

VU Research Portal

Resource extraction and the Green Paradox: Accounting for political economy issues and climate policies in a heterogeneous world

Ryszka, K.A.

2016

document version

Publisher's PDF, also known as Version of record

[Link to publication in VU Research Portal](#)

citation for published version (APA)

Ryszka, K. A. (2016). *Resource extraction and the Green Paradox: Accounting for political economy issues and climate policies in a heterogeneous world*. Tinbergen Institute.

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal ?

Take down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

E-mail address:

vuresearchportal.ub@vu.nl

Chapter 4

Resource Extraction in a Political Economy Framework

4.1 Introduction

In this paper we investigate non-renewable resource extraction in a political economy framework, thereby accounting for the institutional framework and political context of resource depletion in many resource-exporting countries. In particular, we consider an economy where the political elite possesses discretionary decision making power regarding the state-owned resources.

Our motivation to deviate from the optimality framework of a Social Planner is the fact that a large share of the world's non-renewable resource deposits, such as oil and gas, are to a certain extent controlled by the respective country's government or exploited by state-owned or state-controlled companies. Prominent examples comprise resources extracted in Venezuela, Russia, the former Soviet Union, Angola, Nigeria, the Arab countries and Iran, for instance. The BP Statistical Review of World Energy estimates that 70 to 80% of the world's oil and about 75% of the world's gas reserves are located in the aforementioned countries (BP, 2014). The extraction decisions of the politicians in these countries hence determine both their societies' welfare and a considerable share of global CO₂ emissions. Governments and politicians do not usually act as social welfare maximizers. Van der Ploeg (2011a) observes the need to "introduce political economy features" in order to explain economic outcomes that do not comply with the Hotelling and Hartwick rules. Another motivation is the debate about the 'resource curse': it describes the stylized fact that resource rich economies tend to exhibit sluggish growth rates. However, we are not

striving to add another explanation to the already very abundant resource curse literature. Rather, we want to assess the effects of a politician, who has discretion over a country's natural non-renewable resources, on the extent to which the country really benefits from its resource wealth, and the consequences for the resource extraction path and hence global climate change.

Furthermore, analyzing resource extraction in a political economy framework might reveal what actually is the attainable second best for resource-rich countries with a state-owned resource stock and politically controlled resource extraction. Dasgupta (2001, p. C2) remarks that “intertemporal welfare economics was developed for a society in which the State is not only trustworthy, it also optimizes on behalf of its citizens. Policy prescriptions emerging from the theory are for Utopia, [...]”. It seems reasonable to assume that decisions on natural resource depletion taken by politicians (in case the resources are state-owned or the resource management is state-controlled) are not only based on social welfare concerns and that the information available to the decision maker is much more limited than it is generally supposed in the rational agents' framework. Knowledge of the mechanisms and their consequences might help in developing welfare-enhancing policies for resource-rich countries.

Another aspect is related to the relevance of resource depletion and usage for the environment. In addition to the fact that the relevant resources are non-renewable and they will not be available for future generations if extracted now, the consumption of resources, especially oil and gas, has consequences for climate change. A higher speed of resource depletion on a global level might worsen the impact of resource usage on the climate (Ramanathan, 1980). Also Withagen (2012) acknowledges the role of the resource market structure (such as the cartel-versus-fringe model in his case) for the climate due to the strong relationship between climate change and CO₂ emissions as a consequence of burning fossil fuel.

We analyze qualitatively and quantitatively whether and how optimal extraction changes if one deviates from the Social Planner optimality framework by including political economy features. We introduce a political leader who optimizes a weighted sum of his own and society's welfare in a model of resource depletion. The political leader's discount rate differs from the discount rate of the society. Also, his time horizon is finite, whereas the social optimization problem extends to infinity. We investigate how the politician's rapacity and the pace of resource extraction depend on these political economy features. The initial resource stock S_0 is divided into a stock depleted for the good of the society, S_0^S , and a stock

purely used to benefit the political elite, S_0^P . We find that a lower social weight decreases the resource stock available to society, whereas the politician's higher discount rate and a shorter time horizon do not imply less available resources for the society. Yet, they do have an adverse effect on the resource extraction paths and especially on the initial extraction rates: the more the politician discounts the future and the shorter his time horizon, the more extractive he behaves, which can raise resource extraction in the first periods over the optimal levels. This might have disastrous consequences for the climate for three main reasons (Karp, 2015): first, more emissions today might increase the likelihood that we cross a threshold that triggers a catastrophe. Second, the rate of climate change might be speeded up which translates into higher abatement costs when changes occur quickly. Third, higher initial emissions create a higher maximum stock level, and climate costs are likely to be nonlinear in the stock.

In a discrete time setting we motivate the choice of the form of the political leader's optimization problem. The political elite's higher discount rate results from the probability of losing power. This 'staying in power' or 'reelection' probability is determined by social welfare and, depending on the functional form, induces the politician to also account for the utility of the society. In this setup another aspect of the political economy framework of resource extraction is disclosed: the issue of political commitment. In our discrete time setting the politician decides on a period-to-period basis about the resource allocation, without the need to commit to an extraction path *ex ante*. We find this absence of commitment to be detrimental to both the amount of resources available for social production and to the resource extraction path.

The theoretical framework at hand can be related to the literature on the resource curse where political leadership or, generally, the quality of institutions are used as one explanatory factor for the bad economic performance and low economic growth in resource rich countries.¹ Whereas some studies seem to confirm the role of resource rich countries' political economy on their economic performance (Sachs and Warner, 1995, 2001; Gylfason, 2001), the theoretical literature still offers a variety of possible mechanisms. Tornell and Lane (1999), for instance, find a "voracity effect" when powerful groups interact via a fiscal process, which results in a disproportionately high increase in fiscal redistribution. Mehlum et al. (2006) note that the quality of institutions determines the scope of rent

¹Frankel (2010) and Van der Ploeg (2011a) survey a variety of hypotheses and papers on the resource curse.

seeking. Deacon (2009) shows theoretically and empirically that public good provision varies systematically with the quality and form of government. He concludes that public good provision is larger in more inclusive regimes such as democracies than in autocracies. We capture a similar idea in both the exogenous and the endogenous model: the exogenous weight that the politician attaches to society's welfare can be interpreted as a measure of political accountability. In the endogenous model, the reelection probability is directly related to society's welfare: the functional form of the probability of staying in power and its elasticity with respect to social welfare determine the degree to which the politician cares about the society. Bulte and Damania (2008) model the government explicitly as an active player with own objectives and constraints, whose behavior, additional to the rent seeking of private agents, gives a possible explanation for the resource curse. Similarly, Leite and Weidmann (1999) highlight the role of corruption in the presence of resource abundance and its effects on growth in a general equilibrium framework.

In contrast to these more decentralized mechanisms, Robinson et al. (2006) develop a simple two period probabilistic voting model and try to assess the political incentives that are generated by resource endowments. They find that politicians tend to over-extract natural resources. In their model the overall impact of resource booms on the economy depends on institutions as they determine the extent to which political incentives are mapped into policy outcomes. Another attempt to place models of resource depletion in a political economy framework is made by Van der Ploeg (2011b) who derives political counterparts of the Hotelling and the Hartwick rules in a fractionalized economy. There, each societal fraction owns a part of the national resource stock. Yet, ownership rights on the stock are not secure as the resource fields are interconnected and seepage occurs. This induces a dynamic common-pool problem which results in prices and resource depletion increasing faster than suggested by the Hotelling rule: the insecurity of the property rights is an additional factor augmenting the interest rate. In our exogenous model higher initial resource extraction is a result of the politician's higher discount rate, which translates to resource consumption preferences different from society's. In another paper, Van der Ploeg (2012) analyzes how a possible regime switch affects the resource depletion of a monopolistic private owner. He assumes that two types of government are possible: a benevolent and a grabbing populist government. In this model the higher initial oil depletion rates are driven by the higher risk of confiscation in case a regime switch occurs. A higher regime switching probability induces higher resource depletion in both regimes. This is in line with our findings in the endogenous model: we find that a lower reelection probability increases

the politician's discount rate and hence increases his own resource consumption and the extraction rate in general.

We expose the basic intuition for our framework in Section 4.2.1. In Section 4.2.2 we introduce the model and analyze how resource extraction depends on the political economy parameters. In Section 4.3 we endogenize the weight the political leader attaches to societal welfare by modelling the impact of resource extraction and resource use on the political leader's hazard of staying in power in a discrete time setting. Furthermore, we provide a motivation for the political leader's higher discount rate and outline the discrepancy in the commitment and no-commitment solutions. Section 4.4 concludes.

4.2 Resource Extraction in a Political Economy Model

4.2.1 Assumptions and Intuition

Our main assumption is that the political leader or the political elite of a country retains discretionary decision making power regarding the natural non-renewable resources in the country. The government is the direct recipient of *all* the resources extracted by state-owned companies and decides on the resource share that it directly accoaches, and the share which the society can use for productive purposes.

The result of this property rights allocation is that the country's non-renewable resource stock S_0 is *de facto* split up in two stocks, S_0^S and S_0^P , which are both managed in different ways. The problem of managing S_0^S , the resource stock attributed to social use, corresponds to a pure Social Planner problem. The stock extraction hence depends on the social rate of time preference and the elasticity of intertemporal substitution. Similarly, the depletion of S_0^P depends on the politician's elasticity of intertemporal substitution and his rate of time preference. Both, for the society and the politician, the result is a monotonically decreasing resource consumption path.

The reason why a political leader decides not to take *all* of the non-renewable resource for his own benefits is that he is not uncontested. Depending on the type of regime which ranges from democracy to autocracy, the reasons for the incumbent being challenged are likely to differ.² In a democratic regime the incumbent is challenged by political opponents

²Labelling a country's regime as an autocracy or a democracy is not an easy task and there exists

during recurrent elections. As the political leader is the direct recipient of the resource revenues, it is highly profitable to stay in power. Consequently, the incumbent will have an incentive to care about the well-being of the country's population in order to avoid being deselected in case the electorate was dissatisfied with his governance.³

Also in case of an autocratic regime it is likely that political elites are contested. The presence of resource rents provides incentives for potential political challengers to seek power, for instance by conducting a *coup d'état*.⁴

We have argued *why* a politician would not accroach *all* of the resource stock of a country. What are the factors which determine *how much* of the resource he takes for himself? What determines the division of S_0 into S_0^P and S_0^S resulting *ex post* from resource allocation between the politician and the society? In order to answer these questions, we have to put more structure on the problem. In the following section we present a mathematical representation of the intuitive reasoning delineated above and examine the influence of the political economy parameters on the division of S_0 .

4.2.2 A Political Economy Model of Resource Extraction

The political leader's utility function is a linear combination of the utility of his private consumption, defined more broadly as private benefits, and the social welfare function.⁵ Thus, let the political leader's instantaneous welfare function be denoted as:

$$u(C_t^P, C_t^S) = (1 - \gamma)u_P(C_t^P) + \gamma u_S(C_t^S), \quad (4.1)$$

a branch of political science literature concerned with this issue. For simplicity one could follow Deacon (2009) in distinguishing between autocracies, democracies and mixed regimes.

³This idea is found in opportunistic models of political behavior where it is assumed that politicians care solely about being reelected. In his seminal article Nordhaus (1975) finds that opportunistic policy-making in a democratic regime results in socially suboptimal decisions (regarding the trade-off between unemployment and inflation, or social investment, in his case). In our simple framework, by contrast, we employ an exogenous social weight that determines the degree to which the politician decides in a socially optimal way.

⁴Caselli (2006) notes that oil wealthy Nigeria has had eight successful coups since its independence in 1960, for instance.

⁵The objective function will be similar to the one employed by Robinson and Torvik (2005). They model the politician i 's per period utility as $U_t^i = X_t^i + \frac{1}{2}\alpha Y_t^i$, with $i = A, B$ denoting two regional parties and two groups of voters of equal size $\frac{1}{2}$. Politicians and voters with the same label belong to the same region. In their probabilistic voting model each politician cares about his own utility and about the political outcome for agents in his region. X_t^i is the income of the politician in period t , Y_t^i is the income of each member in group i and the parameter α governs how the politician values the outcome for his own group.

with $u_P(C_t^P)$ being the political leader's utility from private consumption of the resource, C_t^P , and $u_S(C_t^S)$ denoting the social welfare function in period t , depending on the level of social consumption of the resource, C_t^S . The parameter $\gamma \in (0, 1)$ determines the extent to which the politician accounts for social welfare.⁶

The model sketched in this section is a partial equilibrium model. Exhaustible resources are the only consumption good which yields utility to both the politician and the society. In order to focus on the political economy framework and on how political economy features change the resource extraction path, we leave open-economy considerations aside.

As described above, the resource can either be used by the society or appropriated by the political leader. The rate of resource depletion equals $R_t = C_t^S + C_t^P \geq 0$ at each time instant t , and the time path of resource depletion must satisfy the resource constraint:

$$\begin{aligned} \int_0^\infty C_t^S dt \leq S_0^S \quad \text{or} \quad \dot{S}_t^S = -C_t^S, \quad S^S(0) = S_0^S, \\ \int_0^\infty C_t^P dt \leq S_0^P \quad \text{or} \quad \dot{S}_t^P = -C_t^P, \quad S^P(0) = S_0^P. \end{aligned} \quad (4.2)$$

Additionally, it has to hold that $S_0^S + S_0^P = S_0$.

Furthermore, we assume that the resource yields direct benefits or 'consumption' to the political leader. It seems natural to assume that the society can benefit in direct utility terms from the resource since it can be used in productive processes. If, in contrast, the resource is appropriated by the politician, it does not yield any benefits to the population. The political leader might thus use the resource revenues to buy off his opponents, construct white elephants, i.e., investment projects with negative social surplus (Robinson and Torvik, 2005), or suppress the opposition. Another interpretation would be that the political elite sells the resource at world market prices abroad and buys foreign goods, such as arms or luxury goods.

The political leader faces the following maximization problem:

$$\max \quad (1 - \gamma) \int_0^T u_P(C_t^P) e^{-\delta t} dt + \gamma \int_0^\infty u_S(C_t^S) e^{-\rho t} dt, \quad (4.3)$$

⁶Note that $\gamma = 1$ denotes the usual Social Planner's problem, whereas $\gamma = 0$ corresponds to the political leader being an absolute dictator who entirely disregards any social welfare considerations. We disregard the latter case on the basis of the reasoning presented above.

subject to the resource constraint (4.2). For the sake of exposition we moved the mathematical analysis of the Hamiltonian corresponding to equation (4.3) to Appendix C.1.1. Using CRRA utility functions, we solve there for the first order conditions and the welfare maximizing resource consumption paths.

A number of things are to be noted regarding the intertemporal form (4.3) of equation (4.1). The political leader's discount rate δ differs from the society's rate of time preference ρ . We assume that $\delta > \rho$. One reason for the politician's intertemporal preferences to be present-biased is that the political leader will be in power in the future only with a certain probability.⁷ Also, the planning horizons might differ between the political leader on the one hand and the society on the other hand. Whereas the society's time horizon is infinite, the politician might have a finite time horizon T . Hence, we suppose that politicians can be short-lived, as in Grossman and Helpman (1998). Constraints on the maximum number of a politician's terms in office in a democratic regime is a motivation for this assumption. But even in a more autocratic regime the political leader faces a different time horizon as he will not live infinitely long and thus will not be able to enjoy his direct private benefits infinitely.⁸

Note also that the solution to the problem (4.3) is intertemporally inconsistent: Gollier and Zeckhauser (2005) and Jouini et al. (2010) have shown that with heterogeneous discount rates the representative agent will have a declining discount rate.⁹ Intertemporal consistency, however, is only guaranteed if $\delta = \rho$ (Strotz, 1955; Frederick et al., 2002). The solution concept we employ here can be compared to an open loop approach: the politician chooses optimal extraction paths at $t = 0$. The underlying assumption, which is that he cannot change or revoke his allocation decisions at any other point in time or that he has a strong commitment device at hand, seems very stringent.¹⁰ However, we opted for an open loop equilibrium instead of a subgame perfect approach because the former can be

⁷This relates to models where resource owners face insecure property rights or an expropriation probability (Long, 1975; Van der Ploeg, 2012; Sinn, 2008). Despite the higher discount rate, we do not yet model reelection uncertainty directly. This is done in Section 4.3.

⁸Though his time horizon might be somewhat lengthened in case he wants to establish or maintain a dynasty.

⁹In a similar setup, De-Paz et al. (2011) made an, as yet unsuccessful, attempt to derive dynamic programming equations in continuous time, whose solutions should be time consistent Pareto efficient equilibria for problems of agents with heterogeneous discount rates.

¹⁰Possible commitment mechanisms could be a country's constitution, which allows the politician to exert his decision making power only once, a country's courts of justice, that would not let him revise his initial decisions, or other institutional constraints on his power.

directly compared to the Social Planner benchmark. Both in the Social Planner and in the open loop approach we solve a set of dynamic programming equations in continuous time using the Pontryagin's Maximum Principle.¹¹ Our aim is to show how the introduction of political economy features results in deviations from the Social Planner outcome, leaving the problem of time inconsistency aside. Tackling the time inconsistency issue would lead to a fundamentally different model with very different outcomes.

How do the eventual division of S_0 and the extraction paths depend on the aforementioned parameters? In order to address this question, we analyze, both analytically and numerically, how changes in the political economy parameters γ, δ and the time horizon T affect the initial resource extraction, i.e., C_0^S and C_0^P , the respective social and the politician's resource usage paths and hence the size of the resulting stocks S_0^S and S_0^P . Note that the initial resource stock S_0 is not *initially* divided into S_0^P and S_0^S , but only *ex post* as a consequence of the politician's extraction decisions at every instant of time.¹² Furthermore, we analytically and numerically assess the welfare consequences for both society and the politician. The parameters used for the numerical exercises can be found in Table C.1 in Appendix C.3, where we also describe our numerical approach in detail.

In the subsequent numerical exercise we separately investigate the effects of the social weight γ , the discount rate δ and the politician's finite time horizon T by changing these parameters one at a time, while holding everything else equal to the baseline scenario. In the baseline scenario the social weight equals $\gamma = 0.7$, the politician's discount rate is equal to $\delta = 0.08$ and hence higher than the social rate of time preference which amounts to $\rho = 0.05$, and the politician's time horizon T is infinite. The initial resource stock is $S_0 = 100$.

Let us first determine the impact of the social weight γ on the division of S_0 and on the extraction path. Proposition 9 summarizes the impact of a change in γ :

Proposition 9 *Everything else being equal, a higher social weight γ results in a lower S_0^P and a lower C_0^P . The politician appropriates less of the resource and behaves less extractive*

¹¹Since we focus on intra-country resource allocation decisions made by a politician in a resource-rich country, our benchmark case is the Social Planner allocation, despite the fact that *global* resource production might be better described by oligopolistic market structures.

¹²However, in the analysis in Appendix C.1.1, we start with fixed S_0^P and S_0^S to compute the corresponding extraction paths, and then find the resulting welfare maximizing shares S_0^{P*} and S_0^{S*} .

initially the higher the social weight is.

Proof. See Appendix C.1.2. \square

We illustrate this finding with the help of the numerical example discussed above. Compared to the effects of the other parameters, a change in the social weight γ has the most severe consequences for the division of the initial resource stock and the social welfare. In our numerical baseline example the initial resource stock is divided into $S_0^P = 10.3$ and $S_0^S = 89.7$ for $\gamma = 0.7$. A higher $\gamma = 0.9$ results in a stock used by the politician which amounts to only $S_0^P = 0.77$, whereas the society gets almost all of the initial resource stock, i.e., $S_0^S = 99.23$. On the other hand, the resource stock that is available for social production falls to $S_0^S = 41.56$ and $S_0^P = 58.44$ when decreasing the social weight to $\gamma = 0.4$. With a lower γ , the politician behaves more extractive in the initial periods, as can be seen in Panel (a) of Figure 4.1: his initial resource consumption shifts clearly upwards for lower levels of the social weight. Panel (b) of Figure 4.1 shows that society's initial resource usage falls due to a lower S_0^S if the social weight decreases. This fall, however, is not able to preclude a rise in the overall initial resource usage, as can be seen in Panel (c) of Figure 4.1. The reason is that, with lower social weight levels, a higher share of the initial resource stock is given to the politician, who uses it in a more rapacious way.

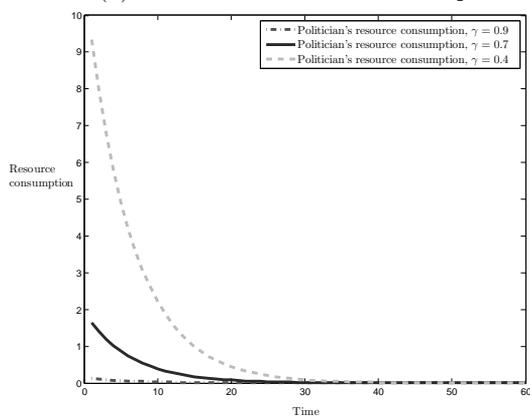
An increase in the social weight also increases society's welfare, whereas the politician's private benefits decrease. Then also his weighted welfare consisting of the social and his private welfare increases with γ : a decrease in the political elite's private welfare is offset by the social welfare gain.¹³ *Vice versa*, a decrease in the social weight results in an overall welfare decrease as the society's lower welfare is not offset by the politician's higher welfare level.

We continue by focusing on changes in the political leader's discount rate. An increase of δ clearly results in a more present-biased resource consumption path, as can be seen in Panel (c) of Figure 4.2. Higher discount rates of the political elite affect the division of the initial resource stock positively for the society: whereas the resource stock is divided into $S_0^S = 84.48$ and $S_0^P = 15.52$ for $\delta = 0.05$, the socially available resource stock amounts to $S_0^S =$

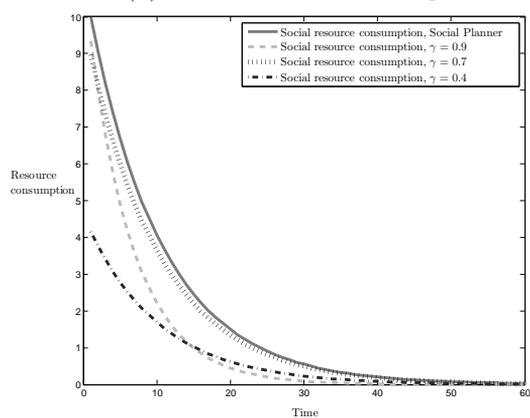
¹³Whereas in the Social Planner case social welfare amounts to $W = 31.62$, for $\gamma = 0.7$ social welfare amounts to $W^S = 29.9$, it increases to $W^S = 31.5$ in case of $\gamma = 0.9$ and decreases to $W^S = 20.4$ in case of $\gamma = 0.4$. The political elite's private welfare falls from $W^P = 19.9$ to $W^P = 8.02$ and $W^P = 2.18$ for $\gamma = 0.4, 0.7, 0.9$, whereas the weighted welfare increases from $W = 19.6$ in case of $\gamma = 0.4$ to $W = 23.4$ if $\gamma = 0.7$ and $W = 28.57$ if $\gamma = 0.4$.

Figure 4.1: Resource consumption paths for $\gamma = 0.9$, $\gamma = 0.6$ and $\gamma = 0.4$, compared to the Social Planner outcome

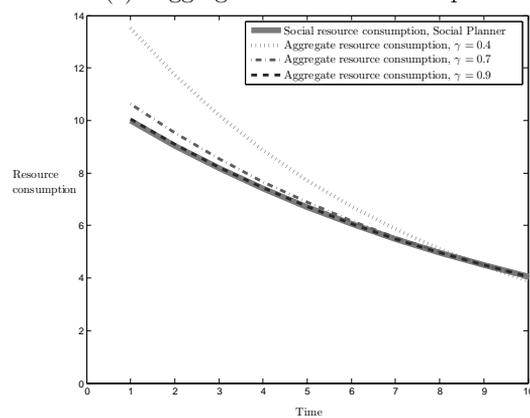
Panel (a): Politician's resource consumption



Panel (b): Social resource consumption



Panel (c): Aggregate resource consumption



89.7 if $\delta = 0.08$ and increases to $S_0^S = 92.98$ if $\delta = 0.12$.¹⁴ This is due to the politician's more extractive behavior and to his more present-biased resource consumption path in the presence of a higher discount rate. This means higher initial but significantly lower resource usage in later periods, resulting in a lower share of the overall resource being consumed by the politician. Hence, more resource S_0^S is available for social production, which increases initial resource consumption of the society. Consequently, aggregate resource usage is higher initially for higher values of the politician's discount rate, as shown in the left upper graph in Figure 4.2. Due to the higher resource stock that is available for productive activities of the society, social welfare is increasing in higher values of δ .¹⁵ Proposition 10 summarizes the findings:

Proposition 10 *Everything else being equal, the politician's higher discount rate δ results in a higher C_0^P and a lower S_0^P . The social resource stock increases in δ . This results in higher initial social resource consumption and hence higher initial overall consumption of the resource.*

Proof. See Appendix C.1.2. \square

So far we have assumed that the political leader operates within an infinite horizon regarding his private welfare. An infinite horizon seems reasonable with respect to the welfare of a society because a benevolent Social Planner might want to maximize social welfare as long as the society exists under the assumption that it does not cease to exist until the infinite future. Regarding private welfare, however, the politician is well aware of the limited time he will serve in office. This gives him a finite time horizon to obtain private benefits. For society this means a higher share of the initial resource stock. The social resource stock is in fact higher the shorter the politicians' time horizon is.¹⁶ This is very intuitive: having a shorter term in office, the politician has less time to accroach resources for himself. This positive result, however, is to a certain degree outweighed by his behaviour, which is more extractive the shorter his time horizon is, as shown in Panel (a) of Figure 4.3.

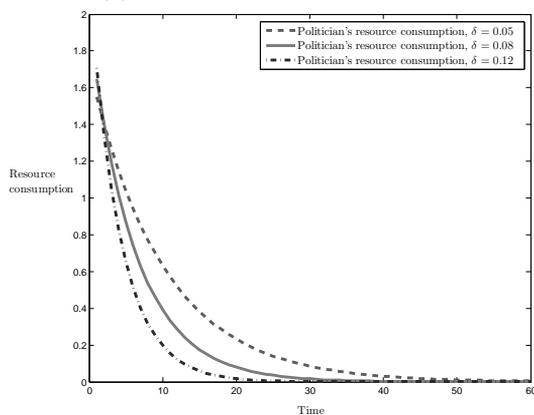
Panel (c) of Figure 4.3 indicates that both the politician's and the society's higher initial resource usage rates lead to higher overall initial resource consumption. Also, due to the

¹⁴For this numerical exercise we hold everything else constant; $\gamma = 0.7$ in all cases.

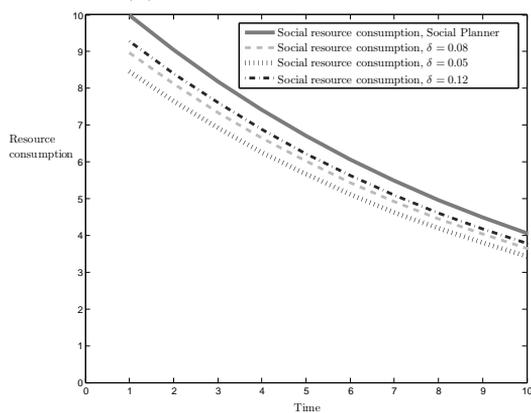
¹⁵Whereas for $\delta = 0.05$ social welfare amounts to $W^S = 29.1$ (with an initial consumption equalling $C_0^S = 8.44$), it increases to $W^S = 30.4$ ($C_0^S = 9.3$) in case of $\delta = 0.12$. The political elite's private welfare decreases from $W = 12.45$ in case of $\delta = 0.05$ to $W = 5.44$ if $\delta = 0.12$, whereas the weighted welfare

Figure 4.2: Resource consumption paths for $\delta = 0.04$, $\delta = 0.08$ and $\delta = 0.12$, compared to the Social Planner outcome

Panel (a): Politician's resource consumption



Panel (b): Social resource consumption



Panel (c): Aggregate resource consumption

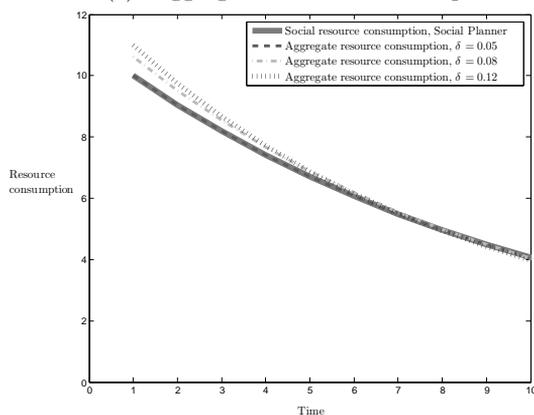
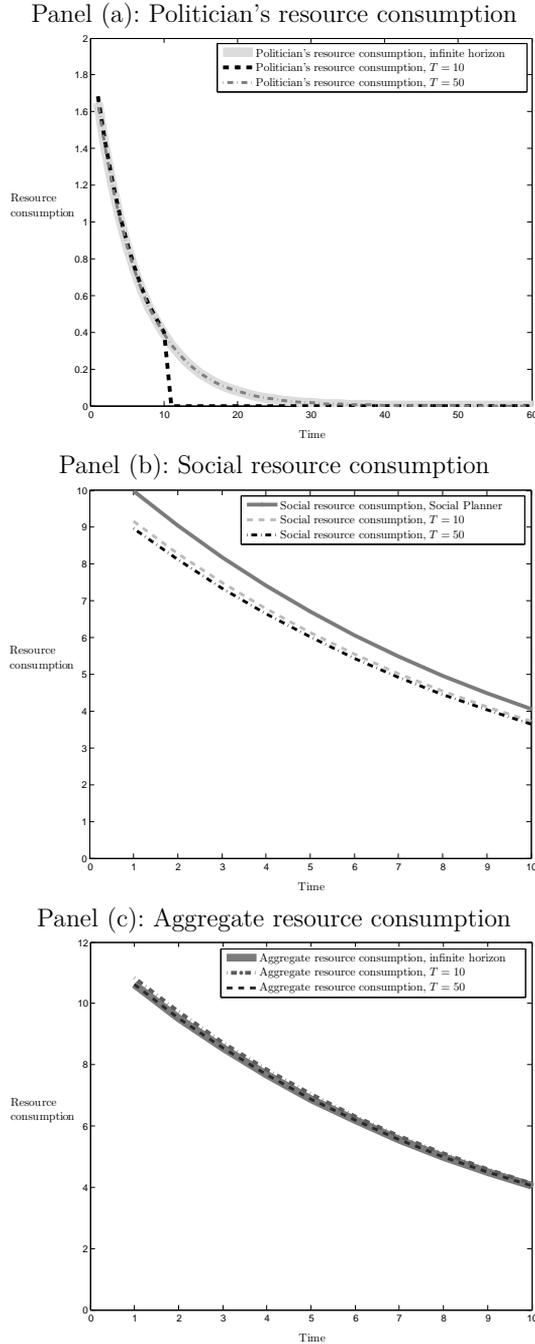


Figure 4.3: Resource consumption paths and for $T = 50$ and $T = 10$, compared to the Social Planner and infinite horizon outcomes



higher resource stock that is available for the society, social welfare increases, albeit only slightly, for shorter political time horizons.¹⁷ We summarize our findings in Proposition 11:

Proposition 11 *Everything else being equal, the politician's shorter time horizon T results in a higher C_0^P , but a lower share of the resource stock S_0^P . The amount of resources used for social production, S_0^S , is higher for shorter time horizons T . The consequences are higher initial social resource consumption and higher initial overall consumption of the resource for shorter time horizons of the politicians.*

Proof. See Appendix C.1.2. \square

4.3 The Endogenous Model

In Section 4.2.1 we analyzed in a formal way how the division of the initial resource stock and the initial resource extraction depends on the parameters in the politician's optimization problem in order to substantiate our intuition about the behavior of politicians in resource rich countries. These parameters, however, were exogenous. In this section we introduce a discrete time model where the weight γ , that the political leader attaches to the welfare of society, is endogenized, and the political leader's probability of staying in power depends on social welfare. Furthermore, we show how the politician's discount rate δ , which is higher than the society's rate of time preference ρ , can be derived with the help of the probability of staying in power π_t (Robinson et al., 2006). The aim of this section is to motivate the assumptions about the political economy features introduced in the political leader's welfare function made in Section 4.2.2.¹⁸

The political leader in this setup is fully self-interested. He shows no direct concerns for the society, which contrasts with approaches taken in models with politicians' partisan

decreases in δ from $W = 24.08$ for $\delta = 0.05$ to $W = 22.9$ for $\delta = 0.12$.

¹⁶For $T = 50$ the social resource stock amounts to $S_0^S = 89.71$ and the politician's resource stock equals $S_0^P = 10.29$; for $T = 10$ the resource stocks amount to $S_0^S = 91.61$ and $S_0^P = 8.39$.

¹⁷For $T = 50$ social welfare increases slightly to $W^S = 29.951$, whereas the politician's welfare decreases to $W^P = 8.0185$; for $T = 10$ they equal $W^S = 30.27$ and $W^P = 5.78$. The weighted welfares equal 23.37 for $T = 50$ and $W = 22.89$ for $T = 10$.

¹⁸However, the model presented in this section cannot be seen as an "endogenous version" of the model presented in Section 4.2. In contrast to Section 4.2, we do not need to assume commitment here as I will explain later.

preferences (Tabellini and Alesina, 1990; Alesina and Tabellini, 1987; Persson et al., 2007). Similar to Section 4.2, we assume that the resource stock is not privately owned, but rather that the political elite can appropriate part of the country's resource stock, leaving only a share for productive activities of the society.

In a setting where the political leader would be certain to stay in office forever (or until the end of his maximum allowed time in office), he would not have any incentives to leave a share of the resource stock for the society. Yet, in our setting, he stays in power only with a certain probability. As argued in Section 4.2.1, this is a consequence of recurrent elections in democratic regimes. But also in more autocratic regimes the political elite is not uncontested, especially in the case of a resource abundant country (Caselli, 2006). Domestic opposition might try to challenge the incumbent politician by staging a coup, for instance.

The probability of staying in power is a function of social welfare in the preceding period only and can therefore be denoted as $\pi_{t+1}(C_t^S)$, i.e., the probability of being in office in period $t+1$.¹⁹ The higher the level of society's satisfaction or utility, the higher the political leader's reelection probability. This idea can be found in Swanson et al. (2012), where the authors consider a dictator who has the implicit property rights regarding the resources of the state and decides each period whether to stay in power and obtain the returns from his investment into productive capacities of the economy, or whether to loot the country and leave. By staying he also runs the risk of being expelled and forced to leave the country without loot. The authors' notion of the staying in power probability, which depends on the well-being of the society, is similar to ours. Yet, we do not model the intertemporal trade-off between investing and looting, but focus on the intratemporal trade-off of immediate consumption and improved chances to stay in power for another period.

The society in our setting is politically not forward-looking. Rather, we assume myopic behavior: the 'popularity' of a politician within the society determines his chances to be reelected or, in general, to stay in office. The level of his 'popularity' among the electorate depends on the level of well-being, i.e., the previous resource consumption of the society. This idea forms the basis of opportunistic models of political behavior (Besley, 2007; Drazen and Eslava, 2006), which predict higher governmental spending prior to elections. Empirical studies seem to confirm the existence of political business cycles (Schuknecht,

¹⁹In Robinson et al. (2006), who try to find political foundations of the resource curse in a two-period probabilistic model, the politician's reelection probability depends on the transfers to citizens and employment in the public sector.

1996; Block, 2002). Brender and Drazen (2005) find empirical evidence in a large cross-section of countries in the case of ‘new’ democracies, both in developed and in less developed countries. Politicians seem to believe that higher spending increases their probability of being reelected. They suppose that higher governmental expenditures augment the social welfare and that the electorate bases its voting decision on the government’s ability to provide social well-being during the time preceding the elections. Hence, from the viewpoint of the political elite, society is not forward-looking and acts myopic.

Due to the social short-sightedness, the political leader has an incentive to care for social well-being only to enhance his probability of being reelected and enjoy benefits from holding office for one more period. He hence solves a maximization problem where, in every period, he has to choose the amount of resources that are supplied to the society and the amount of his own private benefits. Hence, the quantity of resources destined for society signifies an immediate loss of the politician’s consumption and his instantaneous utility. This short-sightedness on the part of the society stands in contrast to the model presented in Section 4.2. There, the politician accounted for the entire resource consumption and utility stream of the society in his maximization problem, not only the society’s current utility level.

This problem structure, furthermore, alleviates the time inconsistency problem we encountered in Section 4.2. There is no resource consumption or social welfare path that the politician needs to commit to. Consequently, at the beginning of every period, the politician faces an immediate trade-off between his own consumption in the given period and the possibility of increasing his chances of consumption in the next periods.²⁰

The functional form of the probability of staying in power and its elasticity with respect to social welfare are central characteristics of this endogenous political economy framework. They determine the extent to which the politician cares about society, yielding the pendant of the social weight γ in Section 4.2.2. The functional forms and their corresponding sensitivities to social welfare are associated with certain political regimes. It seems sensible that the reelection probability in democratic regimes exhibits a higher elasticity with regard to social welfare than in more autocratic regimes.

²⁰As the politician cannot ‘store’ the resource and needs to ‘consume’ it immediately, i.e., in the period of extraction, accroaching the highest possible amount of resources in the first period is thus never an optimal strategy. Since we focus on the politician’s utility derived from the non-renewable resource, we do not tackle the question of the politician’s outside option. In order to avoid that the politician tries to prevent his deselection at all costs, we assume that there is an outside option for the politician, which yields a utility level higher than minus infinity.

In the model below we employ an infinite time horizon for the politician in order to make the setting as general as possible. The fixed initial stock that is available for extraction at the beginning of the first period is denoted by S_0 . The resource constraint thus reads:

$$S_{t+1} = S_t - C_t^S - C_t^P \quad \text{and} \quad S_0 = \sum_{t=0}^{\infty} (C_t^S + C_t^P). \quad (4.4)$$

Although the subsequent analysis is valid also in the case of $T < \infty$, we need to think about what happens in the last period in the case of a finite T . For any finite T the political leader has no incentive to care for the society in the last period; he might just appropriate what is left of the resource. In our setting the society is myopic. When deciding about reelecting the political leader after his pre-last period in office, it does not consider this danger of affliction in the last period as a consequence of the politician's rapacity, but bases its decision solely on the utility obtained in this pre-last period. This social short-sightedness is in line with most of the literature on opportunistic models of political behavior (Nordhaus, 1975).²¹

Due to the society's political shortsightedness, the dictator faces the same maximization problem as expressed in equation (4.5) below every period, after having been successfully reelected:

$$\begin{aligned} \max_{C_t^P, C_t^S, C_{t+1}^P} \quad & \sum_{t=1}^{\infty} \left(\frac{1}{1+\rho} \right)^{t-1} \{ \pi_t (u_S(C_{t-1}^S)) u_P(C_t^P) \}, \\ \text{s.t.} \quad & (4.4), \end{aligned} \quad (4.5)$$

and assuming that $\pi_1 = 1$, i.e., the politician is initially in office and needs to decide on C_1^S and C_1^P in the initial period.

In contrast to the results in Section 4.2.2, the solution to the intertemporal maximization problem in (4.5) is intertemporally consistent. The reason is that after having decided on the resource allocation in period t as a solution to the trade-off between his current-period

²¹Yet, if we allow for a small amount of foresight, it does not seem very plausible that the society will not account for this possibility of penury in the last period. This might drastically lower the political elite's probability of staying in power. On the other hand, it seems unlikely that the politician would not anticipate the effect of his rapacious behavior in the last period on the electoral behavior and thus would not act according to a significantly lower probability of holding onto power, eventually deciding to loot the society in the pre-last period. The society, anticipating this, would never reelect the politician, and the politician, in turn, always would immediately loot the society.

consumption and the probability of enjoying consumption in period $t + 1$, the politician faces ‘elections’ at the end of period t .²² At the beginning of period $t + 1$, the political leader optimizes again, given the fact that he has been reelected, and decides on the current period’s resource allocation, without being constrained by distributional promises for the future. The solution to the political leader’s optimization problem and the ultimately resulting division of the resource stock into S_0^S and S_0^P are not straightforward to determine and have to be found iteratively, by re-optimization in every period.

The politician’s actual reelection is not required for the model to be time consistent. Reelection can also be interpreted as political succession: whether the same politician is in office at time t as at time $t + 1$ does not matter. Both the politician and his potential successor face the same trade-offs.

Using the first order conditions (C.26) to (C.29) listed in the Appendix C.2 and the reasoning above, we obtain the following proposition:

Proposition 12 *The next-period consumption of the politician is determined in the following way:*

$$\frac{u'_P(C_{t+1}^P)}{u'_P(C_t^P)} = \frac{(1 + \rho)\pi_t(u_S(C_{t-1}^S))}{\pi_{t+1}(u_S(C_t^S))}, \quad (4.6)$$

where $\pi_{t+1} < \pi_t$ holds.

Proof. See Appendix C.2.2. \square

We define the politician’s discount rate δ_t by $\frac{\pi_{t+1}(C_t^S)}{\pi_t(C_{t-1}^S)(1+\rho)} \equiv \frac{1}{1+\delta_t}$. If $\pi_{t+1} < \pi_t$, then $\delta_t > \rho$, as was assumed in Section 4.2. Since either the politician reoptimizes every period after he has been reelected, or his successor maximizes the same problem in (4.5), $\pi_t = 1$ and $\pi_{t+1} < \pi_t$ is satisfied. The uncertainty about the politician being in power in the next period, i.e., $\pi_{t+1} \in (0, 1)$ is an addition to his discount factor. It implies higher extraction levels than in a Social Planner’s optimum.²³

²²As explained above, we do not only refer to democratic elections but to events or the absence of events that determine whether the politician will also be in office in period $t + 1$. Examples comprise the presence or absence of a successful *coup d’état*, rebellions, civil wars etc.

²³The idea that uncertainty about the length of one’s lifetime affects the rate at which felicity is discounted can also be found in the Blanchard-Yaari model. Yet, to obtain a higher discount factor $\delta > \rho$ in their continuous time model, one has to assume a specific functional form for the probability to be alive at time τ : $\phi(\tau) = \mu e^{-\mu\tau}$, with $\phi(\tau)$ being the probability of death at date τ and μ being the contribution to the discount factor $\delta = \rho + \mu$.

We solve the endogenous model for five time periods and contrast the result with the outcomes of the exogenous framework discussed in Section 4.2.²⁴ In order to make both models as comparable as possible, we choose a time frame for both models of $T = 5$ and an exogenous social weight $\gamma = 0.28$ to match the resulting endogenous values of γ_t , $t \in [1, 5]$.²⁵ The endogenous social weights that correspond to the politician's choice of C_t^S and C_t^P , which are primarily a consequence of the functional form of the reelection probability $\pi_t(u_S(C_{t-1}^S)) = \frac{C_{t-1}^S}{1+C_{t-1}^S}$, turn out to take values of $\gamma_1 = 0.2565$ and increase to $\gamma_4 = 0.32$, before dropping to $\gamma_5 = 0.25$ for the last period. The endogenous γ_t 's are computed with the help of equation (C.24) in the Appendix C.1.1.²⁶ Also the endogenous discount rate varies; in the calculations of the exogenous model for comparison we take $\delta = 0.1648$ which corresponds to the value of the endogenous discount rate in the first period.

The overall result is that in the open loop approach the politician is more constrained than in the present model with a myopic society. The politician is able to accroach a higher share of the initial resource stock S_0 if he does not have to commit to future resource extraction paths: his overall consumption in the endogenous model equals $S_0^P = 73.09$, as compared to $S_0^P = 61.83$ in the exogenous model. Moreover, the lack of commitment makes him behave in a much more rapacious way: despite equal initial discount rates, the politician's initial resource consumption is higher in the endogenous model, as indicated by Figure 4.4. The absence of commitment is detrimental to the resource extraction path as a whole: the highest initial aggregate resource extraction occurs in the endogenous model, as can be seen in Figure 4.5. This is not only due to the politician's elevated initial consumption, but also to a higher initial social resource consumption, as shown in Figure 4.6. The decision about social consumption reflects the politician's strive to be reelected from period to period in the absence of commitment. In contrast, the social consumption path is characterized by consumption smoothing in the case of commitment.

²⁴We limit the model's time horizon to $T = 5$ due to the high numerical costs of computing.

²⁵The endogenous values of γ_t range from 0.2565 to 0.32; in the exogenous model we employ the arithmetic average of 0.28.

²⁶Given equation (C.24), we solve for γ_t in every period: we compute which allocation S_0^S and S_0^P would be implied by each period's endogenous C_t^S and C_t^P , taking the endogenous resource consumption C_t^S and C_t^P as the initial consumption levels in the exogenous model. Then we compute the corresponding γ_t 's for an exogenous model with the time horizon $T - t$, the number of periods left in the politician's time horizon.

Figure 4.4: The politician's resource consumption in the endogenous and exogenous cases

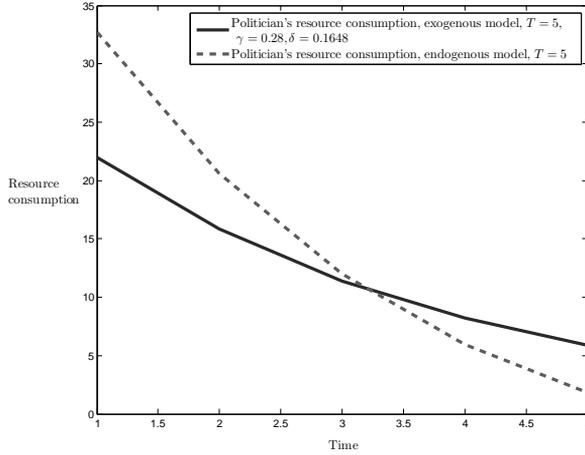


Figure 4.5: Aggregated resource consumption in the endogenous and exogenous cases

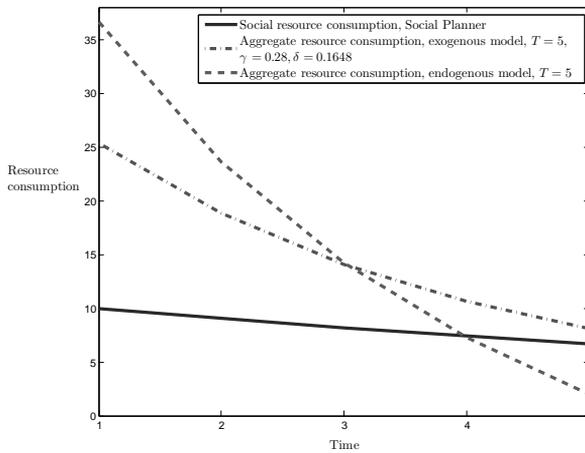
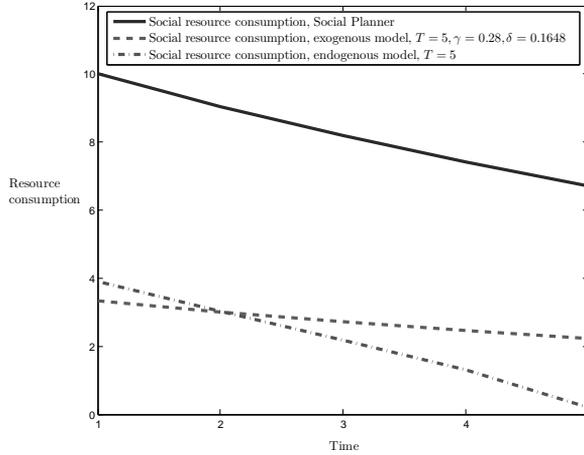


Figure 4.6: Social resource consumption in the endogenous and exogenous cases

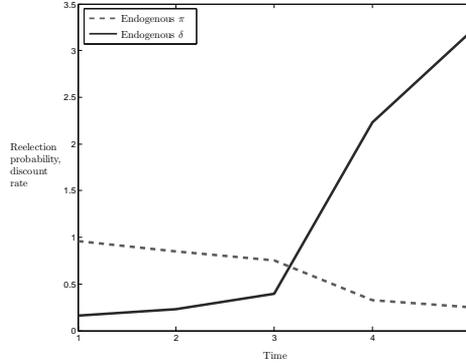


The level of social welfare, the corresponding implicit social weights γ_t and the politician's probability of staying in power are the outcomes of the politician's optimization at the beginning of every period. The resulting probability is reflected in the discount rates of the politician: the pure rate of time preference is augmented by the probability term as in Proposition 12. The graph in Figure 4.7 shows that the discount rates increase over time:²⁷ from $\delta_1 = 0.1648$ in the first to $\delta_5 = 3.2$ in the last period. Given the definition of the endogenous discount factor as $\frac{\pi_{t+1}(C_t^S)}{(1+\rho)} \equiv \frac{1}{1+\delta_t}$, the reason for increasing discount rates lies in the corresponding endogenous reelection probabilities which clearly fall in our endogenous model.

What do these findings mean for our initial question about the extent of rapacity of the political elite? Our comparison between the outcomes of the endogenous and the exogenous models with pre-determined parameters shows that the more realistic scenario of time-consistent, non-committed political decision making reduces social welfare and worsens the suboptimality of the resource extraction paths. The resulting social weight is relatively low and the politician's discount rate is much higher than the social rate of time preference. Just as in Section 4.2.2, a lower γ means lower social welfare and a higher stock S_0^P consumed by the politician, whereas a higher discount rate results in the politician's higher initial

²⁷Relating to the debate on appropriate discounting in project analysis and also for a Social Planner and the recommendation in Weitzman (2014) to use declining discount rates, an increasing discount rate schedule seems suboptimal.

Figure 4.7: The politician's discount rates and reelection probabilities in the cases without and with commitment



resource usage.

4.4 Conclusions

We have built a political economy model of resource depletion, which accounts for the fact that most of the world's non-renewable resources are state-owned or state controlled. The aim of this model is to assess the effects of state ownership or governmental control of non-renewable resources on a country's benefits from its resource wealth, and to unravel the consequences for the resource extraction path and hence for global climate change. We found that the severity of these effects is determined by political economy parameters, such as the weight the politician attaches to social welfare, his discount rate and time horizon. These parameters describe the politician's incentives in contrast to those of a Social Planner.

Accounting for the aforementioned incentives results in a division of the initial resource stock into a stock depleted for the good of the society and a stock purely used to benefit the political elite. We analyze how the politicians' rapacity and the pace of resource extraction depend on these political economy features. We find that a lower social weight decreases the resource stock available to society, but does not necessarily increase initial resource usage. In contrast, both the political elite's higher discount rate and a shorter time horizon tend to rise initial resource usage, leaving, however, more resources available to society.

In the second part of the paper, we endogenize the politician's social weight and the discount rate by making them dependent on the politician's reelection probability. In this setting the politician does not commit to an intertemporally optimal extraction plan. The resulting high endogenous discount rate and the low endogenous social weight diminish the resource availability for the society and worsen the suboptimality of the resource extraction path. The lack of commitment is detrimental for the amount of resources available for social use and with regard to the resource extraction path.

The endogenous model not only provides us with a justification for the modelling choices of our exogenous model, but also reveals the dangers of short-sighted, opportunistic political decision making. It also points at the importance of commitment and adequate commitment devices, which are able to curb the power of politicians, to force them to take longer-term decisions and to prevent them from squandering a country's natural wealth for personal benefits and electoral campaigns. In light of these findings it seems almost impossible for resource-rich countries to come close to a second best outcome if they do not possess strong institutions such as binding laws, the constitution and courts attenuating the power of politicians and constraining their decision-making.

In an economy where the electorate is forward-looking, resource extraction is smoothed over time as compared to our model with myopic voters. Another implication is hence that a country's welfare depends on its electorate and the electorate's ability to hold the politician responsible not only for his last period's extraction decisions, but also for the dynamic consequences of these decisions.

Accounting for political economy features in a model of resource depletion leads to suboptimal resource extraction paths and lower social welfare levels. This pessimistic result also extends to the climate change problem: if we accept that burning fossil fuels contributes to global warming, we need to realize that we do not only deal with market forces of supply and demand, but also with selfish politicians and dictators. Consequently, we have to also bear their incentives in mind when thinking about strategies to curb global resource usage.

In order to focus on the effects of the political economy features, the model is very simple and hence tractable. Adding some real-world complexity might give additional valuable insights at the expense of analytical solutions. The society's demand for the non-renewable resource could be endogenized in a general equilibrium framework. Furthermore, one might question the availability of strong commitment devices for the politician. In that case, the

exogenous model needs to be solved in a time consistent way, by finding Markov perfect equilibria.