

Turning to the political optimum and the effect of lobbying, parameter a in (2.6) represents the government's weighing of a unit of social welfare to a unit of contributions. The higher the a, the less weight the government gives to the lobbies and the more weight to the general welfare. The justification for this form of a government utility function has been discussed extensively by, among others, Grossman and Helpman [16]. Maximizing (2.6) yields

$$I_i \frac{dC_i}{d\theta_i} + I_j \frac{dC_j}{d\theta_i} = -ap_i^w \left[\theta_i p_i^w \frac{dM_i}{dp_i} + \theta_j p_j^w \frac{dM_j}{dp_i} + \phi' \left(T_F \right) \frac{dT_F}{dp_i} \right], \tag{2.10}$$

where I_i is an indicator variable taking the value of one if lobby i organizes and zero otherwise. Thus in equilibrium, the sum of industry contributions equals the deadweight loss from trade protection.

The industries' maximization problem is given by equation (2.4), using equation (2.5). Thus, each industry chooses its contribution to maximize its profits with respect to θ_i:

$$y_i \left[T_i \left(p_i, \ z \right) \right] - T_i \left(p_i, \ z \right) \frac{\partial z}{\partial p_i} = \frac{dC_i / d\theta_i}{p_i^w} \tag{2.11a}$$

$$-T_j \left(p_j, \ z \right) \frac{\partial z}{\partial p_i} = \frac{dC_j / d\theta_i}{p_i^w}, \tag{2.11b}$$

where we assume that $y_i \left[T_i \left(p_i, \ z \right) \right] > T_i \left(p_i, \ z \right) \frac{\partial z}{\partial p_i}$. Industry i's lobbying at the margin is thus determined by the effect that an increase in that sector's output price has on its production, and by how much the change in output price increases the production costs. Therefore, for sector i there is both a positive and negative effect from a rise in its output price. For sector j there is only the negative effect due to the increase in the cost of land and consequently, cost of production. Thus, a higher import tariff or export subsidy to sector i (lower import subsidy or export tax) will solicit a higher contribution from that sector by (2.11a), but a lower contribution from sector j by (2.11b).

Equations (2.11a) and (2.11b) constitute what Grossman and Helpman [16] term "local truthfulness." In equilibrium the industries choose contribution schedules that satisfy conditions (2.10), (2.11a) and (2.11b), which leaves the politician just indifferent between the socially optimal relative tariff/subsidy rate, and introducing the tariffs desired by the industries and receiving the associated contributions. Using the balanced trade condition, the equilibrium tariff rate can be expressed in a modified Ramsey form:

$$\theta_A - \theta_F = \frac{I_A p_A y_A - [I_A T_A + I_F T_F] z \varepsilon_{p_A,\ z}}{a p_A^w M_A \varepsilon_{M_A,\ p_A}} - \frac{\phi'(T_F)\,\delta_A \varepsilon_{T_F,\ p_A}}{\varepsilon_{M_A,\ p_A}} \quad (2.12a)$$

$$\theta_F - \theta_A = \frac{I_F p_F y_F - [I_A T_A + I_F T_F] z \varepsilon_{p_F,\ z}}{a p_F^w M_F \varepsilon_{M_F,\ p_F}} + \frac{\phi'(T_F)\,\delta_F \varepsilon_{T_F,\ p_F}}{\varepsilon_{M_F,\ p_F}}, \quad (2.12b)$$

where $\varepsilon_{M_i,\ p_i}$, $M_i(p_i,\ z)$ and δ_i were defined above, and $\varepsilon_{z,\ p_i} = \frac{p_i}{z}\frac{dz}{dp_i} > 0$ is the elasticity of the land price to output price in sector i. $\varepsilon_{T_F,\ p_F} = \frac{p_F}{T_F}\frac{dT_F}{dp_F} > 0$, and $\varepsilon_{T_F,\ p_A} = -\frac{p_A}{T_F}\frac{dT_F}{dp_A} > 0$ as above. The second term on the RHS in (2.12a) is the same as in equation (2.8), except that we have here included the politically optimal ratio of forest land to the value of imports/exports, δ_i instead of the socially optimal ratio. The first term on the RHS arises from lobbying and is made up of the value of production by sector i minus the effect that the increase in the cost of land has on profits. Thus, because a higher tariff on sector i increases its profits, that sector, given that the lobby organizes, lobbies for a higher tariff rate ($p_i y_i$), but because the higher output price increases the cost of land to both sectors, given that both lobbies organize, they both lobby for a lowering of the relative tariff rate for sector i ($-z\varepsilon_{z,\ p_i}$).

From equations (2.12a) and (2.12b) it is clear that the agricultural sector may get relatively more protection than the forestry sector under certain circumstances. We formulate this in the following proposition:

Proposition 2.2 *Given that the value of the agricultural sector's production is high enough, that sector will get relatively more protection (a higher tariff rate or a greater export subsidy) than the forestry sector.*

Proof. Examining which sector will get a higher tariff (export subsidy) in the political optimum, we note that $\theta_A - \theta_F > 0$ iff $I_A p_A y_A - a\phi'(T_F)\,T_F \varepsilon_{T_F,\ p_A} > [I_A T_A + I_F T_F]\, z\varepsilon_{p_A,\ z}$.

$\theta_A - \theta_F > 0$ further implies that $\theta_F - \theta_A < 0$, which yields $I_F p_F y_F + a\phi'(T_F)\,T_F \varepsilon_{T_F,\ p_F} < [I_A T_A + I_F T_F]\, z\varepsilon_{p_F,\ z}$. Assuming that $\varepsilon_{p_A,\ z} = \varepsilon_{p_F,\ z}$, sector A will get a higher tariff than sector F iff $I_A p_A y_A > I_F p_F y_F + a\phi'(T_F)\,T_F\,[\varepsilon_{T_F,\ p_F} + \varepsilon_{T_F,\ p_A}]$.

Thus, the agricultural sector will get a higher tariff rate (export subsidy) than the forestry sector if the value of it's production is high enough both to overweigh the value of production in forestry, and the by a weighted marginal externality (the last term on the RHS). The more susceptible the government is to lobbying, the smaller the a and the less this term weighs in. ■

Even in the political optimum the positive externality arising from forestland thus serves to raise the relative tariff rate or the export subsidy on forestry. Nevertheless, given either that the government is very susceptible to lobbying or that the value of production in agriculture is high enough, this may not suffice to give the forestry sector more protection than is given to the agricultural sector.

2.3.3 The effect of contributions on tariffs

In order to shed more light to the change of the tariff rate in contributions, following Damania [12], we differentiate equation (2.1) with respect to $C_i(\mathbf{p}, \mathbf{p}^w)$ and $C_j(\mathbf{p}, \mathbf{p}^w)$ to find

$$\frac{d\theta_i}{dC_i}p_i^w y_i - T_i\frac{dz}{dC_i} - 1 = 0 \quad (2.13a)$$

$$\frac{d\theta_i}{dC_j}p_i^w y_i - T_i\frac{dz}{dC_j} - \frac{dC_i}{dC_j} = 0, \quad (2.13b)$$

where $\frac{dz}{dC_i} = p_i^w \frac{\partial z}{\partial p_i}\frac{d\theta_i}{dC_i} + p_j^w \frac{\partial z}{\partial p_j}\frac{d\theta_j}{dC_i} \gtrless 0$ is assumed to be "small." We obtain $\frac{dC_i}{dC_j} = -1 - a\frac{dW}{dC_j}$ by differentiating equation (2.6) with respect to C_j. Setting $a \to 0$ we obtain $\frac{dC_i}{dC_j} = -1$, which we, for simplicity, assume to be the case here.

Rearranging equation (2.13a) we then obtain $\frac{d\theta_i}{dC_i} = \frac{1+T_i\frac{dz}{dC_i}}{p_i^w y_i} > 0$ as long as $1 + T_i\frac{dz}{dC_i} > 0$. From (2.13b) we similarly obtain $\frac{d\theta_i}{dC_j} = \frac{-1+T_i\frac{dz}{dC_j}}{p_i^w y_i} < 0$ as long as $-1 + T_i\frac{dz}{dC_j} < 0$. Intuitively, the first result makes sense since if higher political contributions did not yield higher tariffs, firms would have no incentive to lobby (Damania [12]). Even the latter result makes sense since lobby j lobbies for a lower tariff/subsidy to sector i, and consequently, its contribution must have this effect for lobbying to be sensible.

It can further be easily shown that sector i's "own" contribution has a greater effect on its tariff/subsidy rate than the contribution of sector j, i.e., $\frac{d\theta_i}{dC_i} > -\frac{d\theta_i}{dC_j}$, iff $\left[\frac{dz}{dC_i} + \frac{dz}{dC_j}\right] = p_i^w \left[\frac{d\theta_i}{dC_i} + \frac{d\theta_i}{dC_j}\right]\frac{\partial z}{\partial p_i} + p_j^w \left[\frac{d\theta_j}{dC_j} + \frac{d\theta_j}{dC_i}\right]\frac{\partial z}{\partial p_j} > 0$. If $\left[\frac{dz}{dC_i} + \frac{dz}{dC_j}\right] = 0$, then it does not matter which sector lobbies, since the contributions have similar effects, and if $\left[\frac{dz}{dC_i} + \frac{dz}{dC_j}\right] < 0$, then sector j's contribution has a greater effect than sector i's.

2.3.4 The effect of trade liberalization on land allocation

In this section we conclude the implications of an increase in the world market price of food on land use in both agriculture and forestry.[9] We interpret changes in the international prices as unilateral foreign trade liberalization.[10] This can be

[9] The case where the world market price of food falls is analogous.

[10] International price fluctuations in agricuture are also influenced by factors other than trade liberalization. The most powerful of these factors would seem to be the weather. Whereas the

thought of, for instance, as the effect of unilateral liberalization of agricultural trade by the EU or the US on small countries. Whereas we recognize the probability of such unilateral exogenous trade liberalization to be low, the reciprocal trade liberalization demanded from, especially, the developing countries tends to be in areas other than agriculture and forestry, such as in industrial goods and services. Since we have included neither trade in manufactures, nor the international negotiation process in the model, we consider it sufficient to take foreign trade liberalization as exogenous.[11] Thus, an increase in p_A^w is interpreted either as caused by a lowering of (increase in) an import tariff (subsidy) or the removal of (increase in) an export subsidy (tax) in large foreign countries. A fall in p_A^w is caused by an opposite action by the foreign countries.

We summarize the effect of an increase in the world market price of food on the relative tariff rate in the following proposition:

Proposition 2.3 *In the political optimum, the relative tariff rate in agriculture to forestry increases in the world market price of food.*

Proof. We obtain the change in the relative tariff rate to the world market price of food by differentiating $(\theta_A - \theta_F)$ with respect to p_A^w to obtain $\frac{d(\theta_A - \theta_F)}{dp_A^w} = \frac{\partial \theta_A}{\partial C_A}\frac{\partial C_A}{\partial p_A^w} + \frac{\partial \theta_A}{\partial C_F}\frac{\partial C_F}{\partial p_A^w} - \frac{\partial \theta_F}{\partial C_A}\frac{\partial C_A}{\partial p_A^w} - \frac{\partial \theta_F}{\partial C_F}\frac{\partial C_F}{\partial p_A^w}$. This can be signed using equations (2.11a) and (2.11b) along with equations (2.13a) and (2.13b), which yields $\frac{d(\theta_A - \theta_F)}{dp_A^w} > 0$. ■

As was shown in lemma 2.1, an increase in the output price of food leads to land reallocation from forestry to agriculture. How much the output price changes depends, however, both on changes to the world market price of food, p_A^w, and on changes to the tariff/subsidy rate in agriculture, θ_A. We obtain the change in the output price of food to a change in the world market price of food as $\frac{dp_A}{dp_A^w} = (1 + \theta_A) + p_A^w \frac{\partial \theta_A}{\partial p_A^w}$. For the forestry sector this yields a change in land use of

$$\frac{dT_F}{dp_A^w} = \left[(1 + \theta_A) + p_A^w \frac{d\theta_A}{dp_A^w}\right] \frac{\partial T_F}{\partial z}\frac{\partial z}{\partial p_A} < 0 \tag{2.14a}$$

and for the agricultural sector, land use changes by

$$\frac{dT_A}{dp_A^w} = \left[(1 + \theta_A) + p_A^w \frac{d\theta_A}{dp_A^w}\right] \left[\frac{\partial T_A}{\partial p_A} + \frac{\partial T_A}{\partial z}\frac{\partial z}{\partial p_A}\right] > 0. \tag{2.14b}$$

effect of exceptionally good or bad weather is passing, however, the effect of trade liberalization should result in structural changes to the economy, which have an impact on prices even in a longer perspective.

[11] For an analysis of how the multilateral trading system and trade negotiations work, see, e.g., Bagwell and Staiger (1999). For an analysis of reciprocal trade liberalization between two large countries, see, e.g., Grossman and Helpman (1995).

The tariff/subsidy on agriculture falls in the social optimum as shown in Section 2.3.2, i.e., $\frac{d\left(\theta_A^{so}-\theta_F^{so}\right)}{dp_A^w} < 0$. This mitigates the land use change both in forestry and in agriculture by making the multiplicand $\left[(1+\theta_A)+p_A^w \frac{d\theta_A}{dp_A^w}\right]$ smaller. Consequently, the government acts to counter the effect of the increase in the world market price of food on land allocation to some extent. Nevertheless, even in the social optimum land will be reallocated towards agriculture given that $-\frac{d\theta_A}{dp_A^w} < \frac{(1+\theta_A)}{p_A^w}$, which we assume to be the case.[12]

Since the tariff/subsidy rate on agriculture increases in p_A^w from proposition 2.3, land use in forestry falls by the amount given by equation (2.14a), where $\frac{d\theta_A}{dp_A^w} > 0$. In a corresponding way, land demand by agriculture increases. The change in land demand in the political equilibrium is reinforced by the change in the tariff/subsidy on agriculture, and land demand in forestry falls by more than would be socially optimal. Similarly, land demand by agriculture increases more than would be socially optimal. The political economy considerations consequently lead to excessive deforestation from a socially optimal point of view.

We end by examining what happens to the relative output prices. We noted in Section 2.2 that $\frac{p_A^{w0}}{p_F^{w0}} < \frac{p_A^w}{p_F^w}$. Starting by studying the social optimum, we know that $\theta_A^{so} - \theta_F^{so} < 0$ and that θ_A falls in p_A^w. We then have $\frac{p_A^{so0}}{p_F^{so0}} < \frac{p_A^{w0}}{p_F^{w0}} < \frac{p_A^{so}}{p_F^{so}} < \frac{p_A^w}{p_F^w}$, i.e., we know that the relative output price after the increase in p_A^w lies between the initial relative output price and the world market price, and that since the domestic price moves in the same direction as the world market price (see Hillman [19]), the output price is nevertheless higher than the initial relative world market price.

Turning to the political optimum, we simplify the analysis by assuming that in period 0 the tariff rates were set at their socially optimal levels. We then obtain two cases. In the first one the tariff rate on agriculture increases in p_A^w as shown in proposition 2.3, but not enough for the relative tariff/subsidy rate to become positive, i.e., we still have $\theta_A - \theta_F < 0$. Then, $\frac{p_A^{so}}{p_F^{so}} < \frac{p_A}{p_F} < \frac{p_A^w}{p_F^w}$, i.e., we know that the politically optimal output price is lower than the world market price, but that it is nevertheless higher than the socially optimal relative price. If the tariff/subsidy on agriculture rises sufficiently so that $\theta_A - \theta_F$ becomes positive, we obtain the result that $\frac{p_A^{so}}{p_F^{so}} < \frac{p_A^w}{p_F^w} < \frac{p_A}{p_F}$, i.e., that the relative output price actually exceeds the world market price. This sends the signal that the country has a comparative advantage in agriculture, which, considering the positive externality arising from forestland is not the case in reality.

[12]Hillman [19] shows that the domestic price moves in the same direction as the world market price. Therefore, even though the fall in the tariff/subsidy on agriculture serves to counter the increase in p_A^w to some extent, it will not negate the effect completely.

Relating the above analysis to a standard Dutch disease -type of examination using socially optimal tariffs, we note that the government would use trade taxation on agriculture and forestry to counter the effect of a rise in the world market price of agriculture, therefore alleviating the effect of the boom. If, however, the government is susceptible to lobbying, the price rise strengthens the agricultural lobby so that the relative tariff rate turns more to that sector's advantage. The inclusion of lobbying thus reallocates more land than would be socially optimal towards agriculture. In the extreme case where the absolute level of tariffs/subsidies given to agriculture actually exceeded those given to forestry (i.e., if $\theta_A - \theta_F$ is positive), the relative output price of food to logs would be above the world market price. This has the effect of allocating more land to agriculture than what would be dictated by the world market price even in the absence of the positive externality. A boom in agriculture therefore worsens the situation. Consequently, according to our analysis, political economy considerations may easily worsen a "Dutch disease" where productive resources move from one sector to another as a response to world market price changes. Whereas the initial, "socially optimal" movement of resources raises the national income, the political economy considerations really lead to a "disease" since the situation, in the present context, would only lead to excessive deforestation. Similarly, in the more traditional Dutch disease -type of contexts the type of effect delineated here would lead to an excessive contraction of, for instance, the manufacturing industries (analogous to forestry here).

Finally, it is noteworthy that trade taxation by countries that are susceptible to lobbying and that have more productive agricultural sectors as compared to the forestry sector get a perceived, as compared to real, comparative advantage in the production of food. This finding complements the finding by Chichilnisky [10], who shows how poorly defined property rights may lead to a similar situation and consequently, to excessive resource use.

2.4 Extensions

2.4.1 Exogenous land subsidy

In this section we will briefly consider how the introduction of an optimal policy instrument in order to internalize the positive externality from forestland, namely a subsidy to land use in forestry, would affect the equilibrium trade tax/subsidy rate. To consider an exogenous land use subsidy is naturally unsatisfactory since political economy considerations certainly affect the determination of such a tax as well. In order to keep the model tractable, however, we will contend ourselves with an exogenous subsidy rather than endogenizing it. For the political economy of land taxation in the presence of externalities, we refer the reader to Hammes [18].

We consider an exogenously determined land use subsidy to forestry, denoted by s_F. Equation (2.1) for the forestry sector then becomes

$$\Pi_F(p_F,\ T_F) = p_F y_F(T_F,\ L_F) - (z - s_F) T_F - C_F(\mathbf{p},\ \mathbf{p}^w), \tag{1'}$$

whereas the profit function of the agricultural sector does not change. Total land use is given by

$$T_A(p_A,\ z) + T_F(p_F,\ z,\ s_F) = 1, \tag{2'}$$

which yields the cost of land function as $z \equiv z(\mathbf{p},\ s_F)$. The cost of land increases in the subsidy: $\frac{\partial z}{\partial s_F} > 0$.[13]

Total government revenue is given by

$$R(\mathbf{p},\ s) = \sum_{i=A,\ F} \theta_i p_i^w \left[d_i(p_i) - y_i\left[T_i(p_i,\ z,\ s_i)\right]\right] - s_F T_F. \tag{3'}$$

Since the land use subsidy is exogenous, it does not affect the results in lemma 2.1. Solving for the socially optimal relative tariff/subsidy rate, i.e., maximizing equation (2.6) when $a \to \infty$ yields

$$\theta_A^{so} - \theta_F^{so} = \frac{\left[s_F - \phi'(T_F)\right] \delta_A^0 \varepsilon_{T_F,\ p_A}}{\varepsilon_{M_A,\ p_A}}. \tag{8'}$$

It is clear that if the land use subsidy is set at its socially optimal level so that it equals the marginal utility from forestland, $s_F = \phi'(T_F)$, then the socially optimal relative tariff rate is zero. Consequently, in this case the government does not have to use tariffs/subsidies in order to internalize the negative externality.

If the land use subsidy is set at a lower than optimal level, the government will however use trade tariffs/subsidies in order to correct for the externality and will, as before, give relatively more protection to the forestry sector, i.e., $\theta_A^{so} - \theta_F^{so}$ is negative. If the subsidy is higher than the marginal utility from the externality, this is corrected for by giving more protection to the agricultural sector relative to the forestry sector and consequently, $\theta_A^{so} - \theta_F^{so}$ is positive. Therefore, the inclusion of the exogenous subsidy creates an ambiguity to the sign of equation (8') as compared to equation (2.8).

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[13] Differentiating (2') with respect to s_F yields $\frac{\partial z}{\partial s_F} = -\frac{\partial T_F/\partial s_F}{(\partial T_A/\partial z)+(\partial T_F/\partial z)}$, where we assume that land demand by forestry increases in the subsidy: $\frac{\partial T_F}{\partial s_F} > 0$.

As for the political optimum, the government's maximization problem yields

$$I_i \frac{dC_i}{d\theta_i} + I_j \frac{dC_j}{d\theta_i} = -ap_i^w \left[\theta_i p_i^w \frac{dM_i}{dp_i} + \theta_j p_j^w \frac{dM_j}{dp_i} - s\frac{\partial T_F}{\partial z}\frac{\partial z}{\partial p_i} + \phi'(T_F)\frac{dT_F}{dp_i} \right], \quad (9')$$

and for the lobby groups we obtain marginal conditions equal to those given in (2.11a) and (2.11b). Solving for the equilibrium relative trade taxes/subsidies in the political optimum yields

$$\theta_A - \theta_F = \frac{I_A p_A y_A - [I_A T_A + I_F T_F] z\varepsilon_{z,\, p_A}}{ap_A^w M_A \varepsilon_{M_A,\, p_A}} + \frac{[s - \phi'(T_F)]\, \delta_A \varepsilon_{T_F,\, p_A}}{\varepsilon_{M_A,\, p_A}} \quad (12a')$$

$$\theta_F - \theta_A = \frac{I_F p_F y_F - [I_A T_A + I_F T_F] z\varepsilon_{z,\, p_F}}{ap_F^w M_F \varepsilon_{M_F,\, p_F}} - \frac{[s - \phi'(T_F)]\, T_F \varepsilon_{T_F,\, p_F}}{p_F^w M_F \varepsilon_{M_F,\, p_F}} \quad (12b')$$

These are again similar to equations (2.12a) and (2.12b) except for the land subsidy, s_F, entering the latter term on the RHS. Solving for when the agricultural sector gets a relatively higher tariff rate than the forestry sector, i.e., when $\theta_A - \theta_F > 0$, yields, by a calculation similar to that executed in the proof of proposition 2.2,

$$I_A p_A y_A > I_F p_F y_F - a\,[s - \phi'(T_F)]\, T_F\, [\varepsilon_{T_F,\, p_F} + \varepsilon_{T_F,\, p_A}]\,. \quad (2.15)$$

If $s_F = \phi'(T_F)$, the latter term on the RHS is equal to zero. It is then easy to see that given that the agricultural sector organizes a lobby group, it is sufficient for the value of its production to be greater than the forestry sector's production value for the agricultural sector to get a higher tariff/subsidy than the forestry sector. If $s_F < \phi'(T_F)$, then the latter term on the RHS is positive, thus raising the value of production in agriculture, which is required for that sector to get a higher tariff/subsidy rate, as before, and if $s_F > \phi(T_F)$, the higher subsidy to land use in forestry actually aids the agricultural lobby's attempts to get a higher tariff rate relative to the forestry sector.

Consequently, the inclusion of an exogenous land use subsidy to the forestry sector does not change the results obtained above in Section 2.3.2, except that it makes it easier for the agricultural lobby to obtain a more favorable tariff rate than in its absence. This is because if there is a land use subsidy given to the forestry sector, lobbying only determines the relative tariff rate between the two sectors, and considerations of internalizing the positive externality enter the calculation only to the extent to which the land use subsidy deviates from the optimal subsidy. Consequently, even in the presence of a land use subsidy to forestry, a strengthening of the agricultural lobby because of an increase in p_A^w will lead to excessive deforestation according to an analysis similar to the one executed in Section 2.3.4.

2.4.2 Co-operative lobbying

In some countries, such as Finland and Sweden, one umbrella lobby group represents both those owning agricultural land and those owning forest land.[14] Although separate "sections" exist both for agriculture and forestry within the umbrella group, it is possible that the umbrella lobby group co-ordinates actions between the two sections so as to prevent them from competing in lobbying.

In order to study this we solve the model above for the case where only one lobby group exists that coordinates lobbying both for the agricultural and the forestry sectors. The lobby group's objective function becomes

$$W_L(\boldsymbol{\theta},\ z) = \Pi_A(p_A,\ T_A) + \Pi_F(p_F,\ T_F), \tag{5”}$$

where Π_i is given by equation 2.1. The government's problem remains the same as above.

We solve the lobby group's maximization problem, equation (2.4) for respective tariff rate, keeping the other tariff rate constant and assuming that the lobby group organizes so that we supress the indicator variable I for lobby organization. Substituting the resulting expression into the government's objective function 2.6 and solving for the equilibrium tariff rates yields

$$\theta_A - \theta_F = \frac{p_A y_A - z\varepsilon_{z,\ p_A}}{a p_A^w M_A \varepsilon_{M_A}(p_A)} - \frac{\phi'(T_F)\,\delta_A \varepsilon_{T_F,\ p_A}}{\varepsilon_{M_A}(p_A)} \tag{12a”}$$

$$\theta_F - \theta_A = \frac{p_F y_F - z\varepsilon_{z,\ p_F}}{a p_F^w M_F \varepsilon_{M_F}(p_F)} + \frac{\phi'(T_F)\,\delta_F \varepsilon_{T_F,\ p_F}}{\varepsilon_{M_F}(p_F)}. \tag{12b”}$$

As before, in social optimum we have $\theta_A - \theta_F < 0$ because of the externality. Lobbying again introduces an ambiguity to the relative tariff rate. Thus, it is possible that the relative tariff rate $\theta_A - \theta_F$ is positive if

$$p_A y_A > p_F y_F + a\phi'(T_F)\,T_F\left(\varepsilon_{T_F,\ p_A} + \varepsilon_{T_F,\ p_F}\right).$$

This condition is similar to that found above, except for the absence of the indicator variable. Therefore, even though an umbrella lobby group hinders the competition between the two lobbies, the direction of lobbying will still be determined by the value of production in each sector, mitigated by the marginal externality.

It is thus possible that even an umbrella lobby group that maximizes the sum of profits from the two sectors lobbies for a higher tariff rate in agriculture relative

[14]In Finland that lobby group is MTK (Maa- ja metsätaloustuottajain Keskusliitto) and in Sweden LRF (Lantbrukarnas Riksförbund).

to that in forestry. This has all the same consequences to land allocation as those delineated in section 2.3.4.

2.5 Conclusions

In this study we have considered the effect that a rise in the world market price of food has on land use change between agriculture and forestry in the presence of two lobbies. We have added to the literature examining tariff determination (e.g., Grossman and Helpman [16], Schleich [26]) a general equilibrium effect, which, through a mechanism reminiscent of the so-called Dutch disease, leads to a contraction in one sector as the other sector expands. We further show that if the government is not susceptible to lobbying, it will use trade taxation to counter the effect that an increase in the world market price of food has on forests, so that the change in land allocation will be less than what would be the case in the absence of trade taxation and externalities from the model. If, however, the government is susceptible to lobbying, the increase in the strength of the agricultural lobby, due to a higher world market price, will lead to an opposite effect and more land will be allocated to agriculture than what would be socially optimal.

Another finding of this paper is that qualifying the findings from the senescent industry literature. We have shown that their results depend on the assumptions; mainly that the declining industry is studied in isolation from the rest of the economy. Rather than declining industries being able to lobby preferential tariff/subsidy treatment to themselves, in the present model the government will mitigate the effect of an increase in the world market price in the *social optimum* because of a positive externality from the declining industry, not as a result of increased lobbying by the declining forestry sector. We thus find an effect quite to the contrary to the declining industry literature where declining industries lobby more than growing ones.

The analysis of the Dutch disease in this study is somewhat lacking, however, since we have not considered the effects of changes in labor demand and movements of capital. Nevertheless, the changes in land use can be compared to the effect of changes in capital. Thus, what we show is how the equilibrium outcome changes when lobbying by interested lobby groups is taken into account and affect the final allocation of productive resources. Explicitly including capital and labor movements into the model is however left for future research.

Finally, our results also add to the understanding of factors driving international trade. Thus, the susceptibility of a government to lobbying, together with the presence of lobbies, may lead to a country setting its relative levels of trade taxation in such a way that it gets a perceived, as compared to real, comparative advantage in one sector, in the present case agriculture. This leads to over-conversion of forestland to agriculture.

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Chapter 3

An Empirical Examination of Land Taxation in EU-15

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Abstract: We test the hypothesis that governments determine the taxation of agricultural land by taking into account both contributions by agricultural and forestry lobbies, and social welfare. According to the theory, lobby strength is inversely proportional to the elasticity of land demand by respective sector. Furthermore, we assume that fertilizer, herbicide and pesticide use by agriculture causes a negative externality from that sector. We find empirical support to our hypothesis that a strengthening of the agricultural lobby lowers the land tax and that environmental concerns affect the tax, the effect however being exponential rather than linear. We further find some evidence for the hypothesis that technological progress affects land taxation. The effect works through the effect of technology on the negative externality produced by the agricultural sector. Finally, we find some support for a hypothesis suggesting that richer farmers lobby more and consequently get a higher land subsidy.

JEL Classification: C23, D29, D72, H23

Keywords: Land tax, technology, EU-15, panel data

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3.1 Introduction

Land taxes contribute a disappearingly small proportion of government revenue; this regardless of the literature advocating land taxes in order to boost government revenue and economic growth, which is both old and extensive. It starts with David Ricardo [26], although the greatest proponent of land taxation historically was Henry George [19]. More modern treatises include Feldstein [14], Calvo *et al.* [5] and Eaton [8], who all come to the conclusion that land taxes are good for the general welfare. Lindholm [25] discusses the fact that land is rarely taxed. His explanation is based on a distinction between equity and efficiency, where in practice the former seems to prevail thus preventing the use of land taxes. Jussila Hammes [24] offers an alternative explanation by constructing a political economy model where the presence of agricultural lobbying and technological progress in agriculture explains why land is not taxed but rather subsidized. The aim of this paper is to test the latter model empirically, using 1990-2002 data from 15 European Union countries.

According to the theoretical model underlying this investigation, land taxation is determined by two factors, namely the relative strength of the lobbies in the two sectors that use land as a factor of production, agriculture and forestry, and by the environmental externalities that agriculture produces. The model is based on Grossman and Helpman's [22] principal-agent model with menu auctions, which they use to theoretically study the determination of trade taxation. Grossman and Helpman's model has been tested empirically by Goldberg and Maggi [20] and by Gawande and Bandyopadhyay [18], who both found empirical support, and by Eicher and Osang [10] who compare its performance to other empirical models attempting to explain trade protection. Grossman and Helpman's model fares well also in this comparison. Ederington and Minier [9] further include into their examination the simultaneous determination of several policy instruments, and still find support for Grossman and Helpman's model.

The literature examining the determination of areas of policy other than trade policy within the general framework proposed by Grossman and Helpman has also flourished. Fredriksson and Svensson [17] examine the determination of environmental policy when the government is corruptible and possibly unstable, finding support for their hypothesis that not only do corruptibility and political instability as such impact on the level of environmental policy, but that these two factors interact. Damania, Fredriksson and List [6] study the conjunction of trade policy, corruption, and environmental policy, again finding support for the hypothesis that the effect of trade liberalization on environmental policy depends on the degree of governmental corruption. Fredriksson and Mani [16] study the effect of trade openness and political stability on environmental policymaking. They find empirical support for their hypothesis that trade integration affects the stringency of environmental policies because of changes in industry bribery behavior, and that the effect is conditional on the degree of political stability. Barbier and Damania [3] examine the effect of government corruption and trade liberalization on deforestation, again finding empirical support for the hypothesis that corruption matters for the deforestation rate, and that corruption and trade openness interact in determining the deforestation rate.

The theoretical chain of influence in the present paper works as follows: Like in Grossman and Helpman [22], the government is susceptible to lobbying and decides its land taxation policy as a weighted sum of contributions by the affected industries and considerations of social welfare. The agricultural lobby attempts to influence the government in order to secure a lower level of land taxation, or preferably, a higher land subsidy. The forestry sector for its part suffers if land use in agriculture is subsidized since the two sectors compete for land with each other, and subsidized land use in agriculture increases that sector's demand for land and thereby increases the cost of land to forestry. Therefore, the forestry lobby lobbies the government to raise the land tax on agriculture.

The estimation of lobby strength in the present study differs somewhat from Goldberg and Maggi [20] and Gawande and Bandyopadhyay [18]. Both of these studies construct measures of lobby organization from lobby contributions to Political Action Committees, along with using previously estimated elasticities of import demand as measures of lobby strength. We do not have data on lobby contributions; instead we estimate whether or not the forestry lobby organizes, using data on forest stock per capita in each respective country. The assumption is that if the forest stock per capita is high enough, the economic stakes in forestry are great enough for a lobby to form. We further assume that the agricultural lobby always organizes. Furthermore, since prior estimates of the land demand elasticities in the various European countries are not available, we have been forced to estimate the elasticity of land demand in respective sector and country. Following the theoretical argument in Section 3.2, the relative lobby strength equals the inverse of the elasticity of land demand, multiplied by an indicator variable for the forestry sector indicating whether or not that lobby organizes in each respective country. This distinguishes our study also from Eicher and Osang [10], who use lobby contributions to estimate the strength of each lobby.

We further assume that land use for agriculture produces a negative net externality as compared to forestry. The main source of this externality is assumed to be fertilizer, pesticide and herbicide run-off from fields. Other possible sources of external effects would include changes in biodiversity, although this works in both ways, CO_2 sequestration by growing forests, watershed protection by forests and amenities from an open landscape. Assuming that the latter sources of external effects more or less cancel each other out, we consider a negative *net* externality from agriculture, and approximate it by including measures for expenditure on fertilizers and crop protection. The effect of the externality is assumed to be to raise the level of land taxation.

An additional question of interest in the present inquiry is the effect that technological change in agriculture has on land taxation. In order to shed light to this effect, besides running a regression with lobby strength and an environmental variable in it, we run three regressions with varying measures for the level of technological progress in agriculture. The evidence for the relevance of these variables is not quite straightforward, however. One of the proxies gets insignificant coefficients throughout, the second one gets significant coefficients going in the opposite direction from the predicted and the third one works as expected with significant coefficients. Therefore, we do not make any definite conclusions about the effect of technological change but note that it nevertheless seems to have some effect on land taxation.

Finally, we run a tentative test of the hypothesis forwarded by Bombardini [4], who suggests that larger firms, in our case farmers, are more likely to organize a lobby and besides, give greater contributions to lobbies which in turn leads to more advantageous policies to those sectors with larger firms. We find some support for the hypothesis that the level of land taxation is lower the larger the economic size of agricultural holdings. However, these results are somewhat inconclusive since one of the two measures that we include is insignificant, although with the correct sign. The other measure used is nevertheless significant thus indicating that the larger the average size of farms, the lower the land taxation or the greater the land subsidization.

The two main results of the paper, however, are firstly to find empirical support for our theoretical proposition of the importance of lobby strength in determining the level of taxation. The empirical examination lends support for the hypothesis that land tax policy is set after lobbying by the two lobby groups. Furthermore, we find evidence indicating that the greater the expenditure on fertilizers and crop protection, the higher the land tax. The effect is not linear however, and moreover, at low levels of expenditure this effect actually serves to lower the land tax.

The paper is organized as follows. In Section 3.2 we briefly review the theory developed in Jussila Hammes [24]. In Section 3.3.1 we discuss the data and its sources, and in Section 3.3.2 we present the empirical specification of the theoretical model. Section 3.4 discusses the regression results, where in Section 3.4.1 we present results for the estimation of the elasticities of land demand in agriculture and forestry, and in Section 3.4.2 the results for the land tax. Finally, Section 3.5 concludes.

3.2 The Theoretical Model

In this section we briefly review the theoretical model underlying our empirical examination.

Assume a continuum of individuals, normalizing population size to one. Individuals have identical preferences, given by $U^h = x_O + \sum_{i=A,\ F} u_i(x_i) - \phi(T_A)$, where x_O denotes consumption of the numeraire good and x_i consumption of good $i = \{A,\ F\}$, $i \neq j$, food and logs, respectively. u_i is increasing and concave, and the damage function from agricultural land use, $\phi(T_A)$, where T_A is land use in agriculture, is increasing and convex. These preferences imply demand $d_i(p_i)$, which is the inverse of $u_i'(x_i)$. The indirect utility of an individual with income E is given by $v(\mathbf{p},\ E) = E + S(\mathbf{p}) - \phi(T_A)$, where $S(\mathbf{p})$ is the consumer surplus and p_i is the exogenously given output price of good i.

The numeraire good is produced using labor alone, and goods A and F are produced using land and labor. We assume the labor supply l to be large enough to ensure a positive supply of the numeraire good. The wage rate can then be normalized to one. The return to land in sector i depends on p_i, the cost of land z_i and technology H_i: $\Pi_i(p_i,\ z_i,\ H_i)$. Hotelling's lemma $\frac{\partial \Pi_i}{\partial z_i} = -T_i(p_i,\ z_i,\ H_i)$ yields land demand by sector i.

The government has only one policy instrument at its disposal, namely a land tax or subsidy on agriculture.[2] The tax introduces a wedge between the value of land, z, and the cost of land to agriculture, $z_A \equiv (1 + t_A)z$, where $t_A > 0$ represents a land tax and $-1 < t_A < 0$ a land subsidy. The value of land is determined from the constraint on total land:

$$T_A(p_A,\ z_A,\ H_A) + T_F(p_F,\ z_F,\ H_F) = 1, \tag{3.1}$$

which yields $z(\mathbf{p},\ t_A,\ \mathbf{H})$. The value of land falls in the land tax:

$$\frac{\partial z/\partial t_A}{z} = -\frac{(\partial T_A/\partial z_A)}{(1 + t_A)(\partial T_A/\partial z_A) + (\partial T_F/\partial z)} < 0. \tag{3.2}$$

The government redistributes the revenue from (the cost of) the land tax (subsidy), which is given by $R(t_A,\ z) = t_A z T_A$, in a lump-sum fashion to (from)

[2] For a discussion on the determination of several simultaneous policy instruments, see Dixit [7], Schleich [27] and Ederington and Minier [9].

all citizens. Summing all indirect utilities over individuals yields the aggregate welfare function:

$$W(t_A) \equiv l + \sum_{i=A,\ F} \Pi_i(p_i,\ z_i,\ H_i) + R(t_A,\ z) + S(\mathbf{p}) + z - \phi(T_A). \tag{3.3}$$

We assume that at most two lobbies organize, namely one for agriculture and one for forestry. Following Aidt [1], the lobbies are assumed to be functionally specialized. Summing over the indirect utilities of the lobby members yields the lobby's aggregate welfare:

$$W_i(t_A) \equiv \Pi_i(p_i,\ z_i,\ H_i). \tag{3.4}$$

Lobby i's objective is given by $W_i(t_A) - C_i(t_A)$, where $C_i(t_A)$ denotes the contributions paid to the government. The government's objective is a combination of welfare and contributions:

$$G = \sum_{i=A,\ F} C_i(t_A) + aW(t_A), \quad a > 0, \tag{3.5}$$

where a represents the government's weighing of a unit of social welfare to a unit of contributions. The higher the a, the less weight the government gives to contributions, and the land tax is set according to what is considered to be socially optimal.

The equilibrium is derived in differentiable strategies and follows Grossman and Helpman [22], Dixit [7] and Fredriksson [15]. Thus, policy making is modeled under lobby influence as a two-stage common agency game. The politically optimal policy vector can be characterized by the following equation:

$$\sum_{i=A,\ F} \nabla W_i(t_A) + a\nabla W(t_A) = 0. \tag{3.6}$$

Differentiating equations (3.3) and (3.4), and substituting them into (3.6) and using (3.2) yields the equilibrium land tax rate:

$$t_A = \delta^0 \left[-\frac{I_A}{\varepsilon^A_{T,\ z}} + \frac{I_F}{\varepsilon^F_{T,\ z}} + \frac{a\phi'(T_A)}{z} \right], \tag{3.7}$$

where $\varepsilon^i_{T,\ z} = -\frac{\partial T_i}{\partial z_i}\frac{z_i}{T_i} > 0$ is the price elasticity of land demand, I_i is an indicator variable a taking value of one if lobby $i \in \{A,\ F\}$ organizes and zero otherwise, and $\delta^0 = \frac{\varepsilon^A_{T,\ z}}{a\varepsilon^A_{T,\ z} + I_A} > 0$. The first and the second terms on the RHS arise from lobbying by the agricultural and the forestry sector, respectively. The last term arises from the negative net externality from agriculture. Note that the sign of the tax equation depends on the elasticity of land demand in agriculture. Thus, we might have a land subsidy if a is sufficiently low and given that land demand in agriculture is sufficiently inelastic:

$$0 < \varepsilon_{T,\ z}^{A} < \frac{I_A z \varepsilon_{T,\ z}^{F}}{I_F z - a\phi'(T_A)\,\varepsilon_{T,\ z}^{F}}. \tag{3.8}$$

It is further noteworthy that in social optimum (if $a \to \infty$ or if no lobbies organize) land will always be taxed: $t_A^{so} = \frac{\phi'(T_A)}{z} > 0$.

We can now formulate the first prediction of our model:

Proposition 3.1 *Given that the government is susceptible to lobbying:*

1. *A fall in the elasticity of land demand in agriculture lowers the land tax.*
2. *A fall in the elasticity of land demand in forestry raises the land tax.*
3. *The coefficient on the term measuring the impact of the agricultural lobby is equal to the negative of the coefficient on the term measuring the impact of the forestry lobby, and equals δ^0 for agriculture.*
4. *The effect of the externality on the land tax is non-linear. It serves to raise the tax more the more convex the damage function.*

As was noted above, land demand is a function of technologies. We normalize technology in forestry to one and examine the effect of an improvement in agricultural technologies. The value of land increases in agricultural technology:

$$\frac{\partial z}{\partial H_A} = -\frac{\partial T_A / \partial H_A}{(1 + t_A)(\partial T_A / \partial z_A) + (\partial T_F / \partial z)} > 0. \tag{3.9}$$

An improvement in the agricultural technologies increases land demand by agriculture and lowers it by forestry. This is so because $\frac{dT_F}{dH_A} = \frac{\partial T_F}{\partial z}\frac{\partial z}{\partial H_A} < 0$ and $\frac{dT_A}{dH_A} + \frac{dT_F}{dH_A} = 0$.

Totally differentiating the tax equation (3.7) with respect to H_A yields the effect of technological change on the land tax rate:

$$\frac{dt_A}{dH_A} = \frac{I_A(1+t_A)(\varepsilon_{z,\ H_A} - \varepsilon_{T_A,\ H_A})}{aH_A\varepsilon_{T,\ z}^{A}} - \frac{I_A(\varepsilon_{z,\ H_A} + \varepsilon_{T_F,\ H_A})}{aH_A\varepsilon_{T,\ z}^{F}} + \frac{\phi''(T_A)\,T_A\varepsilon_{T_A,\ H_A} - \phi'(T_A)\,\varepsilon_{z,\ H_A}}{zH_A}, \tag{3.10}$$

where $\varepsilon_{T_A,\ H_A} = \frac{dT_A}{dH_A}\frac{H_A}{T_A} > 0$ and $\varepsilon_{T_F,\ H_A} = -\frac{dT_F}{dH_A}\frac{H_A}{T_F} > 0$ is the elasticity of land demand to technology in agriculture and forestry, respectively, and $\varepsilon_{z,\ H_A} =$

$\frac{dz}{dH_A}\frac{H_A}{z} > 0$ is the elasticity of land price to technology. Technological change lowers the price elasticity of land demand in agriculture, $\varepsilon^A_{T,\ z}$, and it makes land demand in forestry, $\varepsilon^F_{T,\ z}$, more elastic:

$$\frac{\partial \varepsilon^A_{T,\ z}}{\partial H_A} = \frac{\varepsilon^A_{T,\ z}\left(\varepsilon_{z,\ H_A} - \varepsilon_{T_A,\ H_A} + \varepsilon_{t_A,\ H_A}\right)}{H_A} \leq 0 \tag{3.11a}$$

$$\frac{\partial \varepsilon^F_{T,\ z}}{\partial H_A} = \frac{\varepsilon^F_{T,\ z}\left(\varepsilon_{z,\ H_A} + \varepsilon_{T_F,\ H_A}\right)}{H_A} > 0. \tag{3.11b}$$

$\varepsilon_{t_A,\ H_A} = \frac{dt_A}{dH_A}\frac{H_A}{t_A} \gtrless 0$ is the elasticity of the land tax to technology.

It is then straightforward to show that the land tax falls in technological progress if the government is susceptible to lobbying, whereas it would be socially optimal for the tax rate to increase in technology (see Jussila Hammes [24]). These observations yield the model's second prediction:

Proposition 3.2 *The effect of technological change is:*

1. *To increase land demand by agriculture and to reduce it by forestry.*
2. *To make land demand by agriculture more inelastic and to make land demand by forestry more elastic. This leads to a fall in the land tax rate due to changes in lobbying.*
3. *To worsen the environmental externality by increasing agriculture's share of land. This serves to raise the land tax.*
4. *To increase the value of land and therefore lower land demand in agriculture to some extent as compared to a situation with constant land demand. This lowers the negative externality and serves to lower the land tax.*

3.3 Empirical Specification of the Model

3.3.1 Data and Variable Description

We test the predictions in propositions 3.1 and 3.2 using data from EU-15 countries[3] for the 1990 to 2002 period, except for Austria, Finland and Sweden, for which only the years 1995-2002 are used,[4] and Greece, France and the United Kingdom, for which 1990-2001 data is used. The data comes from a number of

[3] These are Belgium, Denmark, Germany, Greece, Spain, France, Ireland, Italy, Luxembourg, the Netherlands, Austria, Portugal, Finland, Sweden and the United Kingdom.

[4] These countries joined the EU in 1995 and therefore, data from the FADN is only available from this year onwards.

sources, the main ones being the Farm Accountancy Data Network (FADN) Public Database (European Commission [12]), the Farm Return (European Commission [11]), which underlies the FADN, and the Eurostat. Additional data comes from FAOSTAT [13], and the World Development Indicators [30]. The advantage of getting most of the used variables from the FADN and the Farm Return is that these data are comparable across countries. The data in these sources comes from surveys of farms in the EU member countries, and has been weighted to yield an aggregate measure for an average farm in each country.

Table 3.2 in the Appendix contains a short description of the variables used and Table 3.3 includes the summary statistics. We will do the estimation in two steps, first estimating the elasticity of land demand for agriculture and forestry, respectively, and then proceeding to fit the land tax equation.

We start the description of the data from variables used to estimate the elasticities of land demand. Data on land use for agriculture, expressed as a percentage of total land area, $agrarea_{kt}$, and for forestry, $forarea_{kt}$, come mainly from Eurostat.[5] As a proxy of food production per hectare, $agrprod_{kt}$, we use data from the FADN, summing variables Total output of crops & crop production and Total output of livestock & livestock products, given in constant 1995 ECU/euro, divided by the Total utilized agricultural area. For forestry production we use data on roundwood production in cubic meters per hectare from FAOSTAT [13] to obtain the variable $forprod_{kt}$.

As a proxy for the level of technology in agriculture we use the yield of wheat in 100 kg/ha, $wheat_{kt}$, from the FADN. To measure labor costs we include the variable $wage_{kt}$ which is Wages and social security charges of wage earners in constant 1995 ECU/Euro.

As a proxy for the cost of land we use the weighted average cost of capital, $r_{WACC_{kt}}$. This is calculated from information in the FADN as $r_{WACC_{kt}} = w_{1_{kt}} r_{D_{kt}} + w_{2_{kt}} r_{E_{kt}}$, where $r_{D_{kt}}$ is interest rate on debt, defined as the Interest paid divided by the sum of Long and medium term loans and Short term loans. The weight on the interest rate on debt, $w_{1_{kt}}$, is given by the ratio of Total liabilities to Total assets. The interest rate on equity, $r_{E_{kt}}$, is defined as the ratio of Cash flow to the Net worth (total assets - liabilities), and the weight on $r_{E_{kt}}$, $w_{2_{kt}}$, is given as the ratio of Net worth to Total assets.

Using the weighted average cost of capital as a proxy for the cost of land has both several advantages and several disadvantages. Among the disadvantages are the strong assumptions we have to make about arbitrage between different kinds of

[5] The data series for forest area were quite limited for some countries, however, and have been amended by data from FAOSTAT [13], WDI2002 [30] and the national statistical offices' homepages, and some missing observations between two existing data points have been extrapolated.

assets, and the assumption of perfectly functioning capital markets. Furthermore, since we assume the interest rate on land to be equal to the interest rate on capital, we have to assume the risk to be the same for both types of assets. Since the European capital markets are among the best-functioning in the world, despite national differences, we deem these caveats, although being important to consider, not to be of such great gravity as to impede our use of the measure.

On the positive side, as is clear from the theoretical part of the paper, a unit measure of land value, for instance land value per hectare, would be endogenous to the model. This is because the value of land is affected both by the taxes and the subsidies paid to agriculture. Since the amount of data points available is limited, solving the problem by two-stage estimation is deemed to be too costly with regard to the degrees of freedom available.[6] A measure of the interest rate applicable to the farmers on the other hand can be considered to be exogenous to the model. Since it not only applies to lending for investment in land but also to capital, changes in land taxation are not likely to have a great effect on it.

Finally, we have chosen to calculate a proxy for the cost of land by ourselves instead of simply using the bookkeeping value of land since this allows us to obtain a market value for land. This is considered important since it is the market value that drives the farmer's decisions; not the bookkeeping value. Besides, the above reasoning about the endogeneity of a measure for the unit value of land also applies to the bookkeeping value of land.

In order to obtain an estimate of the slope of the land demand curve for each country separately, we have created multiplicative dummy variables denoted by $r_{WACC}k_{kt}$, where k denotes the country in question.[7] Variables $r_{WACC}k_{kt}$ take the value of $r_{WACC_{kt}}$ for country k, and zero otherwise.

The dependent variable in the land tax estimating equation is the land tax or subsidy paid per hectare, $landtax_{kt}$, which has been calculated using data from the Farm Returns database and from the FADN. It is defined as Taxes on land and buildings minus Compensatory payments/area payments, divided by the Total utilized agricultural area. The Compensatory payments/area payments have been paid to producers as part of the reform of the Common Agricultural Policy (CAP) in 1992. The development of the level of land taxation, averaged over all the 15 countries for each year, is depicted in Figure 3.1.

The existence of the CAP might pose a problem to our argument of studying

[6] For the estimation of import demand elasticities using such a procedure, see, e.g., Shiells *et al.* [28].

[7] *bel* for Belgium, *den* for Denmark, *deu* for Germany, *ell* for Greece, *esp* for Spain, *fra* for France, *ire* for Ireland, *ita* for Italy, *lux* for Luxembourg, *ned* for the Netherlands, *ost* for Austria, *por* for Portugal, *fin* for Finland, *sve* for Sweden and finally, *uki* for the United Kingdom.

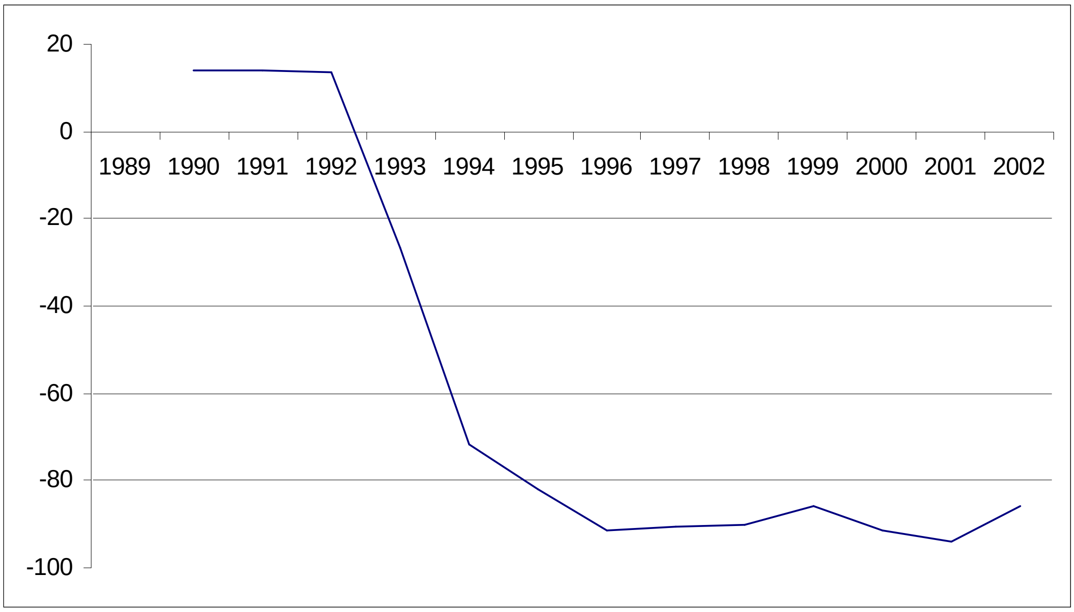

Figure 3.1: $landtax_{kt}$ in 1995 constant ECU/euro per hectare, averaged for each year across the sample.

land taxes set independently by sovereign states. This is because within the CAP, subsidies to agriculture are not decided by each respective country independently, but jointly within the European Communities (EC). Therefore, it might be argued that what we are testing is land taxation at a European level. While accepting that the argument is not entirely without a point, we would nevertheless like to argue for our use of the data. The reason for this is that whereas the subsidies are decided within the CAP, the taxes are still set by each country independently. As our dependent variable measures the *net* tax, which is positive if the taxes paid for land are greater than the subsidies obtained from the CAP, and negative if the subsidies exceed the taxes, the net rate of land taxation is still set independently by each country. Thus, while the countries by themselves cannot subsidize land use according to our use of the measure, they still determine whether land will be taxed or subsidized in net terms.

According to the theory, lobbying explains land taxation. Consequently, we construct a variable for relative lobby strength using the elasticities of land demand calculated from the first stage regression: $rellobbystrength_{kt} = -\frac{1}{agrelast_{kt}} + \frac{I_{F_{kt}}}{forelast_{kt}}$. The exact calculation of $agrelast_{kt}$ and $forelast_{kt}$ will be explained in Section 3.3.2. $I_{F_{kt}}$ is an indicator variable taking a value of one if the forestry lobby in country k organizes and zero otherwise. A quick search on the internet reveals, however, that forest owners in all EU countries organize some sort of lobby. In order to get an idea of the strength of these lobbies we use data on the Growing stock per capita (m^3 overbark/population) in 1995, obtained from

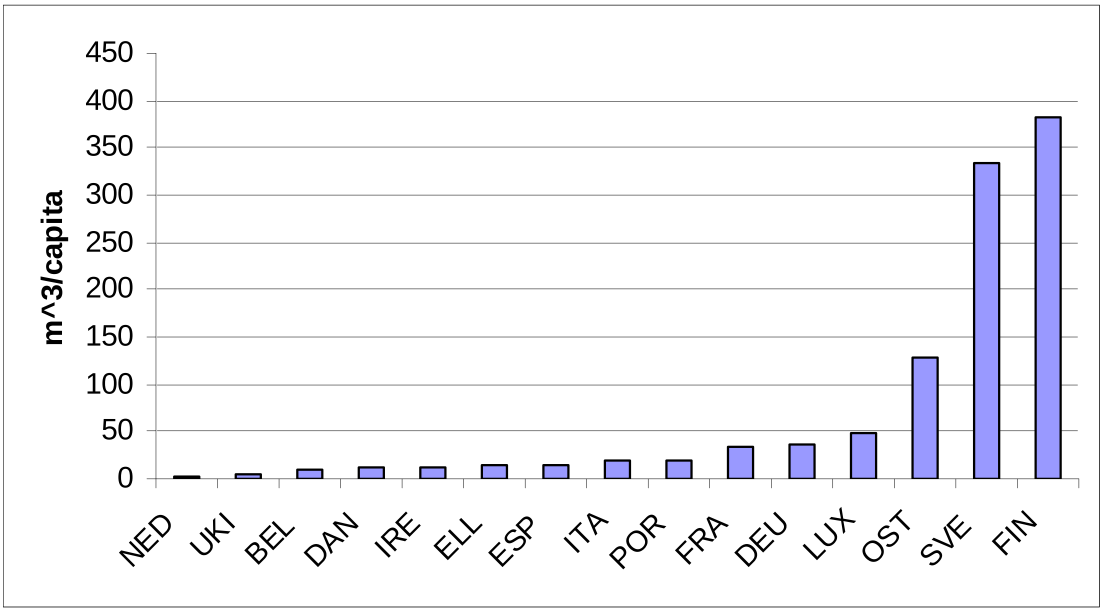

Figure 3.2: Forest stock in m^3/capita.

the Eurostat. As is clear from Figure 3.2, the countries fall quite naturally into two groups, one where the stock of forests per capita is low, and one where it is high. The dividing line goes between Portugal and France, where the former has a growing stock of about 20 m^3 and the latter 34 m^3 per capita. This procedure yields forestry lobbies in Germany, France, Luxembourg, Austria, Finland and Sweden for all the years in the data.[8] We further assume that the agricultural lobby organizes in each country.

In order to obtain an estimate for the slope of the land tax equation for each respective country, we have created multiplicative dummy variables, denoted by $rellobbyk_{kt}$, for each (k) of the 15 countries. These variables take the value of $rellobbystrength_{kt}$ for country k and zero otherwise.

As a proxy for the environmental impact of agricultural land use we use the sum of Expenditure on fertilizers and Expenditure on crop protection divided by Total utilized agricultural area, $fertilizer_{kt}$, from the FADN. We will include this

[8] We also considered other measures of forestry lobby organization, among those one suggesting the organization of a forestry lobby if the share of forests out of total land area exceeded 25%. This yielded forestry lobbies in eight countries, the same six listed in the text plus Portugal and Spain. Unfortunately the forest area is endogenous in the model, for which reason we decided against this measure. Other measures that we considered included looking at the Number of people employed in the manufacturing of wood and wood products divided by total Employment in manufacturing. Depending on whether the limit in employment was set at 3% or 4%, this procedure yielded lobbies in Spain, Austria, Portugal, Finland and Sweden for 4% and besides, Denmark and Italy for 3%. Why the number of people employed in wood manufacturing would indicate the existence of a forest owner lobby is however somewhat unclear, which is one reason for rejecting this measure, the other being that anecdotal evidence testifies to the existence of a rather strong forestry lobby at least in Germany.

variable in levels and squared, as $fertilizer_{kt}^2$. Furthermore, an inspection of the land tax/subsidy data reveals a structural break in the CAP policy. The new area subsidies were introduced in the EU countries either from the beginning of 1993 or 1994. For this reason, for those countries that introduced the new scheme in 1993 we have included the dummy variable $cap1993_{kt}$ that takes a value of one for 1990-92 and zero otherwise. For those countries that introduced the scheme in 1994 we included the dummy variable $cap1994_{kt}$, which takes the value of for 1990-93 and zero otherwise.

The construction of a variable measuring the level of technology, $wheat_{kt}$, was explained above. Alternative proxies to technology are the number of tractors per hectare of agricultural land ($tractor_{kt}$) or the number of internet users per 100 individuals in the population ($internet_{kt}$). However, for $tractor_{kt}$ there is no data available for Luxembourg and the Belgian figures also include the tractors in Luxembourg. For $internet_{kt}$ it is questionable how well a measure of internet users out of the total population actually captures the level of technology in agriculture. In order to include the possible interaction effect between technology and lobby strength we include the interaction variable $lobbywheat_{kt}$ ($lobbytractor_{kt}$ and $lobbyinternet_{kt}$ when $tractorha_{kt}$ and $internet_{kt}$ are included in the regression, respectively). To study the possible interaction with expenditure on fertilizers and crop protection, we have created the interaction variable $fertwheat_{kt}$ ($ferttractor_{kt}$, $fertinternet_{kt}$) and $fert^2wheat_{kt}$ ($fert^2tractor_{kt}$, $fert^2internet_{kt}$).

3.3.2 Specification of the Equations

Equation (3.7) constitutes the basis for the empirical specification. However, strictly taken, we cannot claim to test the theoretical model as we do not have an alternative hypothesis against which to test the performance of the model. The problem arises from the fact that unfortunately, we are not aware of a suitable alternative model against which we might test our model. Nevertheless, we test for the zero restriction on coefficients, and a rejection of this null will be interpreted as lending support for the theoretical model. We will further compare the performance of our model against the hypothesis presented in Bombardini [4] to examine if the explanation forwarded by her to explain the strength of various lobbies bears more weight than the simple model constructed here.

In order to go from the theoretical specification to an empirical one, we need to introduce an error term and specify its distribution. We assume the error term to be *iid* with mean zero and variance σ^2 and introduce it as additive to the rest of the variables, so that the estimating equation becomes

$$landtax_{kt} = a_0^1 + \sum_{k=1}^{15} a_k^1 rellobbyk_{kt} + a_{16}^1 fertilizer_{kt} + a_{17}^1 fertilizer_{kt}^2 + \mathbf{X}_{kt}^1 \mathbf{a}^1 + e_{kt}^1, \tag{3.12}$$

where $\mathbf{X}_{kt}^1$ is a vector of the dummy variables $cap1993_{kt}$ and $cap1994_{kt}$ indicating changes in the CAP policy. The elasticities of land demand entering into the calculation of $rellobbyk_{kt}$, $agrlobby_{kt}$ and $forlobby_{kt}$ are estimated from

$$agrarea_{kt} = c_0^A + \sum_{k=1}^{15} c_k^A r_{WACC} k_{kt} + c_{16}^A wheat_{kt} + \mathbf{X}_{kt}^A \mathbf{c}^A + e_{kt}^A \tag{3.13a}$$

and

$$forarea_{kt} = c_0^F + \sum_{k=1}^{15} c_k^F r_{WACC} k_{kt} + c_{16}^F wheat_{kt} + \mathbf{X}_{kt}^F \mathbf{c}^F + e_{kt}^F. \tag{3.13b}$$

$\mathbf{X}_{kt}^i$ is a vector of controls including $wage_{kt}$, $agrprod_{kt}$ and $forprod_{kt}$. We expect the coefficients of interest, c_k^i, to be negative since land demand is expected to fall as the cost of land increases. We further expect c_{16}^A to be positive so that technological progress in agriculture increases land demand by agriculture, and c_{16}^F to be negative so that technological progress in agriculture reduces land demand by forestry.

Using the slope coefficient estimates from equation (3.13a), the price elasticity of land demand in agriculture in each country and each time period is calculated as $agrelast_{kt} = -c_k^A \frac{r_{WACC_{kt}}}{agrarea_{kt}}$. Similarly, from (3.13b) we obtain for the forestry sector $forelast_{kt} = -c_k^F \frac{r_{WACC_{kt}}}{forarea_{kt}}$. The thus calculated elasticities vary both among countries and among the periods. This is assumed to depend on the changes in the underlying variables, namely the output price of good j and changes in technologies.

Following proposition 3.1 we expect the sign of a_k^1 in (3.12) to be positive so that if land demand by agriculture becomes more inelastic, reflecting an increase in the strength of the agricultural lobby, $-\frac{1}{agrelast_{kt}} + \frac{1}{forelast_{kt}}$ falls thus lowering the land tax. If land demand by forestry becomes more inelastic, reflecting an increase in the strength of the forestry lobby, the term increases therefore increasing the tax. Both the sign of a_{16}^1 and of a_{17}^1 are expected to be positive so that an increase in the environmental impact of agriculture leads to an increase in the land tax rate.

In order to examine the effect of technological change on land taxation, we also estimate the following equation, where the effect of technology is given by its interaction with lobby strength and the use of fertilizers:

$$landtax_{kt} = a_0^2 + \sum_{k=1}^{15} a_k^2 rellobbyk_{kt} + a_{16}^2 fertilizer_{kt} + a_{17}^2 fertilizer_{kt}^2$$
$$a_{18}^2 lobbywheat_{kt} + a_{19}^2 fertwheat_{kt} + a_{20}^2 fert^2 wheat_{kt} + \mathbf{X}_{kt}^1 \mathbf{a}^1 + e_{kt}^1. \quad (3.14)$$

To test the robustness of the technology variable, we further estimate equations including the interactions of $internet_{kt}$ and the interactions of $tractor_{kt}$ instead of the interactions of $wheat_{kt}$.

The expected signs of the coefficients on the added variables in (3.14) follow from proposition 3.2. Thus, we expect the sign of a_{18}^2 to be negative if the government is susceptible to lobbying; but zero otherwise. a_{19}^2 is expected to be negative, and a_{20}^2 is expected to be positive.

3.4 Empirical Results

3.4.1 Estimating the Elasticities

In estimating the elasticities of land demand in agriculture and forestry (equations (3.13a) and (3.13b), respectively), which are used to calculate a measure of lobby strength, the Woolridge [29] test indicated autocorrelation in the errors and the likelihood ratio test indicated heteroscedasticity. For this reason we used feasible GLS correcting both for heteroscedasticity and autocorrelation (AR(1) errors) in the estimation (see, e.g., Baltagi [2], Greene [21] or Hsiao [23] for how to correct for these ailments in error terms). The results from the regression are given in Table 3.4 in the Appendix.

As can be seen from Table 3.4, some of the estimates of parameters $\left\{c_1^A, \ ..., \ c_{15}^A\right\}$ and $\left\{c_1^F, \ ..., \ c_{15}^F\right\}$ have a significant positive sign, whereas others are insignificant.[9] In order to avoid an unnecessary loss of observations, we have kept even the positive estimates, and obtain consequently negative estimates for the elasticity of land demand for these countries. Similarly, we have used the insignificant values where they exist to calculate the elasticities for those countries. The calculation of the elasticities of land demand using the parameter estimates was explained in Section 3.3.2.

[9] Possible reasons for positive and significant estimates include, along the lines of Shiells *et al.* [28]: 1. industry characteristics and/or nonprice factors that have been omitted, or 2. the measure of the cost of land, r_{WACC}, may not have captured underlying price changes. It is further possible that there is too little variation in the land use variable, especially for forestry, for the elasticity to be estimated correctly.

Country	i	Obs	Mean	Std. dev
France	A	13	58.45	7.141
	F	13	18.57	1.935
Spain	A	14	39.43	10.42
	F	12	0	0
Italy	A	14	29.62	5.962
	F	12	0	0
The Netherlands	A	14	15.32	4.651
	F	14	0	0
Luxembourg	A	14	8.213	1.231
	F	13	6.035	.9481
Germany	A	14	7.875	1.076
	F	13	5.948	.8451
Ireland	A	14	5.539	1.174
	F	12	0	0
Denmark	A	14	4.769	1.184
	F	14	0	0
Portugal	A	14	4.302	1.479
	F	13	0	0
United Kingdom	A	13	3.252	.5835863
	F	13	0	0
Belgium	A	14	2.944	.2007
	F	14	0	0
Austria	A	8	2.322	.1915
	F	7	3.163	.2765
Greece	A	12	1.251	.1889
	F	12	0	0
Finland	A	8	.1396	.0222
	F	7	1.525	.2450
Sweden	A	8	.0568	.0048
	F	6	.7474	.0734

Table 3.1: The strength of lobby i=A, F in each respective country, absolute value of the lobby strength estimate.

In order to use the elasticity estimates in the land tax equation, we construct variables for the strength of each respective lobby. We report these in Table 3.1. The countries are listed in the decending order of the absolute mean strength of their agricultural lobby. The table is topped by France, followed by Spain and Italy, while the countries having the weakest agricultural lobbies are Finland and Sweden.

3.4.2 Estimates for the Land Tax

The estimation results of the land tax equation (3.12) are given in Table 3.5, column (2) in the Appendix; Column (1) contains a regression with $fertilizer$

entered only linearly. Results for the technology variables (3.14) are given in Table 3.6. Even here we run the regressions using feasible GLS (Baltagi [2], Greene [21], Hsiao [23]), correcting both for heteroscedasticity and for autocorrelation (AR(1) errors). The reason is that the Woolridge [29] test indicated autocorrelation and that the likelihood ratio test indicated heteroscedasticity of the errors, as shown in Tables 3.5 and 3.6. Moreover, since we lack data for $tractor_{kt}$ for Luxembourg in column (3) of Table 3.6, the variables $rellobbylux_{kt}$ were dropped from the regressions including this variable.

In our interpretation we will here concentrate on column (2) of Table 3.5. The reason for including column (1) was merely to show that $fertilizer$, if entered only linearly into the regression, does not get a significant coefficient, but that the effect from this variable is non-linear. Nevertheless, column (1) illustrates the robustness of the coefficient estimates for the rest of the variables even in the presence of omitted variables.

The interpretation of the variable $rellobbyk_{kt}$ in column (2) of Table 3.5 is somewhat involved. Theoretically, if the variable $rellobbyk_{kt}$ takes a positive value, this indicates that the forestry lobby is stronger than the agricultural one, and vice versa if the variable is negative. Then, if the coefficient for $rellobbyk_{kt}$ is positive, a fall in the strength of the agricultural lobby or an increase in the strength of the forestry lobby would lead to an increase in the land tax. Similarly, if land demand in agriculture would become more inelastic and that sector's lobby would thereby become strengthened, $rellobbyk_{kt}$ would fall and the land tax would fall (the land subsidy would increase). Among the countries where the forestry lobby does organize, none has a negative estimate for the elasticity of land demand in both sectors. This poses the first interpretation difficulty. The second difficulty arises from the fact that some countries where the forestry lobby does not organize have negative elasticities of land demand in agriculture. A negative elasticity in $rellobbyk_{kt} = -\frac{1}{agrelastk_{kt}} + \frac{1}{forelastk_{kt}}$ leads to that lobby's influence going in the same direction as the competing lobby's.

Based on a comparison between the results and the signs of the elasticities of land demand in the two sectors, we come to the following interpretation: in essence, the agricultural lobby determines the sign of the coefficient for $rellobbyk_{kt}$ even in those countries where the forestry lobby organizes. Thus, for those countries for which the elasticity of land demand in agriculture is positive, the coefficient for $rellobbyk_{kt}$ is as a rule positive.[10] Then, the effect of lobbying works the same way as described above: a strengthening of the agricultural lobby is man-

[10] Only counting those countries that have coefficients significant at least at the 10% level, this applies to Germany, (Greece), Italy, Finland and Sweden. The exception is the Netherlands, where the elasticity of land demand in agriculture is negative but the coefficient on $rellobbyned_{kt}$ is negative and significant at 1%.

ifested by the elasticity of land demand approaching zero from the right, which leads to a fall in $rellobbyk_{kt}$ and lowers the land tax. For those countries that have a negative elasticity of land demand in agriculture, the coefficient for $rellobbyk_{kt}$ is as a rule negative. In this case, the agricultural lobby is stronger the closer its elasticity of land demand is to zero, but approaching from the left. Then, a *fall* in $rellobbyk_{kt}$ signifies a strengthening of the agricultural lobby, and the land tax falls lower the stronger the lobby is, because of the negative coefficient for $rellobbyk_{kt}$. Only considering those countries that have coefficients significant at the 10% level, this works for Denmark and the UK. The coefficients for the rest of the countries are insignificant at the 10% level of significance. Therefore, in order to interpret the coefficients for $rellobbyk_{kt}$, we need to know the sign of the elasticity of land demand in agriculture for the country in question.

Turning to the measure of the environmental impact of agriculture on land taxation, $fertilizer_{it}$ and $fertilizer^2$ in column (2) of Table 3.5, the linear effect is negative, which is rather surprising; but the squared effect is positive, as predicted. The marginal effect of expenditure on fertilizers and crop production at the minimum expenditure level (57.19 €/ha) on the land tax is -0.1345, at the mean value of the expenditure (158.7 €/ha) it is -0.0208 and at the maximum expenditure (409.8 €/ha) it is 0.2608. At low levels of expenditure on fertilizers and crop production we thus find that this expenditure actually lowers the land tax, which is contrary to the theoretical predictions. Only at a high enough level of expenditure will the effect be to raise the land tax.

The results for the technology variables included in a regression given by equation (3.14) are shown in Table 3.6; Table 3.7 gives the correlation between some of the included variables. From column (1) of Table 3.6 it is clear that $lobbywheat_{kt}$, $fertwheat_{kt}$, and $fert^2wheat_{kt}$ are insignificant. Thus, either there is no effect from technology directly on the land tax, the yield of wheat per hectare is not a good proxy for this or the insignificant coefficient has to do with the fact that we already used this variable to estimate the land demand elasticities explained in section 3.4.1.

Turning to the alternative definitions of the level of technology, $lobbyinternet_{ki}$, $fertinternet_{kt}$ and $fert^2internet_{kt}$, all are significant but get signs opposite to those predicted in proposition 3.2. However, as we already noted above, it is not clear why the number of internet users out of 100 individuals in the population would be a good proxy for the level of technology in agriculture.

Finally, $lobbytractor_{ki}$ is insignificant but $ferttractor_{kt}$ and $fert^2tractor_{kt}$ are highly significant and get the predicted signs. This yields some credence to our hypothesis that technological change affects land taxation, but combined with the inconclusive results for the other proxies used, we take these results with some caution.

We end this section by examining an alternative theoretical specification based on Bombardini [4], without presenting the underlying theory in any detail. Bombardini's argument is that the size of a firm affects its incentives to participate in industry lobbies: larger firms are more likely to lobby. She tests her theory by estimating an equation for the coverage ratio of non-tariff barriers to imports including measures for the average firm size in industry i and the standard deviation of firm size, finding empirical support for the theory. Following her argument, in order to ascertain ourselves that we have not missed some crucial variables from our examination of the determination of land taxes, we run the following regression:

$$landtax_{kt} = a_0^3 + \sum_{k=1}^{15} a_k^3 rellobbyk_{kt} + + a_{16}^3 fertilizer + a_{17}^2 fertilizer^2 + a_{18}^3 firm\_size_{kt} + \mathbf{X}_{kt}^3 \mathbf{a}^3 + e_{kt}^3, \quad (3.15)$$

where we will use two different measures of $firm\_size$, namely $econsize_{kt}$, which measures the average farm size in each respective country in European Size Units (see European Commission [12]) and net_inc_{kt}, which gives the net income of a farm calculated as the gross farm income minus the balance of current subsidies and taxes in 1995 constant ECU/Euro.[11]

As for the sign of the new variable, Bombardini's argument is that sectors with larger firms and a greater spread of firm sizes lobby more and therefore have a greater impact on trade protection. Translated into our model, the argument would predict that a greater average farm size leads to greater farmer contributions to the farmer lobby, which in turn would result in lower land taxation. The expected sign of a_{18}^3 is thus negative. The results from the regressions in (3.15) are given in columns (3) and (4) of Table 3.5.

With regard to the coefficients of the variables measuring the effect of lobby strength, $rellobbyk_{kt}$, the results are very similar to column (2), further emphasizing the robustness of the model. Also the coefficients on $fertilizer_{kt}$ and $fertilizer_{kt}^2$ are significant at least at the 10% level, and the squared term still gets the predicted sign. The coefficient for $econsize_{kt}$ is further significant at the 10% level and has the predicted negative sign. However, the coefficient on net_inc_{kt} is insignificant, although it has the predicted sign.

We thus conclude that land taxation policy in Europe seems to be partly driven

[11] Unfortunately we do not have data for the standard deviation of farm size in the different countries.

by what we interpret to be environmental concerns, but in a non-linear way so that at a low level of impact from expenditure on fertilizers and crop protection, the land tax actually falls in the expenditure, whereas at higher levels it increases. Whether we have actually captured an effect from environmental concerns by our proxy or not might, however, be disputed, as it might be measuring something else as well. What this other "thing" that $fertilizer_{kt}$ might be measuring is not obvious, however, and therefore we are happy to stick to our definition of concern for negative externalities. The support for Bombardini's hypothesis is not conclusive either, considering that one of the measures included fares fairly well but the other one does not. Nevertheless, it seems that the size of farms might have an impact. Finally, it is clear that the elasticity of land demand in agriculture has a strong effect on land taxation, and that this effect goes in the opposite direction from the regular public economics prediction, which stipulates that taxes on sectors with more inelastic (land) demand should be higher. Therefore, we deem to have found a political economy effect from agricultural lobbying on land taxation in Europe.

3.5 Conclusions

In this paper we test a theoretical model developed in Jussila Hammes [24], explaining the rarity of land taxation and the spread of land subsidies in the European Union, using data from 15 EU countries covering mainly the years 1990-2002. We present a hypothesis according to which land taxation is in essence determined by only two variables, namely the relative strength of the agricultural and forestry lobbies as measured by their inverse elasticity of land demand to land price, and by environmental factors. We further study whether technological change in agriculture can be expected to affect the determination of land taxation.

The empirical findings give general support to the hypothesis that relative lobby strength drives land taxation. Thus, the countries with significant coefficients for the lobby strength variable have the expected sign on that variable. The main indication from this is that a strengthening of the agricultural lobby in a country lowers its level of land taxation. The result seems rather robust.

We further found support for the hypothesis that expenditure on fertilizers and crop protection positively affects the land tax. Our results are, however, qualified in the sense that the effect is positive only at high levels of expenditure; at low levels of expenditure it actually serves to lower the tax rate. We also found some support for the hypothesis forwarded by Bombardini [4] that a larger average economic size of farms should lower land taxation. The support found for this theory is rather tentative, however.

We also obtained some support for including technology directly into the estimating equation. Thus, for one of the proxies used for technology, the interaction term between technology and expenditure on fertilizers and crop protection, and the interaction with squared expenditure, were significant and got the expected signs. These results are taken to broadly indicate a certain disregard by the government of the lobbies in the face of technological progress in agriculture. However, according to the theory, technological progress works mainly through its effect on land demand. The evidence from the regressions of land demand against among other variables a proxy for technology is mixed, however, indicating that agricultural technologies impact the forest area negatively, but does not show an effect on agricultural land demand directly. This aspect of the matter would thus require further study and possibly more advanced econometric modeling.

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3.A Appendix

Variable	Explanation
agrarea	Agricultural area as a percentage of total land area
agrlobby	Estimated strength of the agricultural lobby
agrprod	Total output of (crops&crop production + livestock&livestock products) per hectare in 1995 constant ECU/Euro per hectare
econsize	Economic size of holding expressed in European size units
fertilizer	Expenditure on fertilizers and crop protection per hectare in 1995 constant ECU/Euro per hectare
forarea	Forestland area as a percentage of total land area
forlobby	Estimated strength of the forestry lobby
forprod	Roundwood production in m^3 per hectare
gdp_cap	GDP per capita in 1995 constant ECU/Euro
I_F	Indicator variable taking the value of one if forestry lobby in country k organizes.
internet	Internet users per 100 individuals in the population
landtax	Land tax/subsidy per hectare in 1995 constant ECU/Euro per hectare
net_inc	Net income of the farm: gross farm income - balance current subsidies & taxes in 1995 constant ECU/Euro
rellobbystrength	Estimated relative strength of the two lobbies: -1/*agrlobby* + $(I_F/forlobby)$
r_{WACC}	Weighted average cost of capital, proxy for cost of land (and capital)
wage_h	Wages and social security charges of wage earners in 1995 constant ECU/Euro
wheat	Yield of wheat in 100 kg per hectare
tractorha	Number of tractors per hectare

Table 3.2: List of variables

Variable	Obs	Mean	Std. Dev.	Min	Max
agrarea	208	.4652	.1807	.0704	.7455
agrlobby	188	-3.173	21.43	-61.09	71.39
agrprod	189	2324	1943	596.5	9251
econsize	189	43.20	30.13	5.7	137.7
fertilizer	189	158.7	80.48	57.19	409.8
forarea	195	.2890	.1777	.0710	.7612
forlobby	175	.6130	6.572	-22.31	21.03
forprod	181	2.870	1.404	.5755	7.9
gdp_cap	203	19722	7283	7900	45300
internet	194	11.58	14.73	0	57.31
landtax	177	-62.71	61.43	-176.6	54.12
net_inc	189	35916	25721	3808	110004
rellobbystrength	175	-3.153	26.35	-61.1	93.7
r_{WACC}	189	.0835	.0406	.015	.2102
wage	189	5287	5341	535	23614
wheat	189	57.12	21.92	0	109.1
tractorha	194	62.01	25.05	26.7	108.6

Table 3.3: Summary statistics

Dependent variable:	$agrarea_{kt}$	$forarea_{kt}$
$r_{WACC}bel$	-0.7785056***	-0.293096***
	(.0482315)	(.0705559)
$r_{WACC}den$	1.355016***	-1.571366***
	(.1424403)	(.2172002)
$r_{WACC}deu$	-0.7515357***	0.6026201***
	(.1595806)	(.1140492)
$r_{WACC}ell$	-1.520815***	-0.2299352***
	(.1119753)	(.0792161)
$r_{WACC}esp$	-0.1419929***	0.0975611
	(.0477221)	(.0705923)
$r_{WACC}fra$	0.0543783**	-0.0859813**
	(.0248438)	(.042575)
$r_{WACC}ire$	1.888549***	-3.768449***
	(.2676372)	(.3742937)
$r_{WACC}ita$	-0.2429307**	-0.2729497*
	(.108033)	(.1466985)
$r_{WACC}lux$	-0.6176339***	0.5861839***
	(.1141742)	(.1055002)
$r_{WACC}ned$	-0.3944809***	0.0016871
	(.0982068)	(.1815456)
$r_{WACC}ost$	-1.414034***	1.000711***
	(.0522203)	(.0608267)
$r_{WACC}por$	-1.263744***	0.3881291***
	(.1565942)	(.111149)
$r_{WACC}fin$	-3.054602***	2.963305***
	(.5676258)	(.5533346)
$r_{WACC}sve$	-14.24265***	8.164517***
	(1.524096)	(.9537566)
$r_{WACC}uki$	2.812686***	-2.616738***
	(.4816264)	(.4157366)
$wheat$	-.0000228	-.0002399**
	(.0000628)	(.0001169)
Observations	161	161
LR test, $\chi^2(14)$	254.36	245.60
Woodridge test, $F(1,\ 14)$	29.702	15.438

Table 3.4: Agricultural and forestry land demand function slope estimates. FGLS regressions. Standard errors in parentheses are adjusted for heteroscedasticity and autocorrelation (panel-specific AR(1) errors). ***, **, * denote significance at the 1, 5 and 10 percent levels, respectively. Each regression includes a constant and a number of control variables, not reported.

Dep. var. *landtax*	(1)	(2)	(3)	(4)
rellobbybel	3.758	.3565	-2.360	.8261
	(2.669)	(2.972)	(4.357)	(2.850)
rellobbyden	-10.63**	-9.622**	-7.809*	-8.691*
	(4.163)	(4.155)	(4.377)	(4.480)
rellobbydeu	4.941***	4.551***	4.324***	4.609***
	(1.436)	(1.447)	(1.265)	(1.395)
rellobbyell	22.81*	16.80	24.58*	18.47
	(13.13)	(12.28)	(13.56)	(13.30)
rellobbyesp	.0744	.1037	.3332	.1466
	(.1844)	(.1772)	(.2116)	(.2255)
rellobbyfra	-.1647	-.0731	-.3264	-.1344
	(.4387)	(.4246)	(.3467)	(.4170)
rellobbyire	4.295	3.947	2.564	3.725
	(3.117)	(3.131)	(3.100)	(3.212)
rellobbyita	1.126**	.9165*	1.257***	1.119***
	(.4852)	(.4875)	(.4723)	(.4246)
rellobbylux	.3810	.1513	.0302	.2358
	(.4263)	(.4197)	(.4774)	(.4191)
rellobbyned	-2.075***	-2.239***	-3.428***	-2.268***
	(.5842)	(.5930)	(1.045)	(.5823)
rellobbyost	1.674	1.627	3.084	1.887
	(4.956)	(4.998)	(5.055)	(5.023)
rellobbypor	1.936	3.039	4.594**	3.261
	(2.498)	(2.541)	(2.271)	(2.674)
rellobbyfin	20.67***	17.45**	19.60***	18.76**
	(6.729)	(7.062)	(6.991)	(7.549)
rellobbysve	49.70***	50.88***	53.33***	52.17***
	(10.63)	(10.16)	(11.81)	(11.13)
rellobbyuki	-6.645***	-5.607***	-2.687	-5.829***
	(2.191)	(2.148)	(3.172)	(2.185)
fertilizer	.0620	-.1986*	-.2222*	-.1769*
	(.0388)	(.1178)	(.1312)	(.1016)
$fertilizer^2$		.00056**	.00062**	.00052**
		(.00025)	(.00028)	(.00021)
econsize			-.3177*	
			(.1881)	
net_inc				-.000029
				(.00015)
Observations	163	163	163	163
LR test, $\chi^2\,(14)$	110.1	112.4	98.98	100.4
Woolridge test, $F\,(1,\ 14)$	14.91	15.17	14.49	15.19

Table 3.5: FGLS regressions. Standard errors in parentheses are adjusted for heteroscedasticity and autocorrelation (AR(1) errors). ***, **, * denote significance at the 1, 5 and 10 percent levels, respectively. Each regression includes a constant and two dummy variables, cap1993 and cap1994, not reported.

Dep. var. *landtax*	(1)		(2)		(3)
rellobbybel	.5035		.9652		5.547
	(3.699)		(2.998)		(5.079)
rellobbyden	-9.217**		-8.667*		-7.682**
	(4.323)		(4.451)		(3.833)
rellobbydeu	4.595***		4.836***		5.129***
	(1.447)		(1.512)		(.9753)
rellobbyell	24.68**		16.78		31.56**
	(12.09)		(13.74)		(12.62)
rellobbyesp	.0114		.2567		-1.345
	(.4327)		(.2290)		(.8770)
rellobbyfra	-.0406		-.1491		.4601
	(.6615)		(.3899)		(.7926)
rellobbyire	3.621		1.983		5.585*
	(3.377)		(3.326)		(3.368)
rellobbyita	.8622		.8645*		-.3948
	(.8850)		(.4993)		(2.958)
rellobbylux	.1283		.7014		
	(.4280)		(.4836)		
rellobbyned	-2.427*		-2.642***		-3.252
	(1.314)		(1.023)		(2.361)
rellobbyost	1.634		3.695544		15.29***
	(5.034)		(4.980)		(5.884)
rellobbypor	2.737		4.496**		.1199
	(2.589)		(2.252)		(2.546)
rellobbyfin	17.03**		21.48***		45.96***
	(7.182)		(7.363)		(9.983)
rellobbysve	50.96***		64.61***		69.87***
	(10.17)		(13.84)		(13.17)
rellobbyuki	-5.778**		-7.649***		4.686
	(2.493)		(2.469)		(3.359)
fertilizer	-.4024**		-.2746**		-2.505***
	(.2001)		(.1256)		(.3818)
$fertilizer^2$	.0016**		.00057**		.0087***
	(.0008)		(.0003)		(.0013)
lobbywheat	.0020	*lobbyinternet*	.0274*	*lobbytractor*	.0330
	(.0154)		(.0167)		(.0290)
fertwheat	.0018	*fertinternet*	-.0034**	*ferttractor*	.0222***
	(.0020)		(.0015)		(.0039)
$fert^2wheat$	-.00001	$fert^2internet$	.00002***	$fert^2tractor$	-.00009***
	(8.6e-06)		(5.8e-06)		(.00001)
Observations	163		162		151
LR test, $\chi^2\,(14)$	112.9		108.3		80.99
Woolridge test, $F\,(1,\ 14)$	20.95		15.10		18.959

Table 3.6: FGLS regressions. Standard errors in parentheses are adjusted for heteroscedasticity and autocorrelation (AR(1) errors). ***, **, * denote significance at the 1, 5 and 10 percent levels, respectively. Each regression includes a constant and two dummy variables, cap1993 and cap1994, not reported.

	$econsize$	$fertilizer$	$fertilizer^2$	$fertinternet$	$fert^2internet$	$ferttractor$
$fertilizer$	0.5832	1				
$fertilizer^2$	0.5775	0.9701	1			
$fertinternet$	0.6219	0.2528	0.2455	1		
$fert^2internet$	0.6384	0.4164	0.4199	0.9349	1	
$ferttractor$	0.4866	0.9254	0.9249	0.2491	0.3869	1
$fert^2tractor$	0.5427	0.9286	0.9811	0.2284	0.3907	0.9538
$fertwheat$	0.7775	0.9106	0.9155	0.3331	0.4748	0.8543
$fert^2wheat$	0.6725	0.9155	0.9714	0.2911	0.4553	0.8905
$lobbyinternet$	-0.4457	-0.2175	-0.1993	-0.7213	-0.7358	-0.1707
$lobbytractor$	0.0021	-0.2256	-0.1978	-0.0602	-0.1534	-0.2670
$lobbywheat$	-0.1899	-0.2815	-0.2440	-0.1227	-0.2166	-0.1682
net_inc	0.9191	0.7351	0.7343	0.4452	0.5379	0.6437

Table 3.7: Correlation coefficients.

	$fert^2tractor$	$fertwheat$	$fert^2wheat$	$lobbyinternet$	$lobbytractor$	$lobbywheat$
$fertwheat$	0.8951	1				
$fert^2wheat$	0.9697	0.9569	1			
$lobbyinternet$	-0.1655	-0.2716	-0.2287	1		
$lobbytractor$	-0.2088	-0.1942	-0.1958	0.4264	1	
$lobbywheat$	-0.1838	-0.3098	-0.2653	0.4739	0.8192	1
net_inc	0.7025	0.8873	0.8063	-0.3680	-0.0945	-0.2542

Table 3.8: Correlation coefficients.