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Intergenerational Conflicts and the Resource Policy Formation of a Short-Lived Government*

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Abstract

This paper studies the political economy of resource management in an OLG framework with an intertemporal externality problem. The external-

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ity arises because a common resource used for production is depleted by production of "dirty" goods. An intergenerational conflict arises because the young generation cares about the level of current production of dirty goods. This is so because production of dirty goods affects the future availability of the resource. The old, on the other hand, has no such a concern. We assume that they lobby the government to affect the policy choice - an upper limit on the resource use allowed for production of dirty goods - in their favour. Within a dynamic common agency framework, we study stationary equilibria focussing on a particular class of strategies which we called "*Take It or Leave It*" (TIOLI) strategies, where a lobby makes a positive contribution only when her payoff maximising policy is implemented. It is shown that political competition may lead to a "greener" environment policy and to less resource exploitation than in an unregulated economy. More surprisingly, we also find that resource exploitation may be lower in political equilibrium than in an economy run by a social planner.

Key words: dynamic common agency, efficiency, externalities, political competition, resource policy design

JEL classifications: D72, D90, H23, L51, Q20, Q28

1 Introduction

Most resource and environmental problems have an intertemporal dimension, and the costs and benefits of different actions are distributed asymmetrically through time. For example, the current overuse of a natural resource such as the atmosphere, water, or fisheries may reduce future availability. From a broader point of view, over-extraction or over-catching of a species may endanger the biodiversity of the ecosystem, and this biodiversity is a resource that may be valuable for future generations. Thus, most of the costs associated with current resource usage would be incurred in the future. This is less of a problem if the agents who benefit from usage now were still to be alive in the future, and thus be able to pay for them. On most occasions, however, this is not the case, and the current benefits gained using a natural resource impose costs on future generations who will receive no compensation. Behind the key issue of controlling resource extraction lies these intergenerational trade-offs. It can be seen that some intergenerational conflicts have their roots in intertemporal negative externalities.

The problem of the degradation and the exhaustion of these resources may originate from the nature of the resources. The conventional view taken on genetic materials is that they are *open access common property resources*. Therefore, negative externalities are likely to arise because there are practically no enforceable private property rights. For the efficient use of resources, a society may need to define property rights. These rights can play a fundamental role in governing the use of natural resources, as well as the welfare of individuals who depend on those resources for their living. Policies that shape property rights may promote or discourage economic growth, equity of distribution, and sustainability of the resource base.

Each generation has an interest in the policy outcome set by the regulatory authority. This is because changes in the relevant generation's welfare would be sensitive to the policy regulating the depletion of the resource. Then, a generation with a strong preference for a particular policy may be motivated to appeal for collective actions in promoting their interests in resource management. In recent years, these politically motivated movements have had a significant impact on government decision making processes, notably in trade and environmental policies. This paper focuses on a resource management policy which is decided through a political process that integrates the conflicting views of individuals at different stages in their life cycle. The members of each self-interested generation may form a pressure group. This group seeks influence on the policy making process by making a contribution to the policy maker so that its most preferred policy may be implemented.

To address this intertemporal political problem, we present an *Overlapping Generation* (OLG) model, where difference in the life cycles of each generation, at a given point of time, lead to different attitudes towards the preservation of a common resource. Individuals in this economy consume two types of goods - clean goods and dirty goods. The dirty goods generate some pollution. The future availability of the resource is affected by current production of the dirty goods due to, for instance, the adverse effects of pollution on the biological growth of the resource. In short, the source of intergenerational conflict is that young individuals want an efficient use of a resource throughout their lives, while old individuals does not care about the externality to the future availability of the resource.

The model has the following aspects: (i) in each period, the young and old generation seek to influence the resource policy, and the underlying conflict of interest is resolved by a political process; (ii) the political process is modelled as in *Grossman and Helpman* (1998), and the government is assumed to hold office for one period only; (iii) the biological growth of the resource is assumed to be negatively related to the current production of dirty goods due to pollution. The short-lived government's objective is to collect contributions from the pressure groups either for financing the coming election campaign or for personal use.

The *common agency* framework is used in this paper to analyse the resolution of the intergenerational conflict over resource exploitation. Originally proposed by *Bernheim and Whinston* (1986) , the common agency model describes a situation in which many principals try noncooperatively and simultaneously to influence the policy choice of an agent by offering some contributions. In this structure, it is assumed that the authority is a jurisdictional agent who can enforce the regulation and preservation of resources. His objective is to maximise the sum of contributions obtained from the pressure groups. The opportunistic nature of the politician is characterised by the short term of his office. The young and old generations act as principals who compete with each other by offering contributions to the politician in order to try and secure their most preferred resource preservation policy in each period, given the choice of the other generation.

The model studies a particular class of contribution strategies, which we call "*Take It Or Leave It*" ($TIOLI$) strategies. These basically restrict the principals' strategy sets: a principal contributes to the politician (the agent) in support of one particular resource policy and contributes nothing in support of any other policy. Given these strategies, the politician's policy choice is simple: he only has to choose the policy proposal associated with the maximum contribution. Thus, the principal who offers the highest contribution would get the policy that she proposes to the politician implemented. In equilibrium, the principal whose proposal is adopted pays as much as the other principal (who made the second highest offer) but also a very small amount to induce the politician to set the policy that she most prefers.

This paper forms part of a growing literature on dynamic common agency, and contains some notable features that distinguish it from previous studies. The major contributions of this paper can be summarised as follows. Firstly, most of the literature on intertemporal resource allocation adopts a classical framework of welfare economics as presented in a series of papers by *Howarth* (1991, 1996, and 1998) and *Howarth and Norgaard* (1992, 1993, and 1995). Our approach is a political one as is often the case in modern democratic societies where social problems, such as intergenerational conflicts over a natural resource, can be resolved through political competition between the relevant pressure groups. Second, within the standard OLG structure, the model characterises stationary political equilibria using TIOLI strategies. In this paper, the TIOLI strategies are shown to be a convenient way of characterising equilibria in a complex dynamic game: they are state-independent and look like the bidding style competition observed in auctions. Third, the model by *Grossman and Helpman* (1998) suggests that politics plays a negative role and that in the long run, competition between self-interested pressure groups will have a devastating effect on the economy. Our model, on the contrary, shows that an economy could preserve more resources for the future through political competition than would be preserved by a social planner. At equilibrium, this is due to relatively little consumption of dirty goods by current generations.

The remainder of this paper will be organised as follows. Section 2 contains a brief survey of the recent literature, while section 3 formally defines the fundamental environment of the economy. We characterise the unregulated as well as the social planner equilibrium in sections 4 and 5 as the benchmarks with which to compare the political equilibrium. In section 6, we present the political economy model and characterise TIOLI equilibria. In section 7, we present some comparative statics results in order to compare the three equilibria analysed. Section 8 contains a discussion of the results obtained, and section 9 concludes the paper.

2 Literature Survey

The basic framework used for this paper is related to the works of *Grossman and Helpman* (1998) and *Bernheim and Whinston* (1986) as mentioned in the introduction. *Grossman and Helpman* (1998) analyse the politics of intergenerational redistribution in an OLG model with a short-lived government. Their underlying idea is that each generation of young and old forms a pressure group to influence the intergenerational redistribution policy making of the current government. Characterisation of equilibria in their model is relatively simple because a particular form of linear preference is used and the representative individual works when young and consumes only when old.

Although our model is inspired by their framework, it follows the general set-up of the typical OLG model. We adopt the common agency model to this and assume well-behaved separable log linear utility functions for each generation. As in *Grossman and Helpman*'s model, we adopt the common agency model developed by *Bernheim and Whinston* to resolve the conflict between the generations. This framework has been used by several authors to explain environmental or trade policy issues. Among them, *Aidt* (1998) was the first to show that competition between lobbies is an important source of internalisation of the economic externalities within a common agency setting. His analysis generalises the principal of targeting to distorted political markets (the environmental adjustment is targeted at the source of the externality). Furthermore, *Fredriksson* (1997) explained how a pollution tax and total pollution are affected by movements in prices and the political influence of the lobbies. However, as pointed out by *Aidt* (1998), the common agency framework has some notable drawbacks: (*i*) there is a coordination problem among the principals, where it is hard to justify why some principals overcome the free rider problem of collective action and coordinate perfectly, while others cannot; (*ii*) there is an implicit assumption that the pressure groups can commit to a particular contribution strategy, which is difficult to maintain, particularly in a one-shot game; (*iii*) in the unspecified underlying electoral process it is unclear why the incumbent government cares about campaign contributions.

A dynamic version of the common agency model still remains at an initial stage of development. It can provide important and fruitful implications for the solutions of many intertemporal economic problems. Recently, *Bergemann and Välimaki* (1998) proposed a theoretical model of dynamic common agency with symmetric information. They characterised the *Truthful Markov Perfect Equilibrium* set as a refinement of the Markov perfect equilibria. Their results depend on the assumption of transferable utility for principals and the infinite life span of all the players. *Boyce* (2000) studies a dynamic common agency which is similar to our resource management problem. He considers natural resource regulation problem in which 'harvester' and 'conservative' groups compete in making contributions to influence a regulator who assigns harvester quotas in each period. The basic contrasting feature with our model is that *Boyce* assumes that each player has an infinite time horizon. This makes his solution relatively simple when utilising the backward induction methodology originally developed by *Levhari and Mirman* (1980) to characterise a state independent equilibrium.

3 The Model

3.1 The Economy

We consider an overlapping generation (OLG) economy in which each generation lives for two periods. The economy has an infinite time horizon and time is discrete. There is no population growth and the size of the population is normalized to 2 each period. Hence, at any given point in time t, there is one young representative and one old representative individual alive. Each representative individual is endowed with one unit of labour in each period. Hence, people are assumed to work during their lifetime. The labour endowment of an individual can be combined with the stock of a common natural resource (S_t) available at period t to produce two goods: a clean good, x_t and a dirty good, y_t. The production technology is represented as follows:

$$\begin{aligned} x_t^s &= S_t l_{xt}^s, \\ y_t^s &= S_t l_{yt}^s \end{aligned} \tag{1}$$

where l_{jt}^s represents the amount of labor input allocated to the production of good j at time t by an individual born at time s. We may regard the resource S_t as natural capital and so, the production function is similar to the well known AK technology which is frequently used in the growth literature. The labour endowment of an individual born in period s is divided between the production of the two goods:

$$l_{xt}^s + l_{yt}^s = 1. \tag{2}$$

Then, the total amount of the labour input used at time t to produce good j is

$$l_{jt} = l_{jt}^t + l_{jt}^{t-1}. \tag{3}$$

In each period, the two units of labour are divided between production of clean and dirty goods such that

$$l_{xt} + l_{yt} = 2. \tag{4}$$

So the aggregate production of each good is

$$x_t = x_t^t + x_t^{t-1} = S_t l_{xt}, \tag{5}$$

$$y_t = y_t^t + y_t^{t-1} = S_t l_{yt}. \tag{6}$$

The biological growth of the common natural resource is given by[1]

$$S_{t+1} = S(S_t, l_{yt}^t + l_{yt}^{t-1}) = S_t^{(1-\delta)} \exp(1 - \phi \left(l_{yt}^t + l_{yt}^{t-1} \right)) \tag{7}$$

where $\delta \in (0, 1)$ is the depreciation rate of the resource due to factors other than production of the dirty good and $0 < \phi < 1/ (\max l_{yt})$.[2] As $\delta \to 1$, the growth will be affected only by the size of the labour allocated to production of the dirty good. But, as $\phi \to 1/ (\max l_{yt})$, the future growth is determined by the current stock. The law of motion of the resource has the property that the aggregate labour input allocated to the production of dirty goods at time t has a negative effect on the available resource in the next period. Hence, we can think of the parameter ϕ as an *inverse measure of the effectiveness* of resource preservation. If ϕ is small, then current production of the dirty good has only a negligible impact on the future resource availability, reflecting that a highly effective resource preservation technology is employed. If, on the other hand, ϕ is large, then current production of the dirty goods has a large adverse impact on the resource available tomorrow, implying that a highly ineffective resource preservation technology is employed.[3] Given the resource preservation technology, the only way to preserve resources for the future is to shift current production away from dirty goods towards clean goods.[4] The initial resource endowment available in period 0 is S_0.

The biological growth function (7) is assumed to satisfy the *Inada conditions* is such that

$$\lim_{S_t \to 0} \partial S_{t+1}/\partial S_t = \infty, \ \lim_{S_t \to \infty} \partial S_{t+1}/\partial S_t = 0.$$

This implies the existence and uniqueness of an interior steady state (or fixed

[1]The exponential form is chosen to simplify the analysis of the model as will become clear in the sequel of our analysis.

[2]Notice that the maximum available labour input for the production of the dirty goods is 2. It follows that $\max l_{yt} = 2$.

[3]In order to avoid negative values for the resource endowment S, one should put in each period an upper bound on the size of the parameter ϕ, according to the inherited level of $S_t \geqslant 0$. However, in the sequel of our analysis, we implicitly restrict our attention to a range of values for ϕ which is small enough to ensure a positive value of S_t for all t. That is, $\phi \leqslant 1/ (\max l_{yt})$.

[4]This assumption on the law of motion implicitly indicates that over-production of dirty goods may generate environmental problems, which may in turn attenuate the self-preservation ability of the resource. Hence, the resource management issues in our context are always accompanied by environmental problems. Then, the parameter ϕ may act as an indicator which links these two issues.

point) value of S. In addition, for any stationary labour inputs, l_{yt}^{t}, devoted to the production of dirty goods, the steady state of S is stable.[5]

The government can regulate the use of the resource by controlling the allocation of labour between the two goods. We focus on *Command and Control* resource management policies where the government determines how much labour is allocated to production of dirty goods directly. We only consider government policies that enforce a uniform ($l_{y,t}^{t-1} \equiv l_{y,t}^{t}$) labour allocation. We denote the resource policy at time t by λ_t with $l_{y,t}^{t-1} = l_{y,t}^{t} = \lambda_t$. This uniform standard can be criticised for being less efficient in that different types of individuals must follow one standard.

Under the uniform government regulation, $l_{yt}^{t} + l_{yt}^{t-1} = 2\lambda_t$, and the law of motion equation (7) can be re-specified as

$$S_{t+1} = S(S_t, \lambda_t) = S_t^{(1-\delta)} \exp(1 - \phi\,(2\lambda_t)). \tag{8}$$

In each period, the natural resource is available to all current generations. Each individual, who is endowed with one unit of labour, will produce either clean goods or dirty goods; these are consumed within the same period. There is no capital accumulation and hence no saving allowed in this model. The direct utility function of a representative young individual is defined as

$$u_Y\left(x_t^t, y_t^t\right) = \ln x_t^t + \gamma \ln y_t^t + \beta\left(\ln x_{t+1}^t + \ln y_{t+1}^t\right)$$

where β ($\in (0,1)$) is a time preference discount factor. There is no disutility from working. From the direct utility function, we can derive the reduced-form *gross policy preference function* of a representative young individual born at time t with a given resource level S_t as

$$v_Y\left(S_t\right) = \theta \ln S_t + \gamma \ln \lambda_t + \ln\left(1 - \lambda_t\right) + \beta V\left(\lambda_t, S_t\right) \tag{9}$$

where $\theta = 1 + \gamma$ and $V\left(\lambda_t, S_t\right)$ is the expected gross policy preference at time $t+1$ of the current young individual if in period t the policy action was λ_t and the payoff relevant part of history was S_t. So $V\left(\lambda_t, S_t\right) = 2\ln S_{t+1} +$

[5]By taking the log of (7), we obtain the system $\ln S_{t+1} = (1-\delta)\ln S_t + \left(1 - \phi\left(l_{yt}^{t} + l_{yt}^{t-1}\right)\right)$ which can immediately be proved to be monotonically convergent to the (unique) steady state: in fact $\frac{\partial \ln S_{t+1}}{\partial \ln S_t} = 1 - \delta < 1$. Notice in addition that the unique steady state is given by $\bar{S} = \left(\exp\left[1 - \phi\left(l_{yt}^{t} + l_{yt}^{t-1}\right)\right]\right)^{1/\delta}$.

$\ln \lambda_{t+1} + \ln(1 - \lambda_{t+1})$, where λ_{t+1} is the expected resource policy function at time t. Hence, the gross policy preference function only depends on the policy and the parameters of the model.

The direct utility function of a representative of the old generation[6] living in time t is given by

$$u_O\left(x_t^{t-1}, y_t^{t-1}\right) = \ln x_t^{t-1} + \ln y_t^{t-1}.$$

Then the gross policy preference function has the following form:

$$v_O(S_t) = 2\ln S_t + \ln \lambda_t + \ln(1 - \lambda_t). \tag{10}$$

Here, we redefine each individual's consumption preference as a gross policy preference function, which is a function of the policy rule (λ_t) and the current resource stock (S_t). The parameter γ (> 0) captures the relative "*green preference*" of a new born young individual. If $\gamma < 1$ ($\gamma > 1$), the individual takes less (more) pleasure in consuming dirty goods when young, and so, the individual is said to have a green (an anti-green) preference.[7]

This asymmetry in each generation's preference function is motivated by the fact that the old and the young may have different attitudes towards resource depletion and the accompanying environmental consequences. This difference, in turn, may have resulted from underlying social norms and shared values between members of society, in which the young and the old may perceive those issues differently.

Next, we analyse the decision-making process for the resource allocation policy within this dynamic model. Although, as previously described, we are primarily interested in the political process for the resource allocation policy, we will initially explore policy choices without government intervention and with a hypothetical social planner. This will provide us with the opportunity to compare each of the equilibrium policies that govern the exploitation of the resource under different economic regimes.

[6] The expression of the utility function of an old individual could appear redundant; however, it is useful for the analysis of the political economy model carried out in the sequel.

[7] The assumption that only young people are endowed with a green preference comes from the fact that they look ahead and are interested in the amount of total resource available when old. Conversely, old people are not altruistic and then do not care about the exploitation of the resource.

4 The Unregulated Equilibrium

We begin our analysis by examining the competitive equilibrium of an unregulated economy. In this case, each individual will act on her own behalf without any government interference and subject only to the resource constraint. As is usual in competitive models in which actions of each individual are negligible with respect to the size of the whole economy, we assume that the negative externality associated with production of dirty goods is not internalised by the individuals. Likewise, we assume that the young individual, born at time t, does not take the impact on future resource availability S_{t+1} when deciding how to allocate his labour endowment between production of the two goods. A further assumption is that individuals do not have access to any kind of assets which would allow them to accumulate wealth, and so the equilibrium will be autarkic.[8] Indeed, since the production technology for the two goods is homogeneous and the time horizon of the economy is infinite, there is no room for inter-generational exchange. Additionally, the members of a given generation are also assumed to be homogenous, thus, intra-generational trade will not take place. Therefore, a typical young individual solves her utility maximization problem as if the two different periods of her life time are completely independent. This means that a young individual allocates her labour endowment in each period without taking into account the negative externality generated by the labour input in the process of dirty goods production on the future resource stock S_{t+1}.

Definition 1 ***Competitive Equilibrium:*** *A competitive equilibrium is defined as a collection of sequences* $\{l_{yt}^{t}, l_{yt}^{t-1}, l_{xt}^{t}, l_{xt}^{t-1}\}_{t=0}^{\infty}$ *for each* $t \geqslant 0$ *such that* (1) *the allocation solves the maximization problem of each generation for each* $t \geqslant 0$ *subject to the constraints (2) and (3).* (2) *the production factor market clears in each* $t \geqslant 0$ *according to (3) and (4).*

A straightforward computation shows that the competitive equilibrium labour allocation vector at time t $\left(\left(l_{yt}^{t}\right)^{CE}, \left(l_{yt}^{t-1}\right)^{CE}\right)$ which is employed in the production of dirty goods is given by

$$\left(l_{yt}^{t}\right)^{CE} = \gamma / \left(1+\gamma\right), \quad \left(l_{yt}^{t-1}\right)^{CE} = 1/2.$$

[8] Notice that, since the time horizon of the economy is infinite, there is no room for any kind of intrinsically useless *fiat* money asset.

Hence, the total amount of labour$\left(l_{yt}^{CE}\right)$ allocated to the production of dirty goods at time t is

$$l_{yt}^{CE} = \left(l_{yt}^{t}\right)^{CE} + \left(l_{yt}^{t-1}\right)^{CE} = (1+3\gamma)/(2+2\gamma), \ \forall \ t. \tag{11}$$

It is worthwhile to note that l_{yt}^{CE} is time invariant and is an increasing function of the green preference parameter γ.[9] This is quite intuitive: when γ is large, the young individual has an anti-green preference which encourages her to allocate a relatively large portion of her labour endowment to the production of dirty goods, increasing l_{yt}^{CE}. In competitive equilibrium, the resource evolves according to $S_{t+1} = S_t^{(1-\delta)} \exp(1 - \phi l_{yt}^{CE})$ and the steady state level of the resource is $S^{CE} = \left[\exp\left(1 - \phi l_{yt}^{CE}\right)\right]^{1/\delta}$. One then immediately verifies that for all t the higher γ, the higher the resource exploitation is and so the lower a resource stock would be preserved for the future.

5 The Planner's Solution

The second benchmark case to be examined is the policy rule designed by a benevolent social planner. It is assumed that he has an infinite time horizon and decides in each period how to allocate the consumption of two goods between the generations through a resource policy maximising intertemporal social welfare. Being aware that the resource is accessible to both the young and old, he will consider the negative externality arising from the current production of dirty goods on the resource stock.

Definition 2 ***The Social Planner's Problem****:* *The benevolent social planner dictates a sequence of the resource policy* $\left\{\lambda_t^{SP}\right\}_{t=0}^{\infty}$ *so as to maximise a discounted sum of the life-cycle utility of all current and future generations,*

$$U^{SP} = \textstyle\sum_{t=0}^{\infty} \rho^t \left\{ v_O\left(S_t\right) + v_Y\left(S_t\right) - \beta V\left(\lambda_t, S_t\right)\right\}, \tag{12}$$

under the resource constraint (7). *The parameter* $\rho \in (0,1)$ *represents the time discount factor of the social planner.*

[9] The time-independent property of the competitive equilibrium holds for any specification of the law of motion as long as the young generation does not internalise the externality.

The first order condition associated with the social planner's problem at time $t \geqslant 0$ is given by[10]

$$\partial U^{SP}/\partial \lambda_t = \left\{\lambda_t^{-1} - (1-\lambda_t)^{-1}\right\} + \left\{\gamma\lambda_t^{-1} - (1-\lambda_t)^{-1}\right\} - B = 0. \tag{13}$$

where $B \equiv 2\rho\phi A$ and $A \equiv 3+\gamma$. By solving the F.O.C., we find the socially optimal resource allocation policy at time t,[11]

$$\lambda^{SP} = \frac{1}{2B}\left\{(A+B) - \sqrt{(A+B)^2 - 4B(A-2)}\right\},\ \forall t. \tag{14}$$

From equation (14), we note that the socially optimal resource allocation policy is independent of the resource stock (S_t) as is the competitive equilibrium.[12] The social planner selects a constant resource policy because of two assumptions of the model: the exponential law of motion for S_t in equation (7) and the *Cobb-Douglas* specification of the gross policy preferences. These assumptions reduce the social planner's program to a sequence of static maximisation problems. The social planner's resource policy λ_t^{SP} depends upon all the structural parameters of the model. Among them, we pay special attention to the two key parameters i.e. γ and ϕ. It is trivial to show that $\partial\lambda^{SP}/\partial\gamma > 0$ and $\partial\lambda^{SP}/\partial\phi < 0$. The social planner will allow greater production of dirty goods, the more the young values consumption of those goods, i.e., the higher is γ. On the other hand, the social planner's choice of resource policy is limited by the sensitivity of the resource depreciation due to the production of dirty goods. This is because a large ϕ reduces the resource available tomorrow and so, $\partial\lambda^{SP}/\partial\phi < 0$. Finally, the resource endowment will evolve according to $S_{t+1} = S_t^{(1-\delta)}\exp(1-\phi 2\lambda_t^{SP})$ and the steady state level of the resource under the social planner's regime will be $S^{SP} = \left[\exp\left(1-2\phi\lambda^{SP}\right)\right]^{1/\delta}$.

[10]It is assumed, in this case, that the benevolent planner chooses a *uniform* resource policy which optimises his objective function.

[11]It is easy to see that λ_t^{SP} in (14) belongs to $(0,1)$ for every possible configuration of the structural parameters of the model. At the same time, one can also readily verify that the solution in (14) corresponding to the positive sign before the square root is economically meaningless since λ_t^{SP} is greater than 1 in this case.

[12]Considering the economy in which each individual works and consumes what they have produced in each period without saving, it would be an optimal policy of the social planner to equally allocate the resource between the indiviudals in each period. Thus, the constant policy rule which is identified in (14) is consistent with this conjecture.

6 The Political Economy Model

At the heart of the resource allocation problem under consideration, there is an intergenerational conflict. The difference in preference of each generation over the government's resource policy arises from two sources. First, in contrast to the old generation, the young generation is always concerned about the impact of production of dirty goods on the future availability of the resource. Second, even if the young generation does not internalise this externality, the fact that it has a green (or anti-green) preference (captured by the parameter γ) makes its policy preference different from that of the current old generation. The difference in preferences implies that each generation prefers a different policy rule. The policy maker (the government) has to settle this conflict and the way that this is done depends on the nature of the political process. Within a democracy, each individual can express her preference directly in elections and/or through the membership of lobbies. Here, we focus on special interest group politics in which each generation forms a lobby which actively exercises political influence. This allows us to pay attention to situations in which the resource policy reflects not only the preference structures of the two generations, active in the political market at a given point in time, but also the intensity with which they support and oppose particular policies. This will be evident as the discussion further proceeds.

It is assumed in each period that the young and the old organise lobbies, which we refer to as the Y-group and the O-group, respectively. This structure embodies two important assumptions. First, political participation is complete except for future generations which cannot be presented in the current political process. In general, free rider problems may prevent some potential groups from organising politically (see *Olson* (1965)), but the present model ignores the possibility. Second, membership of the lobby groups is renewed every period. In particular, a young individual who joins the Y-group at time t retires her membership at the end of that period to join the O-group at the start of time $t+1$.

The two lobbies seek to influence the government's resource policy by means of contribution payments. It is assumed that the contribution is financed by a membership fee, and that the fee is paid as a proportion, c_{it}, of the goods produced by the members at time t. So, the total contribution is $C_{it} = c_{it}\left(x_t^i + y_t^i\right) = c_{it}S_t$, where $i \in (Y, O)$ represents a lobby ($Y =$ the Y-group and $O =$ the O-group).[13]

[13] We assume that government is interested in collecting maximum amount of the two goods

Each lobby offers the government a contribution schedule $c_i(\lambda_t, S_t) \in [0,1]$ which depends on the payoff relevant part of history as represented by the state variable S_t and the policy rule λ_t. Hence, a contribution strategy for lobby i is a mapping which assigns for every possible policy action λ_t of the government a nonnegative reward contingent on the payoff relevant history of the game. The two lobbies represent the preferences of the membership sincerely, and the net policy preference function for the Y-group can be represented as:

$$\begin{aligned} n_Y(\lambda_t, S_t) = \;& \theta \ln S_t + \gamma \ln \lambda_t + \ln(1-\lambda_t) + \\ & \theta \ln(1 - c_Y(\lambda_t, S_t)) + \beta N(\lambda_t, S_t) \end{aligned} \tag{15}$$

where the expected net policy preference for period $t+1$ is given by

$$\begin{aligned} N(\lambda_t, S_t) = \;& 2\ln S_{t+1} + \ln \lambda_{t+1} + \ln\left(1-\lambda_{t+1}\right) + \\ & 2\ln\left(1 - c_O\left(\lambda_{t+1}, S_{t+1}\right)\right). \end{aligned}$$

The net policy preference function for the O-group is

$$n_O(\lambda_t, S_t) = 2\ln S_t + \ln \lambda_t + \ln(1-\lambda_t) + 2\ln(1 - c_O(\lambda_t, S_t)). \tag{16}$$

Some features of these net payoff functions should be pointed out immediately. First, we assume that the Y-group, to the extent that it affects the future well-being of the members, recognises the link between the production of dirty goods today and resource availability tomorrow. We also notice that the Y-group takes into account that members are going to resign their membership at the end of the period and join the O-group, to which they pay a fraction of their production, c_{Ot+1}. Second, the net payoff functions are not linear in the contribution payment. This implies, as we shall see more clearly below, that utility cannot be transferred on a one-to-one basis between the lobby groups and the government. This distinguishes our model from previous work on lobby groups (see *Grossman and Helpman*, 1994 and others) in which, with the exception of *Dixit, Grossman and Helpman* (1997), transferable utility is assumed. Third, while the payoff functions are not linear in the individual contributions, it is important for our results that there is separability between S_t, c_{it} and λ_t.

from the generations, no matter what is the share of each of them. In other words, government is not endowed with any green preference and, from its point of view, the two goods are perfect substitutes. This justifies the contribution functions adopted through the paper, where each generation offers the government an aggregate bundle of the two goods and not a two-dimensional vector specifying the amount of each good.

The government is assumed to be short-sighted and opportunistic. There is an election in each period, and the objective of the politician is to collect the maximum contributions from the lobbies to finance the next election campaign. Therefore, in each period, a new government, which is only concerned with the total contribution that it can extract from the lobbies, comes into office. This combination of short-sightedness and opportunism implies that the government has no incentive to internalise the externality unless it is rewarded by the Y-group for doing so. We assume that the government implements the policy rule at no cost. The objective function of the government of period t is assumed to be

$$G(\lambda_t, S_t) = S_t \left\{ c_Y \left(\lambda_t, S_t \right) + c_O \left(\lambda_t, S_t \right) \right\} \tag{17}$$

where S_t is given from the past.

At each period t, three (different) players $-$ two lobbies and a government $-$ are active in the political market. We model the interaction between the three players as a common agency (*Bernheim and Winston*, 1986). The common agency game played in period t has two stages. In the first stage, the two lobbies (the principals) simultaneously choose a contribution function to offer to the government, while looking ahead to the response of the government (the agent) in the second stage. In the second stage of game, the government chooses a resource policy, λ_t, given the contribution payment schedules by the lobbies. The infinite sequence of the common agency game is linked together by the state variable, S_t, as given by equation (7). While the government and the O-group who are active in the common agency game in period t have no stake in the future, the Y-group, whose members are going to be alive in period $t+1$, has an interest in future resource availability. Thus, the Y-group at time t needs to look ahead to period $t+1$ and anticipate how current play affects the future political equilibrium.

6.1 Political Equilibria

The model described above defines an infinite time horizon dynamic common agency game with perfect information. To define the equilibrium, we need first to specify the strategies of the players. While the lobbies could make their strategies contingent on the whole history of the game, we shall restrict attention to the payoff relevant part of history summarized by S_t. A strategy for lobby i active at time t is a contribution function $c_i(\lambda_t, S_t) \in [0, 1]$ which relates to each feasible policy action ($\lambda_t \in [0, 1]$), the fraction of production that it will contribute to the government. We denote the set of feasible contribution functions of group i by Ω_i. A strategy of the government in office in period t is a resource policy $\lambda(S_t) \in [0,1]$ which may depend on the state of the world S_t. We only consider stationary resource policy functions.

Having specified the preferences and the strategies of the players, we can now define political equilibrium more precisely. It is convenient first to define the notion of a best response for the two lobbies, active at a given point in time. We use the notation "$\wedge$" to denote equilibrium values of the relevant variables and functions.

Definition 3 ***Best Response:*** *For $t \geqslant 0$, the contribution function $\widehat{c}_Y(\lambda_t, S_t)$ is a best response to the contribution function $\widehat{c}_O(\lambda_t, S_t)$ if the Y-group active in period t cannot find an alternative contribution function, $\overline{c}_Y(\lambda_t, S_t)$, such that*

$$n_Y\left(\overline{\lambda}_t, S_t\right) > n_Y\left(\widehat{\lambda}_t, S_t\right) \tag{18}$$

where for $t \geqslant 0$,

$$\widehat{\lambda}(S_t) = \arg\max_{\lambda_t} \widehat{c}_Y(\lambda_t, S_t) + \widehat{c}_O(\lambda_t, S_t), \tag{19}$$

$$\overline{\lambda}(S_t) = \arg\max_{\lambda_t} \overline{c}_Y(\lambda_t, S_t) + \widehat{c}_O(\lambda_t, S_t).$$

For $t \geqslant 0$, the contribution function $\widehat{c}_O(\lambda_t, S_t)$ is a best response to the contribution function $\widehat{c}_Y(\lambda_t, S_t)$ if the O-group active in period t cannot find an alternative contribution function, $\underline{c}_O(\lambda_t, S_t)$, such that

$$n_O(\underline{\lambda}_t, S_t) > n_O(\widehat{\lambda}_t, S_t) \tag{20}$$

where $\widehat{\lambda}_t(S_t)$ is defined in equation (19) and

$$\underline{\lambda}(S_t) = \arg\max_{\lambda_t} \widehat{c}_Y(\lambda_t, S_t) + \underline{c}_O(\lambda_t, S_t). \tag{21}$$

The definition of the best response for the O-group active in period t is straightforward. The contribution function $\widehat{c}_O(\lambda_t, S_t)$ is a best response if the group cannot find an alternative contribution function that yields more utility than $n_O(\widehat{\lambda}_t, S_t)$ when it takes into account that the government is going to reoptimise its resource policy in the second stage of the common agency game played in that period in response to a change in the contribution strategy of the group. It also assumes that the play of the other group remains unchanged. The definition of the best response for the Y-group active in period t is more complicated. This is because the Y-group is concerned with the utility of its members in period $t+1$. To evaluate the payoff associated with a deviation from $\widehat{c}_Y(\lambda_t, S_t)$, the Y-group needs to take into account, not only that the current government reoptimises, but also that the change in the resource policy today affects the availability of the resource tomorrow. This in turn changes the political equilibrium in period $t+1$, even for a fixed profile of the strategies of other players. We can now introduce the definition of Political Equilibrium.

Definition 4 ***Political Equilibrium:*** *A political equilibrium is a sequence of contribution functions* $\{\widehat{c}_O(\lambda_t, S_t), \widehat{c}_Y(\lambda_t, S_t)\}_{t=0}^{\infty}$ *and a sequence of resource policies* $\{\widehat{\lambda}\,(S_t)\}_{t=0}^{\infty}$ *such that:*

(1) *The contribution functions and the policy actions are feasible, i.e., for all* i *and* t, $\widehat{c}_i(\lambda_t, S_t) \in \Omega_i$ *and* $\lambda_t \in [0,1]$ *where* Ω_i *is the set of all feasible contribution functions of group* i.

(2) *For all* $t \geqslant 0$,

$$\widehat{\lambda}(S_t) = \arg\max_{\lambda_t} \ \widehat{c}_Y(\lambda_t, S_t) + \widehat{c}_O(\lambda_t, S_t). \tag{22}$$

(3) *For all* $t \geqslant 0$, *the contribution function* $\widehat{c}_Y(\lambda_t, S_t)$ *is a best response to* $\widehat{c}_O(\lambda_t, S_t)$ *and vice versa.*

The definition of the equilibrium is basically a standard definition of a subgame perfect Nash equilibrium in a dynamic common agency game with perfect information, with the restriction that strategies can only depend on the current state S_t. Without further restrictions on the space of the feasible contribution functions that the lobbies can employ, this game will have multiple political equilibria. We will identify a particular type of political equilibrium by restricting the feasible contribution strategies to the class of so called "*Take-It-Or-Leave-It*" (TIOLI) contribution functions. Formally, we define a TIOLI contribution function as follows:

Definition 5 ***TIOLI Contribution Function:*** *A TIOLI contribution function* $\widehat{c}_i\,(\lambda_t, S_t)$ *is a function of the following type:*

$$\widehat{c}_i\,(\lambda_t, S_t) = \begin{cases} \widehat{c}_i(S_t) & \textit{if} \ \ \widehat{\lambda}(S_t) = \lambda^i(S_t) \\ 0 & \textit{otherwise} \end{cases} \tag{23}$$

where $\lambda^i(S_t)$ *is the policy proposal of group* i *where* $i \in \{Y, O\}$.

We see from the definition of the TIOLI contribution function that a lobby group offers the government a payment only if it implements the resource policy asked for by the group. Generally, the policy proposal may be a function of S_t. Then, following from definition (5), the optimal resource policy rule of the government active in period t takes the following form if the lobbies use TIOLI contribution functions:

$$\widehat{\lambda}(S_t) = \begin{cases} \lambda^O(S_t) & \text{if } \;\; \widehat{c}_O(S_t, \lambda_t) \geqslant \widehat{c}_Y(S_t, \lambda_t) \\ \lambda^Y(S_t) & \text{if } \;\; \widehat{c}_O(S_t, \lambda_t) < \widehat{c}_Y(S_t, \lambda_t). \end{cases} \tag{24}$$

That is, the government implements the policy in period t proposed by the lobby which demonstrates the greatest willingness to pay in support of its proposal. Thus, we note that political competition in TIOLI strategies will give rise to extreme policy outcomes rather than to a compromise between the policy proposals of the two groups.

6.2 Characterization of Equilibria

Given the biological growth function defined in equation (7) and the use of a *Cobb-Douglas* preference structure, it is relatively simple to characterise the political equilibrium in TIOLI strategies. Suppose political competition takes place between the Y-group and the O-group in period t. For a given resource inherited from the past, we can now identify the two TIOLI contribution strategies employed by the two groups, and the corresponding optimal resource management policy of the short-lived government as follows. First, consider the policy proposals made by the two groups. The O-group is not concerned about the future and so, for a given contribution payment, $\widehat{c}_O(S_t, \lambda_t)$, and keeping the strategy of the Y-group constant, it proposes the policy that maximises its net payoff given by equation (16), i.e.,

$$\lambda^O(S_t) = \arg\max_{\lambda_t} n_O(\lambda_t, S_t). \tag{25}$$

A simple calculation shows that the policy proposal from the O-group will be $\lambda^O(S_t) = \lambda^O = 1/2$. We notice that the proposal is independent of S_t as well as the contribution payment that goes with it. On the other hand, the Y-group is concerned about the welfare of its member in period t as well as in period $t+1$, and so, it has to anticipate correctly the political equilibrium in period $t+1$ and take into account how current play affects resource availability tomorrow. Looking one period ahead, the Y-group foresees that $\lambda(S_{t+1}) = \widehat{\lambda}_{t+1}$ and that $c_i(\lambda(S_{t+1}), S_{t+1}) = \widehat{c}_i(\widehat{\lambda}_{t+1}, S_{t+1})$. Taking the contribution strategy of the current O-group as given, for given $\widehat{c}_Y(S_t, \lambda_t)$, it proposes the following policy

$$\lambda^Y(S_t) = \arg\max_{\lambda_t} n_Y(\lambda_t, S_t) \tag{26}$$

where $n_Y(\cdot)$ is given by equation(15). Solving this optimization problem yields

$$\lambda^Y = \left\{(\theta + C) - \sqrt{(\theta + C)^2 - 4C\gamma}\right\}/2C \tag{27}$$

where $\theta = (1+\gamma)$ and $C \equiv 4\phi\beta$.[14] We notice that the policy proposal of the Y-group is also independent of the payment that goes with it ($\widehat{c}_Y(S_t, \lambda_t)$) as well as of $S_{t.}$ This shows that the current policy proposal is independent of future proposals. It intuitively follows that the policy proposal made when young will be quite different from that made when old. Second, it follows directly from the equation(19) that the government, faced with the TIOLI contribution strategies which are associated with the policy proposals given by $\lambda^O = 0.5$ and (27), implements the following policy rule:

$$\widehat{\lambda}(S_t) = \begin{cases} \lambda^O & \text{if } \widehat{c}_O(S_t, \lambda_t) \geqslant \widehat{c}_Y(S_t, \lambda_t) \\ \lambda^Y & \text{if } \widehat{c}_O(S_t, \lambda_t) < \widehat{c}_Y(S_t, \lambda_t). \end{cases} \tag{28}$$

To close the characterization of the political equilibrium in period t, we need to specify the payments that go with the two proposals. To this end, we introduce the notion of *willingness to pay*. Consider the following question: how much would the O-group be willing to pay to induce the government to implement its policy proposal ($\lambda^O = 1/2$), as opposed to accepting that the government implements the policy proposal of the Y-group (λ^Y) without paying any contribution ($c_O(\lambda^Y, S_t) = 0$)? The answer to this question defines the O-group's willingness to pay in support of its policy proposal. The following result can be derived:

Lemma 1 ***Willingness to Pay:*** *The willingness to pay of the two groups active in period t is independent of S_t. In particular, the O-group's willingness*

[14]We rule out another positive root which is larger than $1/2$ since we assume that the Y-group is more conservative than the O-group in the sense that it has to foresee availability of the resource when it becomes old. Simple calculation shows that the condition $0 < \gamma < \frac{A}{2} + 1$ is needed for this assumption.

to pay to achieve $\lambda^O = 1/2$ *is*

$$c_O^{\max}(\beta,\gamma,\phi) = 1 - \exp\left\{(1/2)\left[\ln\left(1-\lambda^Y\right) + \ln\lambda^Y - 2\ln(1/2)\right]\right\} \tag{29}$$

while the Y-group's willingness to pay to achieve λ^Y *is*

$$\begin{aligned} c_Y^{\max}(\beta,\gamma,\phi) = \; & 1 - \exp\left\{\theta^{-1}\left[\theta\ln(1/2) - \ln\left(1-\lambda^Y\right) - \gamma\ln\lambda^Y\right] + \right. \\ & \left. \theta^{-1}4\beta\phi\left(\lambda^Y - 1/2\right)\right\}. \end{aligned} \tag{30}$$

Proof. See Appendix A ■

Paying contributions is obviously costly to the two groups. Although they are willing to pay a limited amount in support of their policy proposals, they prefer to pay less if they can still get their policy proposals through the political process. This implies that the group with the greatest willingness to pay can succeed by offering the government a payment that corresponds to the willingness to pay of the other group (and a small amount more). We formalise this idea in the following proposition:

Proposition 2 *Suppose that the old and young generation lobby the government using the TIOLI strategies and that the resource policy function is given by equation* (28)*. Then the following constitute stationary political equilibria.* (1) *For arbitrary small* $\epsilon > 0$,

$$\begin{aligned} \widehat{\lambda} &= \lambda^O \\ \widehat{c}_Y(\lambda) &= \begin{cases} 0 & \text{for } \widehat{\lambda} \neq \lambda^Y \\ c_Y^{\max} & \text{for } \widehat{\lambda} = \lambda^Y \end{cases} \\ \widehat{c}_O(\lambda) &= \begin{cases} 0 & \text{for } \widehat{\lambda} \neq \lambda^O \\ c_Y^{\max} + \epsilon & \text{for } \widehat{\lambda} = \lambda^O \end{cases}, \end{aligned} \tag{31}$$

if and only if $c_O^{\max} > c_Y^{\max}$*.* (2)

$$\begin{aligned} \widehat{\lambda} &= \lambda^Y \\ \widehat{c}_Y(\lambda) &= \begin{cases} 0 & \text{for } \widehat{\lambda} \neq \lambda^Y \\ c_O^{\max} + \epsilon & \text{for } \widehat{\lambda} = \lambda^Y \end{cases} \\ \widehat{c}_O(\lambda) &= \begin{cases} 0 & \text{for } \widehat{\lambda} \neq \lambda^O \\ c_O^{\max} & \text{for } \widehat{\lambda} = \lambda^O \end{cases}. \end{aligned} \tag{32}$$

if and only if $c_O^{\max} \leqslant c_Y^{\max}$*.*

Proof. See Appendix B ■

In the light of equation (31) and (32), it is noticed that the political equilibrium in period t is independent of the amount of the resource inherited from the past.

Corollary 3 *The resource policy implemented in period t is independent of the state of the world S_t.*

This corollary has an important implication. Since the stationary political equilibrium in period t does not depend on the amount of resources left over from the past (S_t), the political equilibrium obtained in period $t-1$ cannot affect the equilibrium play in period t. Therefore, the Y-group active in period $t-1$ can anticipate the political equilibrium in period $t-1$ without having to calculate how the political equilibrium in the current period affects future play via the impact on resource availability in the future. The result states that a stationary political equilibrium path is a sequence of the identical equilibrium resource policies. Since the resource evolves along the political equilibrium path, the welfare of each group changes over time. This does not, however, affect the political strategies of the players due to the assumptions about the law of motion, preferences and TIOLI contribution functions. It follows from the proposition that if, for example, the O-group has the greatest willingness to pay in support for its policy proposal (in the first period), then the political equilibrium implemented will be the policy proposal preferred by the old in each subsequent period, and, vice versa, if the Y-group has the greatest willingness to pay. The willingness to pay of a group depends on the underlying parameters of the model. In the next section, we investigate how the resource policy implemented as the political equilibrium (for some t) depends on two key parameters of the model: (i) the green preference γ of the young; and, (ii) the inverse measure of the effectiveness in the resource preservation ϕ with respect to the production of dirty goods.

7 The Comparative Statics Analysis

7.1 Comparative Statics for the Political Equilibria

We now discuss some comparative statics results in order to examine the influence of the key parameters such as γ and ϕ on the equilibrium policy choice (λ). For this purpose, we define the explicit function

$$\psi(\gamma,\phi) = c_Y^{\max}(\gamma,\phi) - c_O^{\max}(\gamma,\phi). \tag{33}$$

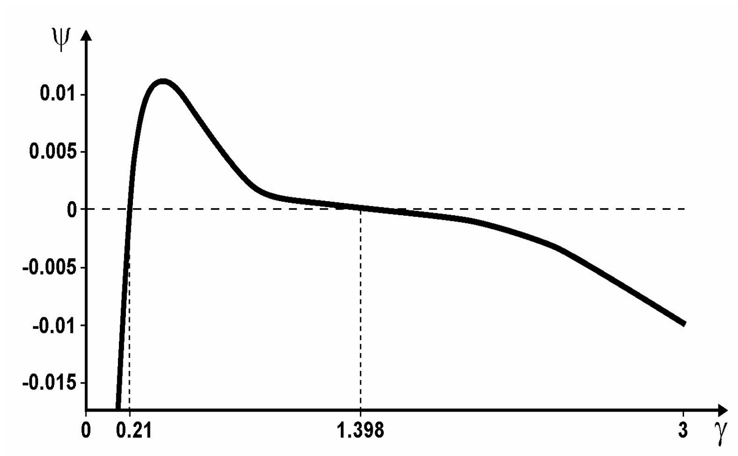

Figure 1: The function ψ with respect to γ

Each group's willingness to pay can be expressed as a function of the key parameters and the equilibrium resource policy depends on the sign of the function $\psi(\gamma, \phi)$. We will focus on how changes in each parameter affect the formation of policy.

• **The green preference of the young** (γ)

In figure 2.1, ψ is presented as a function of γ, given the other parameters $(\beta = 1,\ \phi = 0.2)$. We see that there exists two critical values of γ, $\gamma_L \simeq 0.210$ and $\gamma_H \simeq 1.398$ at which $\psi(\gamma)$ is zero. For values of γ between these roots, the Y-group is willing to contribute more than the O-group to get its preferred resource policy $\left(\lambda^Y\right)$; for low and high values of γ, the policy choice is λ^O.

Figure 2.2 illustrates this: for low values of γ $(\gamma < \gamma_L)$, the government chooses the resource policy which is preferred by the old, i.e. 0.5; but, for $\gamma \in (\gamma_L, \gamma_H)$, the policy is that supported by the young $\lambda \left(= \lambda^Y\right)$. The figure shows that the policy rule $\lambda \left(= \lambda^Y\right)$ defined in (27) is increasing in γ. Finally, when γ becomes larger than γ_H, the equilibrium policy choice is 0.5 again.

The intuition is as follows. For very low γ, the Y-group has a strong green preference and so allocates most of its labour endowment to production of clean goods. However, with the relatively efficient resource preservation technology $(\phi = 0.2)$, the Y-group is not as sensitive to the government policy choice as the O-group. In other words, the O-group would be forced to give up consumption of the dirty good if the government enforced λ^Y, which is very small for low γ. The

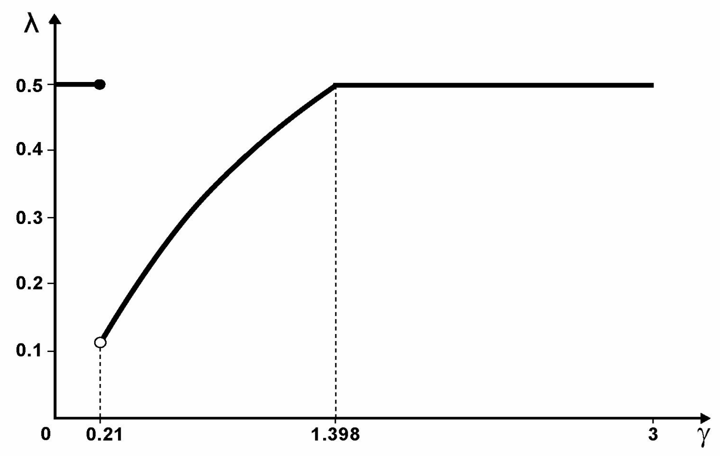

Figure 2: Changes in the political equilibrium λ over γ

O-group would then seek to avoid this by contributing more than the Y-group.

A similar explanation applies when $\gamma > \gamma_H$. For $\gamma > \gamma_H$, λ^Y is higher than 0.5 because the Y-group prefers to consume dirty goods rather than clean goods. So it would allocate more labour to production of dirty goods. Being aware that the current over-consumption of dirty goods would generate some adverse effects on the future resource availability, the Y-group would not be motivated to contribute much. Rather, it will be the O-group who is sensitive to the choice of the resource policy because λ^Y is higher than its most preferred policy level.

For $\gamma \in (\gamma_L, \gamma_H)$, the Y-group prefers a policy which is lower than 0.5 and would more actively compete with the O-group. If the government enforced the resource policy preferred by the O-group $\lambda_t = 1/2$, then the Y-group has to bear the negative future consequences on the resource stock. They are also forced to consume less of clean goods due to an increase in the dirty goods consumption by the old. Therefore, the Y-group would have a strong incentive to make a contribution to the government when $\gamma \in (\gamma_L, \gamma_H)$ and, at equilibrium, outbids the O-group.

• **The inverse measure of the efficiency of resource preservation** (ϕ)

Next, we examine how the political equilibrium is affected by changes in the parameter ϕ, which is a inverse measure of the efficiency of resource preservation. Again, the Y-group contributes more than the O-group, provided that the function $\psi(\phi)$ is positive. We fix $\gamma = 0.4$ and $\beta = 1$.

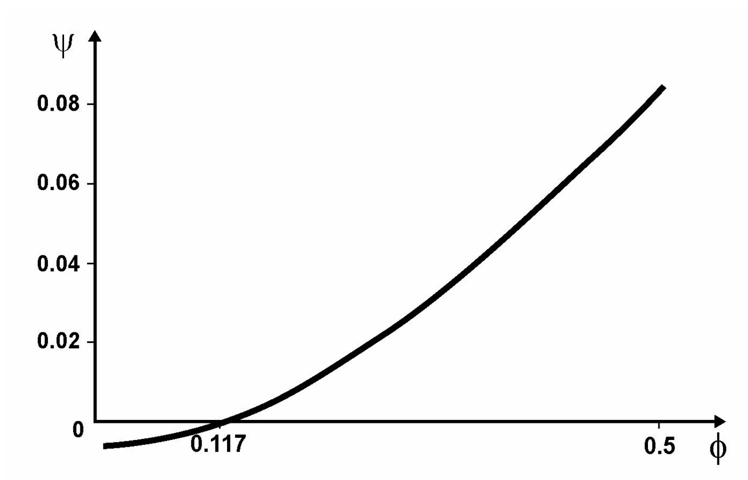

Figure 3: The function ψ with respect to ϕ

Figure 2.3 indicates that the Y-group wins the competition for large ϕ, and that the O-group wins for small ϕ. Faced with decreasing efficiency of resource preservation ($\phi \uparrow$), the Y-group seeks to reduce the negative externality by getting the politician to restrict the allocation of labour to production of dirty goods by regulation. This reflects the fact that as ϕ is getting larger, the Y-group is concerned with reducing the current production of dirty goods in order to save future resources. Therefore, the Y-group is strongly motivated to contribute to the government, so that it can regulate the production of dirty goods.

For very small values of ϕ, however, the impact of current production of dirty goods on the resource stock is minor, and, consequently, the negative externality from the production of dirty goods is insignificant. Then, the Y-group has relatively little incentive to bid in favour of its much preferred policy and the O-group gets its policy implemented. The political equilibrium level of λ as a function of ϕ is shown in figure 2.4, where $\widehat{\lambda} = 0.5$ for $\phi \leqslant 0.117$, and $\widehat{\lambda} = \lambda^Y$ for $\phi > 0.117$. We see that λ^Y is decreasing in ϕ.

This indicates that the Y-group is much motivated to outbid the O-group as the resource preservation technology gets less efficient. This is mainly due to a gloomy expectation that the future resource would be less available, which could stimulate a willingness to pay by the Y-group. That is, faced with a relatively high ϕ, the Y-group would try to overcome the problem of securing the future resource stock by low λ through competition with the O-group.

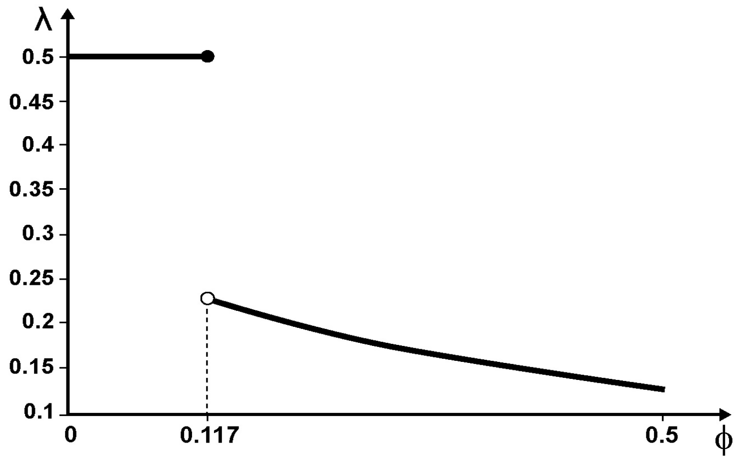

Figure 4: Changes in the political equilibrium λ over ϕ

7.2 Comparison of the Three Regimes

In this sub-section, we compare the equilibrium resource policies that we have examined so far. These are the equilibrium policies emerging at political equilibrium, from the social planner's solution, and from the unregulated economy. We will compare what happens to the total amount of the labour endowment allocated to the production of dirty goods when the values of γ and ϕ are varied. In figures 2.5 and 2.6, the thick line represents the political equilibrium, the normal line represents the unregulated (competitive) equilibrium, and the dashed line the social planner's equilibrium.

Figure 2.5 presents the *aggregate* equilibrium policies (2λ) under the three regimes as functions of the green preference parameter γ of the young generation, given the parameter values $\beta = 1$, $\rho = 0.85$, $\phi = 0.2$. The figure shows that the order of the equilibrium policy level is reversed as γ increases $\left(\lambda^P > \lambda^{SP} > \lambda^{CE} \text{ to } \lambda^P < \lambda^{SP} < \lambda^{CE} \text{ as } \gamma \uparrow\right)$.[15] If the social planner cares more for the future generation's welfare ($\rho \uparrow$), the social planner's equilibrium policy (represented by the dashed line) would more shift down. If the resource preservation technology becomes less efficient ($\phi \uparrow$), the social planner's equilibrium policy would shift down, and the range over which the Y-group wins ($\gamma \in (\gamma_L, \gamma_H)$)

[15] Here, λ^P denotes the political equilibrium level of policy choice.

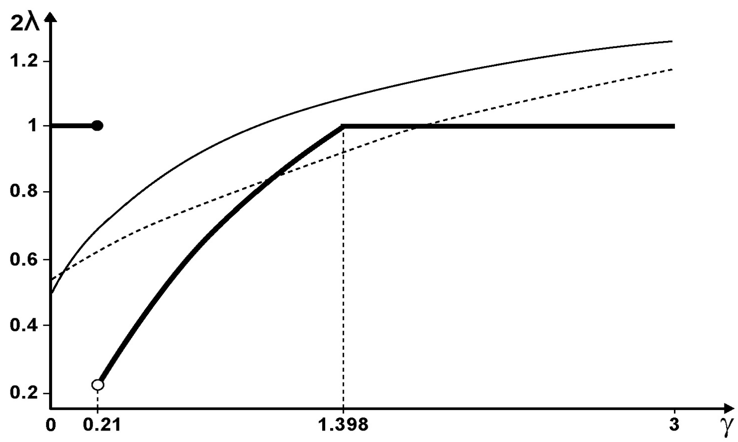

Figure 5: Changes in the tree equilibria over γ

would widen.

First of all, for low γ, the unregulated equilibrium starts has the lowest value of λ but λ^{CE} monotonically increases until it asymptotically approaches an upper bound. It has the highest λ among the three equilibria for $\gamma = 3$. This is due to the nature of the unregulated equilibrium. The λ chosen by the social planner' also increases with γ, and it is lower than the unregulated equilibrium policy for intermediate value of γ since the benevolent planner considers future generations' welfare and so takes into account the negative externality generated by the current production of dirty goods. However, the policy implemented by the social planner when γ is large is the highest of all since he should considers a serious anti-green nature in the preference of the current young generation. Moreover, if there was a relatively inefficient resource preservation technology, the social planner has to restrain further the use of dirty goods, thus causing a downward shift of the dashed line. Hence, the policy choice by the social planner would be sensitive to changes in the parameters such as ϕ and ρ. Figure 2.5 shows that the political equilibrium is always lower than the unregulated equilibrium except for very small value of γ and allows the least production of dirty goods among the three regimes when γ is high enough. The order of the equilibrium policy level is changeable over small γ.

Next, in figure 2.6, we carry out the same analysis, but with respect to the parameter ϕ. The given parameter values are $\beta = 1$, $\gamma = 0.4$ and $\rho = 0.85$. The

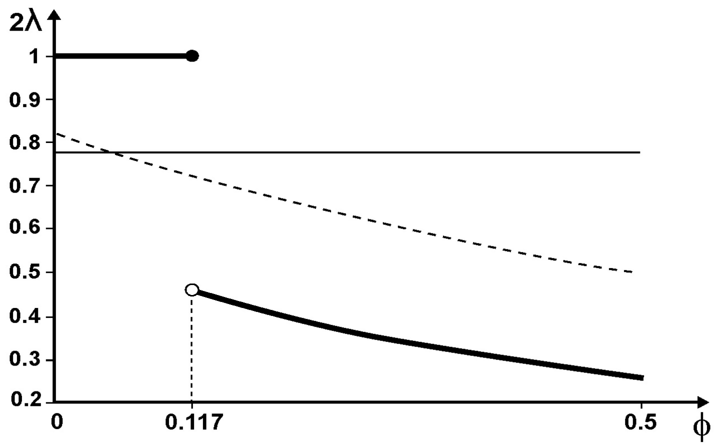

Figure 6: Changes in the three equilibria over ϕ

unregulated equilibrium is independent of ϕ since individuals under that regime do not care about the externalities they generate. Then, as the young individual desires more dirty goods consumption, so would the level of unregulated equilibrium be higher. It is not difficult to deduce that both the social planner's and the political equilibrium policy would regulate the labour input for dirty goods production, since these regimes do consider the growing externalities to future generations as the resource preservation technology becomes less efficient. This is mainly because an urgent need for sustainable resource preservation for the future generations is reflected in the equilibrium policy formation process.

In figure 2.6, we show a case in which the young has a relatively pro-green preference ($\gamma = 0.4$). It is noted that the political equilibrium is lower than the social planner's, when the resource preservation technology is sufficiently inefficient ($\phi \uparrow$). This is because the resource policy adopted in political equilibrium when the Y-group wins responds more to changes in γ than the social planner's policy. Indeed, the social planner's equilibrium policy is lower than the political equilibrium policy only when γ is unusually large. Therefore, the political equilibrium would usually show the lowest values when ϕ increases. In short, we note that the political equilibrium characterised by TIOLI strategies often implement the most strict resource management policy as compared to the other equilibrium policy regimes.

This observation has immediate implications for the long-run level of the resource. To see this, fix the parameter values of $\beta = 1$, $\rho = 0.85$, $\phi = 0.2$, $\gamma = 0.4$, $\delta = 0.5$. The following values show the steady state levels of the resource stock under the three policy regimes.

Policy Regime	TIOLI (λ^Y)	social planner's	unregulated
$\overline{S}$	6.317	5.647	5.396

where $\overline{S}$ denotes a steady state level of the resource. The table shows that the political equilibrium could generate the largest amount of the long run sustainable resource stock provided that the young generation wins the political competition.[16]

8 Discussion

It is well known that common agency models typically have multiple equilibria. Among these, this paper focuses on equilibria in the TIOLI strategies. With separable log linear utility functions and the exponential form of the biological growth function of the resource, the TIOLI strategies are state independent. Thus, it is relatively easy to characterise stationary equilibria in TIOLI strategies. However, if we relax these assumptions, then the equilibrium would be more complicated because the equilibrium strategies would be state dependent. If so, we have to further take into account the evolutionary behaviour of the state variable when deriving the equilibrium strategies in each time.

One feature of the TIOLI strategy equilibria is that they are not jointly efficient for the politician (government) and the lobbies.[17] Equilibria in TIOLI strategies are characterised by "extreme" policy implementation that favours one generation at the expense of the other. Therefore, only the winner's payoff would be maximised under the TIOLI competition. This feature contrasts with an equilibrium concept first introduced by *Bernheim and Whinston* (1986). They considered a particular class of equilibria named "*Truthful*". The truthful strategy refers to a contribution schedules of a principal, which coincides with that principal's indifference surface when contributions are positive.[18] One of

[16] For the given parameters, the willingness to pay for the Y-group is higher than that for the O-group ($c_Y^{\max} > c_O^{\max}$). Thus, the resource policy adopted will be λ^Y.

[17] Joint efficiency is achieved when the sum of payoffs for all the players (the agent and prinicipals) is maximised.

[18] The truthful contribution schedule is alternatively called the "*compensating*" schedule by

the appealing properties of the truthful equilibrium is that it is jointly efficient for all the players in the game. Instead of the extreme competition in our case, if each generation follows the truthful strategy by taking a partial contribution so that the government implements a resource policy which is in an intermediate position between λ^Y and λ^O, then total payoff for the generations and the government would be increased.

However, *Kirchsteiger and Prat* (2001) provide an argument in favour of using TIOLI strategies despite the fact that they lead to inefficient outcomes. They argue that people, in general, are not likely to play truthful strategies because they are complex with increasing computational time as the number of principals increase. In addition, the strategy requires each principal to make positive contribution offers on all, or most, possible alternatives. So even those principals who would know how to play the truthful strategy might decide to play a rather simple strategy out of risk-dominance considerations. They go on to propose another equilibrium concept termed "*Natural*" which is motivated by such considerations. The "natural" strategy is similar to the TIOLI strategy used in this article.[19] They provide experimental evidence that "natural" strategies are a better predictor of behaviour than the "truthful" strategies.[20] The experimental shows that the outcome predicted by the natural equilibrium more closely matches real behaviour (in 65% of the matches) than the one predicted (less than 5%) by the truthful equilibrium.

The equilibrium in TIOLI strategy has some interesting similarities with a *Vickery* (second-price sealed-bid) auction. In both cases, the player with the highest valuation wins and pays the bid of the second highest bidder. But, unlike the TIOLI equilibria, the *Vickery* auction is efficient. This is because total surplus which is the sum of the surplus to the seller and to the buyer is

Grossman and Helpman (2001) because, when a lobby group makes positive offers for two different levels of the policy, the difference between the two positive offers compensates for the difference in the lobby group's evaluation of the two policies.

[19] In a common agency game, Natural equilibrium and the TIOLI strategy equilibrium are similar in that each principal makes only one strictly positive offer on the one alternaitve the agent chooses. However, in Natural equilibrim, principals ($\geqslant 2$) are divided into two sub-sets groups so that one side supports one alternative that maximises its surplus and the other sider another. That is, each principal contributes only to the alternative supported by her side. But, in the TIOLI strategy equilibrium, each principal has her own alternative which she hopes to contribute. For details, see *Kirchsteiger and Prat* (2001).

[20] The experiment was conducted in the following ways: first, they design a simple common agency game with two principals and three alternatives. Second, The game was repeated with different players and the choices of strategies by the principals are observed.

maximised, while the payoff of the other buyers are not changed. Thus, the player who bids the highest value will win at a price which is equal to the value of the second-highest bidder, and the allocation would be Pareto-efficient. That is, the winning bid is equal to the largest of the reservation prices and the actual sales price equals the second highest of these reservation prices. In contrast, equilibria in TIOLI strategies are inefficient because the policy choice of the government generates a negative externality that affects the payoff of the generation who loses the political competition. This is because all generations are required to accommodate the uniform policy rule adopted by the government whatever they like it or not.

9 Conclusion

Intergenerational conflict is a central issue in relation to intertemporal common resource management. In this paper, we have studied an infinite horizon OLG model with interest group politics, in which the pressure groups organised by the young and old generations compete by lobbying the policy maker for the implementation of their favorite resource policies. In each period, it is assumed that a short lived government enforces the resource management policy which affects the resource utilisation patterns in the production process. The basic framework of our model is the dynamic common agency model, and it shares structural similarities with that of *Dixit, Grossman and Helpman* (1997) in that we assume non-transferable utility for each generation. The "*Take-It-Or-Leave-It*" (TIOLI) class of contribution strategies is adopted in the model. This provides us with a simple way of characterising the equilibrium policy. In the "TIOLI strategy equilibrium", the lobby group with the greatest willingness to pay attains its most preferred resource policy. However, unlike the truthful strategies used in most of the common agency literature, the TIOLI strategy is not jointly efficient.

The resource policy characterised by the TIOLI strategy is compared with those of the unregulated, as well as of the planned economy. We examined how changes in the key parameters in the model affect these equilibria. In particular, it is shown that the political equilibrium could allow more sustainable resource management and a greener environment than other equilibrium policies. In other words, political competition may lead to the highest steady state resource stock, even though an inefficient resource preservation technology and an anti-green attitude of the young generation are prevalent in the economy.

A Proof of Lemma 1.

The O-group is willing to pay a contribution $c_O(\lambda_t, S_t)$ to get its policy proposal $\lambda^O = 1/2$ if and only if this gives it a utility level greater than or equal to the one it would get by accepting that the government implements the policy λ^Y proposed by the Y-group without paying any contribution. This is true when the following inequality is satisfied:

$$n_O\left(\lambda^O, S_t, c_O(\lambda_t, S_t)\right) \geqslant n_O\left(\lambda^Y, S_t, 0\right). \tag{34}$$

Since $n_O(\lambda_t, S_t, c_O(\lambda_t, S_t))$ is decreasing in $c_O(\lambda_t, S_t)$, the O-group's willingness to pay, $c_O^{\max}$, corresponds to that payment that makes equation (34) hold with equality. From (15), (16) and (27) and after some tedious but straightforward computations, one obtains the expression of $c_O^{\max}$ provided in (29).

The Y-group's willingness to pay, $c_Y^{\max}$, can be obtained using same logic:

$$n_Y\left(\lambda^Y, S_t, c_Y(\lambda_t, S_t), \widehat{\lambda}_{t+1}, \widehat{c}_{Ot+1}\right) \geqslant n_Y\left(1/2, S_t, 0, \widehat{\lambda}_{t+1}, \widehat{c}_{Ot+1}\right) \tag{35}$$

where $\widehat{\lambda}_{t+1}$and $\widehat{c}_{Ot+1}$ denote the expected equilibrium resource policy rule of the government in office in period $t+1$ and the expected equilibrium contribution rate of the O-group in period $t+1$ respectively.

The contribution - that makes them hold with equality - corresponds to the function given in (30). In view of (29) and (30), the willingness to pay in any period t for both groups is independent of S_t and so constant over time.

B Proof of Proposition 2.

(**A**) **Necessity:** We characterise the stationary equilibrium strategies. Let the two types of groups play stationary TIOLI strategies, let the willingness to pay for the Y and O-group given in equation (29) and (30), respectively, and let the resource policy decision process by the government be given in equation (28). (i) We begin by proving part (1) of proposition 2. Thus, assume that $c_O^{\max} > c_Y^{\max}$. Given the strategy of the Y-group:

$$\widehat{c}_Y\left(\widehat{\lambda}\right) = \begin{cases} 0 & \text{for } \widehat{\lambda} \neq \lambda^Y \\ c_Y^{\max} & \text{for } \widehat{\lambda} = \lambda^Y \end{cases}, \tag{36}$$

it will be shown that the contribution function

$$\widehat{c}_O\left(\widehat{\lambda}\right)=\begin{cases}0 & \text{for } \widehat{\lambda}\neq\lambda^O\\ c_Y^{\max}+\epsilon & \text{for } \widehat{\lambda}=\lambda^O\end{cases} \tag{37}$$

represents a best reply of the O-group.

Suppose that stationary government resource policy is $\widehat{\lambda}=1/2$ for all time t. Then the O-group is willing to bid $c_O^{\max}$ to get $\lambda(S_t)=1/2$ implemented, where $c_O^{\max}$, by definition, satisfies $n_O\left(\lambda^O,S_t,c_O^{\max}\right)=n_O\left(\lambda^Y,S_t,0\right)$. Given the strategy choice of the O-group, the only possible deviation by the Y-group is to offer a slightly higher contribution than the O-group and thereby to induce the government to set the resource policy λ^Y instead of λ^O. That is, to offer the government $c_O^{\max}+\eta$ for arbitrarily small η. This gives the Y-group $n_Y\left(\lambda^Y,S_t,c_O^{\max}+\eta,1/2,0\right)$.

Now, by definition, the Y-group is willing to offer at most $c_Y^{\max}$ to get λ^Y when $c_Y^{\max}$ is defined by

$$n_Y\left(\lambda^Y,S_t,c_Y^{\max},1/2,0\right)=n_Y\left(1/2,S_t,0,1/2,0\right)\ \forall\ t. \tag{38}$$

Since $\partial n_Y/\partial c_Y^{\max}<0$, we see that

$$n_Y\left(\lambda^Y,S_t,c_O^{\max}+\eta,1/2,0\right)<n_Y\left(1/2,S_t,0,1/2,0\right)\ \forall\ t \tag{39}$$

is implied by the assumption $\left(c_O^{\max}>c_Y^{\max}\right)$. Hence, the Y-group has no incentive to deviate. Knowing this, the O-group will accordingly offer the government $c_Y^{\max}+\epsilon$ for arbitrarily small ϵ while the Y-group bids $c_Y^{\max}$, at maximum. Therefore the stationary political equilibrium profile in this case is such that

$$\left(\widehat{\lambda}\left(S_t\right)=1/2,\widehat{c}_O=c_Y^{\max}+\epsilon,\widehat{c}_Y=0\right),\ \forall t.$$

This is exactly consistent with the equilibrium contribution strategy given in (36) and (37).

The proof of the second part of proposition 2 follows analogous lines. By the same token, the other political equilibrium profile in this game accordingly be characterised as

$$\left(\widehat{\lambda}\left(S_t\right)=\lambda^Y,\widehat{c}_O=0,\widehat{c}_Y=c_O^{\max}+\epsilon\right),\ \forall t.$$

(**B**) **Sufficiency:** Suppose that the profile $\left(\widehat{\lambda}\left(S_t\right)=1/2,\widehat{c}_O=c_Y^{\max}+\epsilon,\widehat{c}_Y=0\ \forall t\right)$

does not represent a TIOLI strategy equilibrium. In this case, the Y-group would bid $c_O^{\max} + \epsilon$ and try to attain $\widehat{\lambda}(S_t) = \lambda^Y$ since condition (35) does no longer holds. This implies that

$$n_Y\left(\lambda^Y, S_t, c_O^{\max} + \epsilon, 1/2, 0\right) > n_Y\left(1/2, S_t, 0, 1/2, 0\right) \ , \ \forall t.$$

However, we know the condition for deriving the Y-group's willingness to pay which is given by

$$n_Y\left(\lambda^Y, S_t, c_Y^{\max}, 1/2, 0\right) = n_Y\left(1/2, S_t, 0, 1/2, 0\right) \ , \ \forall t.$$

This leads us to conclude that

$$n_Y\left(\lambda^Y, S_t, c_O^{\max} + \epsilon, 1/2, 0\right) > n_Y\left(\lambda^Y, S_t, c_Y^{\max}, 1/2, 0\right), \ \forall t.$$

For this inequality to be hold, it must be that $c_O^{\max} + \epsilon < c_Y^{\max}$ with very small ϵ. This implies that $c_Y^{\max} > c_O^{\max}$ as $\epsilon \to 0$. This is the contrapositive proof for part (1) of proposition 2. Thus, it is shown that the equilibrium profile $\left(\widehat{\lambda}(S_t) = 1/2, \widehat{c}_O = c_Y^{\max} + \epsilon, \widehat{c}_Y = 0 \ \forall t\right)$ exists as a TIOLI strategy equilibrium if and only if $c_O^{\max} > c_Y^{\max}$.

Also, suppose that another profile $\left(\widehat{\lambda}(S_t) = \lambda^Y, \widehat{c}_O = 0, \widehat{c}_Y = c_O^{\max} + \epsilon \ \forall t\right)$ does not represent an equilibrium. Then the O-group would instead bid $c_Y^{\max} + \epsilon$ and try to get $\widehat{\lambda}(S_t) = 1/2$ since the condition (34) no longer holds. Thus,

$$n_O\left(1/2, S_t, c_Y^{\max} + \epsilon\right) > n_O\left(\lambda^Y, S_t, 0\right), \ \forall t.$$

However, once again the willingness to pay of the O-group is derived from the condition

$$n_O\left(1/2, S_t, c_O^{\max}\right) = n_O\left(\lambda^Y, S_t, 0\right), \ \forall t.$$

And this condition convince us to conclude that

$$n_O\left(1/2, S_t, c_Y^{\max} + \epsilon\right) > n_O\left(1/2, S_t, c_O^{\max}\right), \ \forall t.$$

For this inequality to be hold, it must be that $c_Y^{\max} + \epsilon < c_O^{\max}$ with very small ϵ. This implies that $c_Y^{\max} < c_O^{\max}$ as $\epsilon \to 0$. This is the contrapositive proof for part (2) of proposition 2. Thus, it is shown that the equilibrium profile $\left(\widehat{\lambda}(S_t) = \lambda^Y, \widehat{c}_O = 0, \widehat{c}_Y = c_O^{\max} + \epsilon \ \forall t\right)$ as a TIOLI strategy equilibrium exists if and only if $c_O^{\max} < c_Y^{\max}$. **Q.E.D.**

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