Political Conflict, Natural Resource Abundance and Human Capital[1]

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Abstract

This paper proposes a political economy analysis for the nexus between natural resource abundance and human capital accumulation in a multi-sector economy framework. I investigate the incentives of various social groups to finance human capital accumulation through public education under different political coalition formations. In particular, I show that the preferred tax rates of the manufacturers and of the coalition of manufacturers and landowners coincide with the socially optimal tax rate. On the other hand, although the natural resource owners support human capital accumulation, if in power they choose an excessively high tax rate that suppresses aggregate output to a suboptimal level. Moreover, when landowners have the political power they prefer a tax rate lower than the socially optimal tax rate.

Keywords: *Natural resource abundance, Human capital accumulation, Political economy, Economic growth.*

JEL Classifications: *O13, O15, O41, O43, P16, Q00*

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1. Introduction

The last three decades have witnessed the highly divergent economic performance of several natural resource abundant countries. During the period 1975 – 2007, the average growth rates of GDP per capita of Norway and Botswana were 2.77% and 4.46% respectively. On the other hand, in the same period, resource-rich Venezuela and Zambia experienced average rates of growth of -0.26% and -0.30% GDP per capita (Penn World Table, 2009). Hence, rather paradoxically, natural resource-abundant countries are among both the richest and the poorest countries in the world. Some resource-abundant countries have achieved high and sustainable economic growth; while others have ended up as economic growth disasters.[3]

Thus, consider, for instance, Norway, one of the richest natural resource-abundant countries. In the late 1960s, after it discovered oil, Norway used its oil revenues to finance the education of a highly skilled labor force and high-technology industries (Gerlagh and Papyrakis, 2004). On the other hand, Venezuela is usually cited as the contrasting example to Norway. Due to widespread corruption and the strong impact of the landowners on government policies, Venezuela has turned out to be an economic failure.

The purpose of this study is to shed new light on the nexus between natural resource abundance and human capital accumulation from a political economy perspective. This paper suggests that the effect of natural resource abundance on human capital accumulation is at least partially determined by the identity of the social groups

[3] See van der Ploeg (2009) for a detailed overview.

that hold political power and the level of economic benefits these groups derive from a more educated labor force in a multi-sector economy. Here human capital constitutes the engine of economic growth and is complementary to both natural resources and physical capital. One consequence of this is that not only the manufacturers but also the owners of natural resources support human capital accumulation financed through public education expenditures.

If the manufacturers have the political power or join in a political coalition with the landowners, the implemented tax rates are equal to the socially optimal tax rate. If the landowners are in power, they prefer a level of expenditure on public education expenditure that is lower than the efficient level by choosing a tax rate smaller than the socially optimal one. There are two opposing factors affecting the landowners' decision. Firstly, as the complementarity between human capital and land is low, an increase in human capital reduces the return to land as labor migrates from agriculture to the manufacturing and natural resources sectors. Secondly, since human capital accumulation increases the marginal return to labor, landowners also obtain an increase in their wage income with a rise in human capital accumulation. Whether landowners support financing of public education depends on the relative strengths of these two effects. When natural resource owners have the political authority, they prefer a tax rate higher than the socially optimal tax rate. This distortionary tax policy decreases the marginal return to physical capital because of the labor transfer from the manufacturing sector to the natural resources sector.

In short, the paper offers an alternative explanation as to why some natural resource abundant countries, such as Norway, succeed in attaining high levels of sustained economic growth, while others, such as Nigeria, fail to do so. The suggestion here is that in those natural resource abundant countries where manufacturers have a certain degree of political power the tax policy chosen supports human capital accumulation through public. On the other hand, in those natural resource abundant countries where political power is in the hands of landowners the support for public education is not as strong. Wherever the natural resource owners hold the political authority the tendency is to implement a distortionary tax policy designed to raise their returns from the natural resource stock as much as possible.

The theoretical analysis in this paper thus presents a three-class economic conflict among the manufacturers, natural resource owners and landowners. Here we differ from other studies proposing mainly a two-class conflict between the manufacturers and landowners (Galor, Moav and Vollrath, 2009), or between the landowners and workers.

The paper is organized as follows. Section 2 discusses the related literature this paper stands on. Section 3 presents the general theoretical model, and Section 4 develops various political economy implications about human capital accumulation. Finally, Section 5 provides the conclusion.

2. Literature Review

This paper mainly stands at the nexus of two strands in the literature. One of these attempts is to link economic growth and institutions, while the other looks at the connection between natural resource abundance and economic growth. Both of these literatures are vast and it is beyond the scope of this paper to discuss them in detail. I will, therefore, focus on certain papers in the areas of natural resource abundance, human capital accumulation, economic growth and political economy that are closely related to the issues addressed in this paper.

The relationship between economic growth and political decisions is emphasized in North's seminal work. North (1981) argues that the political elite may not adopt growth-enhancing policies, such as those promoting human capital accumulation, if these policies do not maximize the revenues of the political elite. This view of the policies adopted by the political elite preventing economic growth due to potential economic losses is consistent with the theory proposed in this paper. In their 2000 and 2006 papers where they analyze the political roots of economic backwardness, Acemoglu and Robinson argue that the social groups which have political power, particularly landlords, may prevent technological developments and the adoption of growth-enhancing institutions if they see these as a threat to their political power and economic rents. In a related work, Bourguignon and Verdier (2000) analyze the circumstances under which an educated oligarchy invests in the human capital accumulation of the poor through education and how this affects democratization movements in a dynamic political economy model. I abstract from the dynamics of political power and the particular election mechanisms in this paper. Glaeser et al. (2004) focus on the relationship between human capital accumulation and institutional development, and find that human capital formation leads to the emergence of growth-enhancing political institutions.

The social class conflicts analyzed in the political economy setup here is based on Galor, Moav and Vollrath (2009) and on the analysis done in Acemoglu and Robinson's (2006) influential book "Economic Origins of Dictatorship and Democracy." In particular, the theoretical model analyzed in this paper follows from the multi–sector, multi–class model in Galor et al. (2009), which argues that inequality in the distribution of landownership negatively affects human capital accumulation. Unlike this latter work, this paper analyzes the effect of social class conflicts and the political power struggle on human capital accumulation policies in an economy that is abundant in natural resources.

Certain aspects of the relationship between natural resource abundance and economic growth, commonly referred to as the "resource curse," have been widely studied in literature. Torvik (2009) and van der Ploeg (2009) provide good overviews of the recent empirical and theoretical research on the resource curse. Nevertheless, there is still limited research done on the nexus between natural resource abundance and human capital accumulation, and most of these studies are empirical. Using a model with two sectors that incorporates the effects of both endogenous growth and reallocation of resources, Bravo – Ortega and De Gregorio (2002) argue that a high level of human capital can alleviate the negative effect of natural resources on economic growth rate. They find support for their argument empirically using panel data for the period 1970-1990. Birdsall et al. (2001) and Gylfason (2001) find a negative correlation between resource abundance and human capital accumulation. In contrast, Stijns (2006) finds a positive relationship between human capital formation and resource abundance in an empirical study. He argues that Birdsall et al. (2001) and Gylfason (2001) reach biased results because of the questionable natural resource abundance indicators they used.

Regarding these conflicting empirical results, van der Ploeg (2009) states that the use of certain variables can create serious endogeneity problems.

3. General Structure of the Model

The theoretical setup is an overlapping-generations, small, open, natural resource abundant economy in the process of development. Natural resource abundance of a country is defined as the higher amount of subsoil resources compared to other countries. The prices of goods are normalized to one for simplicity. A single homogeneous good used for consumption and investment is produced in a manufacturing sector and an agriculture sector every period. There is also a natural resource sector which functions as an intermediate industry producing an input used in the manufacturing sector. The main inputs used to produce the final output are natural resources, physical capital, human capital, land and unskilled (raw) labor. In this economy, human capital is assumed to be the engine of modern economic growth. In every period, the stock of human capital is determined by the aggregate public investment in education in the preceding period.

In period t, the final output in the economy, Q_t, is defined by the aggregate output produced in the manufacturing sector, Q_t^M, and in the agriculture sector, Q_t^A,

$$Q_t = Q_t^M + Q_t^A \tag{1}$$

3.1 Natural Resource Sector (Intermediate Sector)

The production in the natural resource sector takes place within a period according to a neoclassical, constant-returns-to-scale, Cobb-Douglas production technology using natural resources and human capital as inputs. We define the output produced at time t, Q_t^N, as the following,

$$Q_t^N = F^N(N_t, H_t^N) = N_t^{\beta} H_t^{N\,(1-\beta)} = H_t^N n_t^{\beta},\; n_t \equiv N_t/H_t^N,\, \beta \in (0,1) \tag{2}$$

where N_t is the natural resources stock (which is mainly unprocessed subsoil wealth such as oil, minerals etc.) and H_t^N is the quantity of human capital (measured in efficiency units) employed in production at time t. In the natural resource sector, producers operate in a perfectly competitive environment. Hence, the wage rate per worker, w_t^N, and the rate of return to natural resources stock, v_t, in period t are expressed as the following:

$$w_t^N = F_{H^N}^N(N_t, H_t^N) \tag{3}$$

$$v_t = F_N^N(N_t, H_t^N)$$

Moreover, the labor share in the natural resource sector is given by

$$s_t^{H^N} = H_t^N w_t^N \tag{4}$$

The share of natural resources in the natural resource sector is

$$s_t^N = \beta Q_t^N$$

3.2 Manufacturing Sector

The production in the manufacturing sector occurs within a period according to a neoclassical, constant-returns-to-scale, Cobb-Douglas production technology using physical capital, K_t, human capital, H_t^M (measured in efficiency units), and the output of the natural resource sector, Q_t^N (from now on called the resource input), employed in production at time t. The output produced at time t, Q_t^M, is

$$Q_t^M = F^M(K_t, H_t^M, Q_t^N) = K_t^\alpha H_t^{M(\theta)} Q_t^{N(1-\alpha-\theta)} \quad ; \qquad \alpha \epsilon (0,1) \ , \ \theta \epsilon (0,1) \qquad (5)$$

Physical capital depreciates fully after one period. In the manufacturing sector, producers operate in a perfectly competitive environment. The rate of return to physical capital, R_t, the wage rate per worker, w_t^M, and the rate of return to the resource input, ρ_t, in period t, factor prices can be defined as:

$$R_t = F_K^M(K_t, H_t^M, Q_t^N) \qquad (6)$$

$$w_t^M = F_{H^M}^M(K_t, H_t^M, Q_t^N)$$

$$\rho_t = F_{Q^N}^M(K_t, H_t^M, Q_t^N)$$

3.3 Agriculture Sector

In the agriculture sector, the Cobb-Douglas production technology uses land, Z_t, and raw labor, L_t, as inputs. Production occurs in a perfectly competitive environment as in the natural resource and manufacturing sectors. The output produced at time t, Q_t^A, is

$$Q_t^A = F^A(Z_t, L_t) = Z_t^\gamma L_t^{1-\gamma} = L_t z_t^\gamma ; z_t \equiv Z_t / L_t \ , \gamma \epsilon (0,1) \qquad (7)$$

The rate of return to land, x_t, and the wage rate per worker, w_t^A can be defined as

$$x_t = F_Z^A(Z_t, L_t) \qquad (8)$$

$$w_t^A = F_L^A(Z_t, L_t)$$

3.4 Individuals, Preferences and Income

A generation is a continuum of individuals of measure 1 born in every period. Both within and across generations, individuals are identical regarding their preferences and innate abilities. Nevertheless, they may differ from each other in terms of their wealth. Each individual lives for two periods, and has a single parent and a single child. The preferences of an individual i of generation t are defined over the second period consumption, c_{t+1}^i , and a transfer to the offspring, b_{t+1}^i, with a log-linear utility function

$$U_t^i = (1-a)\, ln\, c_{t+1}^i + a\, ln\, b_{t+1}^i \quad , \quad a \in (0,1) \tag{9}$$

Individuals acquire human capital in the first period of their lives. In the second period they join the labor-force, earn a wage income, and the returns to natural resources, physical capital, and land. They allocate their second period income between consumption and an income transfer to their children. Hence, an individual i born in period t is given an income transfer, b_t^i, in the first period of life.

Now, an individual i born in period t earns the competitive market wage w_{t+1} by joining the labor-force; she may also obtain income from the return on natural resources ownership, $m^i v_{t+1}$, where m^i is agent i's endowment of natural resources, from physical capital ownership, $(1-\tau_t) b_t^i R_{t+1}$, and from the return on land ownership, $s^i x_{t+1}$, where s^i is the quantity of land owned by agent i. In this framework, workers do not own any natural resources, physical capital, or land. In the second period natural resource owners leave all the natural resources, and landowners leave all the land to their offspring. These assumptions preserve the social class structure over time.

Now, we can define the individual's second period income as the following,

$$y_{t+1}^{i} = w_{t+1} + (1-\tau_t) b_t^i R_{t+1} + m^i v_{t+1} + s^i x_{t+1} \qquad (10)$$

where $m^i = N_t/\sigma$, and N_t is the total stock of natural resources, $\sigma \epsilon (0,1)$ is the fraction of natural resource owners in the economy among whom the natural resources stock is shared equally. In addition, $s^i = Z_t/\mu$, where Z_t is the total amount of land, and $\mu \epsilon (0,1)$ is the fraction of landowners in the economy who equally share all the land among themselves.[4]

The individual i born in period t allocates second period income between consumption, c_{t+1}^i, and income transfers to the offspring, b_{t+1}^i, in order to maximize his utility subject to the second period budget constraint, so

$$c_{t+1}^i + b_{t+1}^i \leq y_{t+1}^i \qquad (11)$$

The optimal transfer and consumption of the individual i born in period t can be shown to be the following:

$$b_{t+1}^i = a y_{t+1}^i \qquad (12)$$

$$c_{t+1}^i = (1-a) y_{t+1}^i$$

3.5 Human Capital Accumulation and the Political Mechanism

[4] Note that $m^i$and s^i may be equal to zero depending on the social group that the individual belongs to.

As mentioned above, individuals spend the first period of their two-period lives to acquire human capital. The political authority invests in human capital through public education. The amount of human capital accumulated increases with the real resources invested in public education. Here human capital accumulation is a strictly increasing, strictly concave function of real expenditures, e_t, on the education of a member of generation t

$$h_{t+1} = h(e_t) \quad , \tag{13}$$

where h_{t+1} is the human capital of each individual of generation t in period $t+1$, $h(0) = 1$, $\lim_{e_t \to 0^+} h'(e_t) = \infty$, $\lim_{e_t \to \infty} h'(e_t) = 0$.

Thus, even if the real expenditure on public education is zero, individuals own one efficiency unit of human capital that forms the basic skills required for the natural resources sector and manufacturing sector to operate in every period.

In this economic environment, there are four distinct groups of agents: Natural resource owners, manufacturers, landowners and workers. The across-group heterogeneity is mainly formed by the distinction that in period t natural resource owners, manufacturers, landowners and workers get their incomes from the respective resources they own. This argument is based on a similar analysis in Acemoglu and Robinson (2006, Chapter 8 and Chapter 9). Due to the existence of heterogeneous social groups and their different economic incentives, policies for human capital accumulation change as the political authority changes hands among these groups. The social groups holding the political power have ultimate control on public education policies.

In order to finance public education for human capital accumulation, the current political authority collects a fraction τ_t of the income each group receives. The primary motivation here is that when a social group has political power, it chooses to invest in human capital accumulation if the benefits the group's agents receive from a more educated labor force exceed the costs of financing public education by paying taxes from their bequest incomes and intergenerational income transfers.

The main concentration of this paper is on the economic effects various social groups and political authorities have on human capital accumulation policies, but not on the political process by which the political authorities and coalitions come about. Therefore, note that the social group which holds the political authority or shares the political power with another group in a coalition is determined historically, and so this side of the political mechanism is exogenous in the theoretical model. I also ignore within social group conflicts in the analysis.

4. Public Education Policies under Different Political Authority Formations

4.1 Efficient Human Capital Accumulation Policies and Aggregate Output

As it follows from equation (12), the aggregate level of intergenerational transfers in period t is a fraction a of the aggregate income Q_t. In order to finance public education, the political authority collects a fraction τ_t of income transfer as the tax revenues, so, to be saved for future consumption a fraction $1-\tau_t$ of the transfers is left. Now, the aggregate intergenerational transfers can be written as the following

$$aQ_t = b \tag{14}$$

where b is defined as the total amount of bequest incomes. Then, the physical capital stock in period $t+1$ can be defined as,

$$K_{t+1} = (1-\tau_t)\, aQ_t = (1-\tau_t)b \tag{15}$$

and the education expenditure per young individual in period t, e_t , is

$$e_t = \tau_t aQ_t = \tau_t b \tag{16}$$

Let's define δ_{t+1}^N, δ_{t+1}^M, δ_{t+1}^A to be the numbers (and so fractions) of workers employed in the natural resources sector, in the manufacturing sector, and in the agriculture sector respectively. Then, the stock of human capital employed in natural resource sector in period $t+1$, H_{t+1}^N, can be defined as,

$$H_{t+1}^N = \delta_{t+1}^N h(e_t) = \delta_{t+1}^N h(\tau_t aQ_t) \tag{17}$$

The amount of natural resource stock is fixed over time at a level $N > 0$, so output in the natural resource sector in period $t+1$ is,

$$Q_{t+1}^N = N^{\beta} H_{t+1}^{N\,(1-\beta)} = N^{\beta}[\delta_{t+1}^N h(\tau_t aQ_t)]^{1-\beta} \equiv Q^N(Q_t, \tau_t, \delta_{t+1}^N, N) \tag{18}$$

Similar to the case in natural resource sector, the stock of human capital employed in manufacturing sector in period $t+1$, H_{t+1}^M, can be written as

$$H_{t+1}^M = \delta_{t+1}^M h(e_t) = \delta_{t+1}^M\, h(\tau_t aQ_t) \tag{19}$$

then output produced in the manufacturing sector can be written as

$$Q_{t+1}^M = K_{t+1}^{\alpha} H_{t+1}^{M(\theta)} Q_{t+1}^{N(1-\alpha-\theta)} \tag{20}$$

$$Q_{t+1}^M = [(1-\tau_t)aQ_t]^\alpha \, [\delta_{t+1}^M \, h(\tau_t aQ_t)]^\theta \, \left[N^\beta[\delta_{t+1}^N h(\tau_t aQ_t)]^{1-\beta}\right]^{(1-\alpha-\theta)}$$

$$Q_{t+1}^M \equiv Q^M(Q_t, \tau_t, \delta_{t+1}^N, \delta_{t+1}^M, N)$$

In agriculture sector the labor supply L_{t+1} ($L_{t+1} = \delta_{t+1}^A$) can also be expressed as $(1-\delta_{t+1}^N - \delta_{t+1}^M)$, and the land size is constant over time at a level $Z > 0$. Thus, output in agriculture sector in period $t+1$ can be written as

$$Q_{t+1}^A = Z^\gamma L_{t+1}^{1-\gamma} = Z^\gamma(\delta_{t+1}^A)^{1-\gamma} = Z^\gamma(1-\delta_{t+1}^N - \delta_{t+1}^M)^{1-\gamma} \equiv Q^A(\,\delta_{t+1}^N, \delta_{t+1}^M, Z)$$

(21)

Individuals are perfectly mobile between the manufacturing sector, natural resources sector and agriculture sector. Thus, they can earn the wage incomes $h_{t+1}w_{t+1}^M$, $h_{t+1}w_{t+1}^N$ or the wage w_{t+1}^A by supplying h_{t+1} efficiency units of labor to the manufacturing sector or natural resources sector, or one unit of labor to the agriculture sector respectively. The number of workers in the manufacturing sector, δ_{t+1}^M,and in natural resource sector, δ_{t+1}^N, equalize the marginal products of workers in the three sectors under each political coalition. Therefore,

$$h_{t+1}w_{t+1}^M = h_{t+1}w_{t+1}^N = w_{t+1}^A = w_{t+1} \qquad (22)$$

The fractions of workers employed by the manufacturing sector, natural resource sector and agriculture sector in period $t+1$, are uniquely determined with respect to the tax policy the political authority imposes under each political coalition:

$$\delta_{t+1}^M = \delta^M(Q_t, {\tau_t}^j, N, Z)\;; \delta_{t+1}^N = \delta^N(Q_t, {\tau_t}^j, N, Z)\;;\; \delta_{t+1}^A = \delta^A(Q_t {\tau_t}^j, N, Z) \qquad (23)$$

In equation (23), ${\tau_t}^j$ refers to the tax rates imposed by different political coalitions. Further, given the natural resource stock, N, and agricultural land size, Z, in period $t+1$ prices are uniquely determined by Q_t and ${\tau_t}^j$ under each political coalition:

$$w_{t+1} = w(Q_{t,}{\tau_t}^j, N, Z) \tag{24}$$

$$R_{t+1} = R(Q_t, {\tau_t}^j, N, Z)$$

$$v_{t+1} = v(Q_t, {\tau_t}^j, N, Z)$$

$$x_{t+1} = x(Q_t, {\tau_t}^j, N, Z)$$

$$\rho_{t+1} = \rho(Q_t, {\tau_t}^j, N, Z)$$

Hence, the prices given in (24), and the employment shares given in (23) are moving endogenously with the specific tax policy each political coalition implements.

The model predicts that given the aggregate income in period t, aQ_t, the level of natural resources stock, N, and the amount of land, Z, there exists a unique tax rate, τ_t^*, which maximizes the aggregate output, Q_{t+1}, in period $t+1$.

$$\tau_t^* \equiv argmax\ Q_{t+1}$$

Furthermore, the numbers of workers employed in the manufacturing sector, $\delta^{M*}(Q_t, \tau_t^*, N, Z)$, and in the natural resources sector, $\delta^{N*}(Q_t, \tau_t^*, N, Z)$, in period $t+1$ are uniquely determined with respect to τ_t^*, satisfying the socially optimal labor distribution in the three sectors. Figure 1 demonstrates the aggregate output according to the human capital accumulation policy (tax policy) of the political authority. As depicted in Figure 1, the socially optimal tax rate, τ_t^*, achieves the maximum aggregate output and efficient public education at the point B.

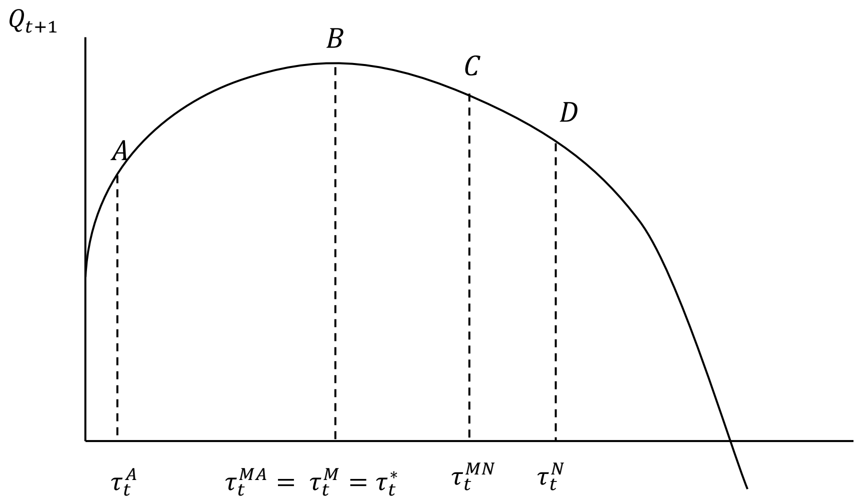

Figure 1. The aggregate output with various tax policies under different political authority formations

4.2 Manufacturers Have the Political Power

Manufacturers comprise a fraction $\vartheta \in (0,1)$ of all individuals in the society. They do not own any natural resources and any land, so we can write the second period income function of a manufacturer as the following:

$$y_{t+1}^M = w_{t+1} + (1 - \tau_t^M) b_t^M R_{t+1} \tag{25}$$

$$y_{t+1}^M = w(Q_t, \tau_t^M, N, Z) + (1 - \tau_t^M) b_t^M R(Q_t, \tau_t^M, N, Z)$$

where $w(Q_t, \tau_t^M, N, Z)$ is the wage income, b_t^M is the portion of total bequest income that a manufacturer gets, and $R(Q_t, \tau_t^M, N, Z)$ is the rate of return to physical capital. When manufacturers hold the political power their main objective is to reach the highest level of their income in the second period.[5] Thus, they choose such a tax rate, τ_t^M, that maximizes each manufacturer's income function in period $t+1$. Since manufacturers earn their income from wage and bequest transfers of physical capital ownership, τ_t^M also maximizes the manufacturing sector output. Therefore, manufacturers collect a fraction τ_t^M of intergenerational income transfers (bequest incomes) as tax revenues in order to finance public education, so a fraction $1-\tau_t^M$ of the transfers is saved for future consumption. Since human capital is complementary with physical capital in the manufacturing sector, manufacturers get economic benefits from a more educated labor force, so they are in favor of human capital accumulation. [6]

Proposition 1 When the manufacturers hold political power they support human capital accumulation through public education expenditure with a preferred tax rate τ_t^M.[7] Hence,

$$\tau_t^M = argmax y_{t+1}^M$$

In this subsection, it is demonstrated that the preferred tax rate from the point of view of the manufacturers, τ_t^M, is equal to the socially optimal tax rate that maximizes the aggregate output, τ_t^*. Hence, as the manufacturers have the political power, the tax rate chosen to be implemented by them (τ_t^M) is identical to the tax rate which achieves the efficient level of investment in public education (τ_t^*). In addition to this, the evolution of the manufacturing sector output, Q_{t+1}^M, according to the tax policy implemented by the political authority of manufacturers will be identical to the graph of the aggregate output depicted in Figure 1. Therefore, under the political authority of manufacturers the

[5] This is equivalent to the utility maximization subject to the second period budget constraint explained in Section 3.4.

[6] For this statement, the calibration explanations and results can be seen in Section 4.7.

[7] A demonstration is provided in Section A.2 in the Appendix.

maximized aggregate output and the efficient human capital accumulation level will be achieved again at point B.

<u>Lemma 1</u> Suppose that τ_t^M is the tax rate preferred by manufacturers and maximizes the output of the manufacturing sector in period $t+1$, so

$$\tau_t^M \equiv argmaxQ_{t+1}^M = argmaxQ^M(Q_t, \tau_t, \delta_{t+1}^N, \delta_{t+1}^M, N) \tag{26}$$

This tax rate is also equal to the socially optimal tax rate, τ_t^*.

Proof. As follows from (1), Appendix A.1 and from the envelope theorem

$$\partial Q_{t+1}/\partial \tau_t = \partial Q^M(Q_t, \tau_t, \delta_{t+1}^N, \delta_{t+1}^M, N)/\partial \tau_t \tag{27}$$

Moreover, since $\tau_t^* = argmax\ Q_{t+1}$, then $\partial Q^M(Q_t, {\tau_t}^*, \delta_{t+1}^N, \delta_{t+1}^M, N)/\partial \tau_t = 0$, and so it follows from (20) that,

$$\delta_{t+1}^M w_{t+1}^M h'(\tau_t^* a Q_t) + \rho_{t+1} \delta_{t+1}^N w_{t+1}^N h'(\tau_t^* a Q_t) = R_{t+1}$$

Therefore,

$$\tau_t^* = argmaxQ^M(Q_t, \tau_t, \delta_{t+1}^N, \delta_{t+1}^M, N) =$$

$$argmax[(1-\tau_t)aQ_t]^\alpha\ [\delta_{t+1}^M\ h(\tau_t a Q_t)]^\theta \left[N^\beta [\delta_{t+1}^N h(\tau_t a Q_t)]^{1-\beta}\right]^{(1-\alpha-\theta)} \tag{28}$$

Hence, $\tau_t^* = \tau_t^M$.

Thus, under the political authority of manufacturers the socially optimal level of the aggregate output is also achieved.

Now also, following from (6), (20) and Section A.2 in the Appendix; $(1-\tau_t)aQ_t R_{t+1} = \alpha Q_{t+1}^M$

Then, $(1-\tau_t)R_{t+1} = \alpha Q_{t+1}^{M}/(aQ_t)$, and so $\tau_t^* = argmax(1-\tau_t)R_{t+1}$

Hence, τ_t^* also maximizes the after tax returns from physical capital ownership.

4.3 Landowners Have the Political Power

Landowners set up a fraction $\mu \epsilon (0,1)$ of all individuals in the total population, and they equally share the entire land in the economy in all periods. Landowners do not hold physical capital and they do not own any natural resources. Then, we can write the second period income function of a landowner like the following;

$$y_{t+1}^{A} = w_{t+1} + s^{A}x_{t+1} \tag{29}$$

where s^A is the return on land ownership. [8] When the landowners have the ultimate political power they will implement a tax rate that maximizes the income of a landowner in period $t+1$. Landowners do not obtain any earnings from the ownership of physical capital and natural resources with which human capital is used in the industrial production. Therefore, an increase in human capital will reduce the return to land due to labor migration from the agriculture sector to the natural resources and manufacturing sectors, so depending on the effect of returns on land ownership landowners want to retain as much unskilled labor as they can on the land. On the other hand, following from (22) since human capital accumulation increases the marginal returns to labor in the manufacturing and natural resource sectors, and the marginal products of workers are

[8] Landowners might get economic benefits from human capital accumulation due to physical capital and natural resource ownerships, labor supply to the manufacturing sector and natural resources sector, and the provision of public goods. Nevertheless, in the consideration of the landowners' income function in period these possibilities are excluded from the analysis.

equalized across the three sectors landowners also obtain an increase in their wage income with a rise in human capital accumulation. Under their political authority, these two opposing effects make the landowners prefer a tax rate, τ_t^A, which is greater than zero but lower than the tax rate chosen by the manufacturers, τ_t^M, and so lower than the socially optimal tax rate, τ_t^*. Thus, the tax policy chosen by the landowners does not achieve the efficient public education investment level, and the aggregate output obtained under the political authority of landowners remains at a suboptimal level compared to the maximum level of aggregate output.[9] This lower aggregate output and the tax policy preferred by the landowners can be shown with point A in Figure 1. Note in Section A.1 in the Appendix, the profit maximization condition of the manufacturers' second period income function is defined as,

$$\Bigg\{\Bigg\{[(1-\alpha-\beta+\alpha\beta+\theta\beta)h'(\tau_t^M aQ_t)[h(\tau_t^M aQ_t)]^{-1}] - [\alpha(1-\tau_t^M)^{-1}] +$$

$$\left[\theta(\delta_{t+1}^M)^{-1}\frac{\partial\delta^M(Q_t,\tau_t^M,N,Z)}{\partial\tau_t^M}\right] +$$

$$\left[(1-\beta)(1-\alpha-\theta)(\delta_{t+1}^N)^{-1}\frac{\partial\delta^N(Q_t,\tau_t^M,N,Z)}{\partial\tau_t^M}\right]\Bigg\}[(\theta(\delta_{t+1}^M)^{-1}) + (\alpha b_t^M(\ aQ_t)^{-1})] -$$

$$\left[\theta(\delta_{t+1}^M)^{-2}\frac{\partial\delta^M(Q_t,\tau_t^M,N,Z)}{\partial\tau_t^M}\right]\Bigg\} = 0$$

The expression $[\alpha b_t^M(\ aQ_t)^{-1}]$ refers to the bequest incomes that the manufacturers earn from physical capital ownership. The landowners do not own physical capital, and so they do not obtain any earnings from capital ownership. Since human capital is complementary to physical capital making it more productive when used together,

[9] This statement is discussed in Section A.3 in the Appendix.

employing more human capital in the manufacturing sector increases the returns to physical capital. Therefore, manufacturers will prefer a higher tax rate than the tax rate landowners prefer. Hence,

$$\tau_t{}^A < \tau_t{}^M \tag{30}$$

4.4 Natural Resource Owners Have the Political Power

The natural resource owners set up a fraction $\sigma \epsilon (0,1)$ among the total population. Natural resource owners equally own the entire natural resource stock, and they also obtain returns from physical capital ownership, but they do not own any land. Thus, we can define the second period income function of a natural resource owner as

$$y_{t+1}^N = w_{t+1} + (1 - \tau_t^N) b_t^N R_{t+1} + m^N v_{t+1} \tag{31}$$

where b_t^N is the portion of total bequest income that a natural resource owner gets, and m^N is the endowment of natural resource stock a natural resource owner owns and v_{t+1} is the rate of return to natural resources stock as defined in section 3.4 and in equation (3) respectively.

As the natural resource owners have the political power, their aim will be to obtain the highest level of their second period income. Thus, in order to finance human capital accumulation through public education, they will implement a tax policy which maximizes their income in period $t + 1$. For a given natural resource stock level, in order to increase the rate of return to natural resource stock, v_{t+1}- and equivalently the income earned from natural resources ownership, $m^N v_{t+1}$, in equation (31), and so maximize their second period income, natural resource owners will want to employ a higher number of "skilled" workers than the number that is sufficient to achieve the socially optimal aggregate output. Hence, natural resource owners will favor a high amount of human capital accumulation, and to finance this high level of human capital accumulation natural resource owners prefer a rather high tax rate, τ_t^N.

Nevertheless, employing the number of skilled workers higher than the level required to produce the socially optimal aggregate output in the natural resources sector indicates a labor transfer from the manufacturing sector to the natural resources sector, reducing the marginal product of physical capital. On the whole, the excessively high tax rate preferred by the political authority of natural resource owners has a suppressing impact on the aggregate output in the economy. The lower aggregate output level obtained with this high tax rate is depicted at the point D in Figure 1. In order to maximize their second period income, when the natural resource owners have the political authority they prefer a tax rate, τ_t^N, which is higher than the socially optimal tax rate, τ_t^*, and which leads to a suboptimal aggregate output level.[10] Hence, the tax rate, τ_t^N, maximizing the second period income of natural resource owners also satisfies the following condition,

$$\tau_t^N > \tau_t^M = \tau_t^* > \tau_t^A \tag{32}$$

4.5 Political Coalition of Manufacturers and Natural Resource Owners

[10] The calibration explanations and results validating the statements in the Proposition 3 can be seen in Section 4.7. A related discussion is provided in Section A.4 in the Appendix.

Manufacturers and natural resource owners can form a political coalition against a possible political authority of landowners. As explained in Section 4.3 and shown in Section 4.7, under the political authority of landowners, landowners want to keep almost the whole labor force in the agriculture sector, and so the tax rate they implement under their political authority is rather low. The very low tax rate and employing low numbers of skilled workers in the manufacturing and natural resources sectors are not preferred by manufacturers and natural resource owners since these will make both social groups economically worse off. As they set up a political coalition, their primary objective will be to maximize their joint income in period $t+1$. The coalition's joint income function is defined as an equal – weighted summation of each social group's second period income function, revealing the condition that the two groups share the political power equally in the coalition, as the following

$$y_{t+1}^{MN} = y_{t+1}^{M\prime} + y_{t+1}^{N\prime} \tag{33}$$

$$y_{t+1}^{MN} = [w_{t+1} + (1-\tau_t^{MN})b_t^M R_{t+1}] + \ [w_{t+1} + (1-\tau_t^{MN})b_t^N R_{t+1} + m^N v_{t+1}]$$

where τ_t^{MN} is the tax rate chosen by manufacturers–natural resource owners political authority. Since both manufacturers and natural resource owners get economic benefits from human capital accumulation and in order to maximize their joint second period income, so become economically better off than they would under a landowners political authority, they will implement the positive tax rate, τ_t^{MN}, that is higher than the manufacturers' preferred tax rate, τ_t^{M}, and lower than the natural resource owners' preferred tax rate, τ_t^N, but maximizes their joint income.[11] The simulation results in Section 4.7 imply that the tax rate, τ_t^{MN}, satisfies the following condition

$$\tau_t^N > \tau_t^{MN} > \tau_t^M = \tau_t^* > \tau_t^A \quad (34)$$

Therefore, in order to maximize the second period joint income function, both manufacturers and natural resource owners will be content to a tax policy that is not originally preferred under either social group's political authority. Nonetheless, the tax rate, τ_t^{MN}, does not achieve the efficient level of public education, and so the efficient human capital accumulation level from the society's point of view. Thus, this tax policy does not achieve the socially optimal aggregate output. The combination of the preferred tax rate, τ_t^{MN}, and the aggregate output obtained with this tax policy is shown at the point C in Figure 1.

4.6 Political Coalition of Manufacturers and Landowners

Manufacturers and landowners may have an incentive to form a political coalition to protect themselves from the adverse economic effects of the political authority of natural resource owners and its distortionary tax policy. The natural resource owners support human capital accumulation mainly because they employ skilled workforce in the natural resources sector. However, under the political authority of natural resource owners an excessively high tax rate, τ_t^N, is implemented to finance human capital accumulation through public education expenditures, and furthermore there occurs a substantial labor migration from the manufacturing sector to the natural resources sector,

[11] The calibration explanations and results validating this statement can be seen in Section 4.7.

so this drastic decrease in employment level in the manufacturing sector suppresses the incomes of manufacturers making them economically worse off. Furthermore, τ_t^N is a much higher tax rate than the preferred tax rate by landowners, τ_t^A, which is even lower than the socially optimal tax rate, τ_t^*. When manufacturers and landowners form a political coalition, their main aim will be to obtain the highest amount of their joint income in period $t+1$. The coalition's joint income function can be defined as an equally weighted summation of each social group's second period income function since the two groups share the political power equally. Hence, we can define the coalition's joint income function in period $t+1$ as the following,

$$y_{t+1}^{MA} = y_{t+1}^{M\prime} + y_{t+1}^{A\prime} \tag{35}$$

$$y_{t+1}^{MA} = [w_{t+1} + (1-\tau_t^{MA})b_t^M R_{t+1}] + [w_{t+1} + s^A x_{t+1}]$$

where τ_t^{MA} is the tax rate that maximizes the second period joint income of manufacturers and landowners. The sensitivity analysis results in Section 4.7 show that the tax rate, τ_t^{MA}, is below the very high tax rate preferred by natural resource owners, and in the case of a political coalition of manufacturers and landowners, the preferred tax rate, τ_t^{MA}, is equal to the tax rate chosen by manufacturers, τ_t^M, and so also it is equal to the socially optimal tax rate, τ_t^*, which achieves the maximum aggregate output level as demonstrated at point B in Figure 1. Hence, the simulation results imply the following[12],

$$\tau_t^N > \tau_t^{MN} > \tau_t^{MA} = \tau_t^M = \tau_t^* > \tau_t^A \tag{36}$$

[12] The calibration explanations and results validating this statement can be seen in Section 4.7.

4.7 Sensitivity Analysis

In all the simulations total population is equalized to 100 to get plausible numerical results, and for efficiency units of human capital the following function is used;

$h_{t+1} = h(e_t) = h(\tau_t b) = 1 + (\tau_t b)^{0.5}$

The initial parameter values used in the simulations are as the following:

$b = aQ_t = 10$; $\alpha = 0.3$; $\beta = 0.6$; $\theta = 0.4$; $\gamma = 0.6$; $N_t = N_{t+1} = N = 10$;

$Z_t = Z_{t+1} = Z = 5$; $b_t^M = 0.15$; $b_t^N = 0.133$; $\sigma = 30$; $\mu = 20$; $\vartheta = 40$

In all simulations the following two conditions are satisfied,

(1) $\frac{\partial Q_{t+1}^M}{\partial \delta_{t+1}^M} = \frac{\partial Q_{t+1}^N}{\partial \delta_{t+1}^N} = \frac{\partial Q_{t+1}^A}{\partial \delta_{t+1}^A}$, which refers to the condition of wage rate equalization across sectors in equation (22), $h_{t+1} w_{t+1}^M = h_{t+1} w_{t+1}^N = w_{t+1}^A = w_{t+1}$.

(2) $\delta_{t+1}^M + \delta_{t+1}^N + \delta_{t+1}^A = 100$

Hence, using the above parameter values and taking into account the specified conditions, under different political coalitions the following calibration results are obtained:

Table 1.Simulation Results under Different Political Coalitions

Political Authority	Tax Rate	δ^M_{t+1}	δ^N_{t+1}	δ^A_{t+1}	Q_{t+1}
Socially Optimal	$\tau^*_t = 0.362315$	51.0557	39.2914	9.6529	40.9107
Manufacturers	$\tau^M_t = 0.362315$	51.0557	39.2914	9.6529	40.9107
Natural Resource Owners	$\tau^N_t = 0.844238$	37.4938	52.0187	10.4875	32.8045
Landowners	$\tau^A_t = 0.132704$	0.870404	0.952376	98.1772	20.5046
Manufacturers-Natural Resource Owners	$\tau^{MN}_t = 0.573543$	47.7302	42.7966	9.4732	39.5818
Manufacturers-Landowners	$\tau^{MA}_t = 0.362315$	51.0557	39.2914	9.6529	40.9107

The following sensitivity analysis investigates how preferred tax rates and endogenously determined labor shares change when some of parameter values change under various coalitions.

a) Political Authority of the Manufacturers

Table 2. Sensitivity Analysis Results under the Political Authority of Manufacturers

α = 0.5	$\tau^M_t = 0.205907$	$\delta^M_{t+1} = 43.1165$	$\delta^N_{t+1} = 44.5706$	$\delta^A_{t+1} = 12.3129$
α = 0.1	$\tau^M_t = 0.684588$	$\delta^M_{t+1} = 60.721$	$\delta^N_{t+1} = 32.4023$	$\delta^A_{t+1} = 6.87632$
θ = 0.6	$\tau^M_t = 0.417286$	$\delta^M_{t+1} = 79.609$	$\delta^N_{t+1} = 16.4693$	$\delta^A_{t+1} = 3.92164$
θ = 0.2	$\tau^M_t = 0.296658$	$\delta^M_{t+1} = 22.6761$	$\delta^N_{t+1} = 61.5415$	$\delta^A_{t+1} = 15.7824$
β = 0.8	$\tau^M_t = 0.330983$	$\delta^M_{t+1} = 67.6948$	$\delta^N_{t+1} = 14.2635$	$\delta^A_{t+1} = 18.0417$
β = 0.4	$\tau^M_t = 0.390983$	$\delta^M_{t+1} = 25.5593$	$\delta^N_{t+1} = 71.2763$	$\delta^A_{t+1} = 3.16437$
γ = 0.8	$\tau^M_t = 0.362315$	$\delta^M_{t+1} = 54.7539$	$\delta^N_{t+1} = 41.6492$	$\delta^A_{t+1} = 3.59691$
γ = 0.3	$\tau^M_t = 0.362315$	$\delta^M_{t+1} = 28.9062$	$\delta^N_{t+1} = 24.458$	$\delta^A_{t+1} = 46.6357$
N = 20	$\tau^M_t = 0.362315$	$\delta^M_{t+1} = 42.8632$	$\delta^N_{t+1} = 50.8861$	$\delta^A_{t+1} = 6.25071$
N = 5	$\tau^M_t = 0.362315$	$\delta^M_{t+1} = 57.081$	$\delta^N_{t+1} = 28.7786$	$\delta^A_{t+1} = 14.1403$
Z = 25	$\tau^M_t = 0.362315$	$\delta^M_{t+1} = 35.4284$	$\delta^N_{t+1} = 28.977$	$\delta^A_{t+1} = 35.5946$
Z = 3	$\tau^M_t = 0.362315$	$\delta^M_{t+1} = 53.2834$	$\delta^N_{t+1} = 40.715$	$\delta^A_{t+1} = 6.00158$

When α increases the marginal productivity of physical capital rises relative to the human capital and natural resource employed in the manufacturing sector. Therefore, the manufacturers prefer a lower tax rate compared to the tax rate when the value of α is lower, and also there will be a labor transfer from the manufacturing sector to the natural resource and agriculture sectors. When θ rises, marginal returns from human capital increase relative to physical capital and natural resource employed in the manufacturing sector. Hence, manufacturers now prefer a higher tax rate, and there will be a labor transfer from the natural resource and agriculture sectors to the manufacturing sector. When β increases the marginal productivity of natural resource stock rises relative to human capital in the natural resource sector. This change has a small decreasing effect on the manufacturers' preferred tax rate, and it will bring about a labor migration from natural resource sector to the manufacturing and agriculture sectors. When γ rises marginal returns from land increase relative to unskilled labor employed in the agriculture sector. This change does not have any effect on the level of the tax rate chosen by manufacturers, though it creates a labor transfer from agriculture sector to manufacturing and natural resource sectors.

As the amount of natural resource stock increases, this effect does not change the manufacturers' preferred tax rate. Since now there is more natural resource stock to supply with human capital in the natural resource sector, and natural resource is an input used in manufacturing sector there will be a labor transfer from manufacturing and agriculture sectors to natural resource sector. As the amount of land increases, this does not change manufacturers' preferred tax rate. Since now there is more land to supply with raw labor and the labor migration is free across sectors, there will be a worker transfer from manufacturing and natural resource sectors to agriculture sector.

b) Political Authority of the Natural Resource Owners

Table 3. Sensitivity Analysis Results under the Political Authority of Natural Resource Owners

α = 0.5	$\tau_t^N = 0.790478$	$\delta_{t+1}^M = 21.8404$	$\delta_{t+1}^N = 64.8675$	$\delta_{t+1}^A = 13.2922$
α = 0.1	$\tau_t^N = 0.963519$	$\delta_{t+1}^M = 54.6216$	$\delta_{t+1}^N = 37.9718$	$\delta_{t+1}^A = 7.406654$
θ = 0.6	$\tau_t^N = 0.737921$	$\delta_{t+1}^M = 74.2848$	$\delta_{t+1}^N = 21.2805$	$\delta_{t+1}^A = 4.4347$
θ = 0.2	$\tau_t^N = 0.907133$	$\delta_{t+1}^M = 12.5831$	$\delta_{t+1}^N = 72.967$	$\delta_{t+1}^A = 14.4499$
β = 0.8	$\tau_t^N = 0.62967$	$\delta_{t+1}^M = 64.7119$	$\delta_{t+1}^N = 15.901$	$\delta_{t+1}^A = 19.3871$
β = 0.4	$\tau_t^N = 0.971226$	$\delta_{t+1}^M = 6.91574$	$\delta_{t+1}^N = 90.4025$	$\delta_{t+1}^A = 2.68173$
γ = 0.8	$\tau_t^N = 0.838916$	$\delta_{t+1}^M = 40.943$	$\delta_{t+1}^N = 55.2206$	$\delta_{t+1}^A = 3.83642$
γ = 0.3	$\tau_t^N = 0.889706$	$\delta_{t+1}^M = 17.4031$	$\delta_{t+1}^N = 31.5812$	$\delta_{t+1}^A = 51.0157$
N = 20	$\tau_t^N = 0.904211$	$\delta_{t+1}^M = 25.1397$	$\delta_{t+1}^N = 68.1107$	$\delta_{t+1}^A = 6.74956$
N = 5	$\tau_t^N = 0.781715$	$\delta_{t+1}^M = 47.7192$	$\delta_{t+1}^N = 37.0536$	$\delta_{t+1}^A = 15.2272$
Z = 25	$\tau_t^N = 0.872229$	$\delta_{t+1}^M = 23.5285$	$\delta_{t+1}^N = 38.2374$	$\delta_{t+1}^A = 38.2341$
Z = 3	$\tau_t^N = 0.84102$	$\delta_{t+1}^M = 39.5423$	$\delta_{t+1}^N = 53.928$	$\delta_{t+1}^A = 6.52965$

When α increases the marginal productivity of physical capital rises relative to the human capital and natural resource employed in the manufacturing sector. Since the natural resource owners own physical capital they now prefer a lower tax rate, and there occurs a labor transfer from the manufacturing sector to the natural resource and agriculture sectors. When θ rises, marginal returns from human capital increase relative to physical capital and natural resource employed in the manufacturing sector. Thus, natural resource owners now prefer a lower tax rate. Yet, due to the unconstrained labor migration across sectors, there will be a labor transfer from the natural resource and agriculture sectors to the manufacturing sector. When β increases the marginal productivity of natural resource stock rises relative to human capital in the natural resource sector. This change reduces the tax rate preferred by the natural resource owners, and it will bring about a labor migration from natural resource sector to the manufacturing and agriculture sectors. As γ rises marginal returns from land increase relative to unskilled labor employed in the agriculture sector. This change has a small reducing effect on the natural resource owners' preferred tax rate, though it creates a labor transfer from agriculture sector to manufacturing and natural resource sectors.

When the amount of natural resource stock increases since now there is more natural resource stock to supply with human capital in the natural resource sector, natural resource owners prefer a higher tax rate, and there occurs a labor migration from manufacturing and agriculture sectors to the natural resource sector, and. As the amount of land rises since there is more land to supply with unskilled workers, and the wage rates across sectors are equalized through free labor migration, there will be an employment transfer from the manufacturing and natural resource sectors to the agriculture sector.

c) **Coalition of the Manufacturers and Natural Resource Owners**

Table 4. Sensitivity Analysis Results under the Coalition of Manufacturers-Natural Resource Owners

α = 0.5	$\tau_t^{MN} = 0.408029$	$\delta_{t+1}^{M} = 38.4396$	$\delta_{t+1}^{N} = 49.673$	$\delta_{t+1}^{A} = 11.8874$
α = 0.1	$\tau_t^{MN} = 0.834666$	$\delta_{t+1}^{M} = 59.2746$	$\delta_{t+1}^{N} = 33.8762$	$\delta_{t+1}^{A} = 6.84913$
θ = 0.6	$\tau_t^{MN} = 0.537046$	$\delta_{t+1}^{M} = 78.4471$	$\delta_{t+1}^{N} = 17.5973$	$\delta_{t+1}^{A} = 3.95563$
θ = 0.2	$\tau_t^{MN} = 0.614792$	$\delta_{t+1}^{M} = 19.4477$	$\delta_{t+1}^{N} = 66.1485$	$\delta_{t+1}^{A} = 14.4038$
β = 0.8	$\tau_t^{MN} = 0.443004$	$\delta_{t+1}^{M} = 67.1516$	$\delta_{t+1}^{N} = 14.6854$	$\delta_{t+1}^{A} = 18.1631$
β = 0.4	$\tau_t^{MN} = 0.674599$	$\delta_{t+1}^{M} = 20.0516$	$\delta_{t+1}^{N} = 77.1866$	$\delta_{t+1}^{A} = 2.76186$
γ = 0.8	$\tau_t^{MN} = 0.574198$	$\delta_{t+1}^{M} = 51.117$	$\delta_{t+1}^{N} = 45.3386$	$\delta_{t+1}^{A} = 3.54433$
γ = 0.3	$\tau_t^{MN} = 0.566046$	$\delta_{t+1}^{M} = 27.4378$	$\delta_{t+1}^{N} = 26.8053$	$\delta_{t+1}^{A} = 45.757$
N = 20	$\tau_t^{MN} = 0.616633$	$\delta_{t+1}^{M} = 38.3406$	$\delta_{t+1}^{N} = 55.6092$	$\delta_{t+1}^{A} = 6.05017$
N = 5	$\tau_t^{MN} = 0.535891$	$\delta_{t+1}^{M} = 54.8998$	$\delta_{t+1}^{N} = 31.1079$	$\delta_{t+1}^{A} = 13.9923$
Z = 25	$\tau_t^{MN} = 0.569072$	$\delta_{t+1}^{M} = 33.3379$	$\delta_{t+1}^{N} = 31.6113$	$\delta_{t+1}^{A} = 35.0508$
Z = 3	$\tau_t^{MN} = 0.573953$	$\delta_{t+1}^{M} = 49.7765$	$\delta_{t+1}^{N} = 44.3361$	$\delta_{t+1}^{A} = 5.88739$

Under the political coalition of manufacturers and natural resource owners, the directions of labor transfer are the same as in the two previous political authority cases. From the point of view of manufacturers, when θ rises since now manufacturers own natural resource stock and obtain income returns from natural resources ownership, as in the case of political authority of natural resource owners, the coalition members prefer a lower tax rate.

The sensitivity analysis results for the cases of the aggregate output and the manufacturers – landowners coalition are the same as the results of political authority of manufacturers. These simulation conclusions are consistent with the theoretical model.

Under the political authority of landowners, the same parameter changes which have been observed in other coalitions do not have any effect on the landowners' preferred tax rate and on the endogenous allocation of labor shares. Only the second period income of landowners increases when γ or the amount of land, Z, rise.

5. Conclusion

This paper proposes a theoretical model about the relationship between natural resource abundance and human capital accumulation from a political economy perspective, unlike most of the existing studies which heavily focus on either economic effects of natural resource abundance on economic growth, or rent–seeking activities. The analysis suggests that the ultimate impact of the natural resource abundance on economic growth and on the accumulation of human capital depends on which social group(s) holds the political power in the society and on their preferred tax policy to finance human capital accumulation through public education expenditures.

First the socially optimal tax rate that achieves the efficient human capital accumulation level and maximum aggregate output is found. Then, public education policies under different political economy formations are investigated. Under each political coalition, the second period aggregate output and labor shares in the three sectors are endogenously changing with the unique tax policy each political coalition imposes. When the landowners hold the political authority, mainly due to substantial reduction in the return from land which is caused by the increase in human capital, landowners favor human capital accumulation at a rather low degree. When the manufacturers have political power under either their own political authority or in a coalition with the landowners, since human capital is complementary to both physical capital and natural resources stock, and also the natural resource output is used as a factor of production in the manufacturing sector, the tax policies of these two political formations become the same with the socially optimal tax policy.

On the other hand, when the natural resource owners hold the ultimate political power, they want to get the full advantage of the complementarity between human capital and natural resources stock, having a rent – seeking point of view. In order to extract the highest possible return from the natural resources stock, they prefer an excessively high tax rate which causes the aggregate output, and so economic growth to be at suboptimal levels. Although the political coalition of manufacturers and natural resource owners implement a lower tax rate, it does not still completely remedy the distortionary tax effect hurting aggregate output and economic growth. Hence, even though natural resource owners favor human capital, their preferred tax rates diminish aggregate output which leads to the less funds available for human capital accumulation in the future generations.

The political economy analysis proposed in this paper implies a multi – social class economic conflict among the natural resource owners, manufacturers and landowners, and provides an answer for the highly differentiated economic performances of the natural resource abundant countries.

Appendix

A.1. Socially Optimal Tax Rate

As follows from (1), (18), (20) and (21), in period $t+1$ the aggregate output, Q_{t+1}, is written as the following,

$$Q_{t+1} = Q(Q_t, \tau_t, N, Z) = Q^M(Q_t, \tau_t, \delta^M(Q_t, \tau_t, N, Z), \delta^N(Q_t, \tau_t, N, Z), N) + Q^A(\delta^M(Q_t, \tau_t, N, Z), \delta^N(Q_t, \tau_t, N, Z), Z)$$

$$Q_{t+1} = [(1 - \tau_t)aQ_t]^\alpha [\delta^M(Q_t, \tau_t, N, Z)\, h(\tau_t aQ_t)]^\theta \left[N^\beta [\delta^N(Q_t, \tau_t, N, Z)\, h(\tau_t aQ_t)]^{1-\beta}\right]^{(1-\alpha-\theta)} + Z^\gamma(1 - \delta^N(Q_t, \tau_t, N, Z) - \delta^M(Q_t, \tau_t, N, Z))^{1-\gamma}$$

$$\partial Q_{t+1}/\partial \tau_t = -\, aQ_t \alpha Q^M_{t+1} K^{-1}_{t+1} + aQ_t \theta Q^M_{t+1}[h(\tau_t aQ_t)]^{-1} h'(\tau_t aQ_t) + aQ_t(1-\beta)(1 - \alpha - \theta) Q^M_{t+1}[h(\tau_t aQ_t)]^{-1} h'(\tau_t aQ_t) = 0$$

$$\partial Q_{t+1}/\partial \tau_t = aQ_t\, [-R(Q_t, \tau_t^*, N, Z) + \delta^{M*}_{t+1} w^M_{t+1} h'(\tau_t^* aQ_t) + \rho_{t+1} \delta^{N*}_{t+1} w^N_{t+1} h'(\tau_t^* aQ_t)] = 0$$

Then, it follows that

$$[\delta^{M*}(Q_t, \tau_t^*, N, Z)\, w^M_{t+1} h'(\tau_t^* aQ_t)] + [\rho_{t+1} \delta^{N*}(Q_t, \tau_t^*, N, Z) w^N_{t+1} h'(\tau_t^* aQ_t)] = R(Q_t, \tau_t^*, N, Z)$$

Hence, τ_t^* equates the marginal returns to human capital employed in the natural resources sector and manufacturing sector to the marginal return to physical capital. This shows that τ_t^* is the socially optimal tax rate which both maximizes the aggregate output and achieves the efficient level of investment in public education.

A.2. Preferred Tax Rate of the Manufacturers

As follows from (6), (20), (22) and (25), the second period income function of a manufacturer can be written more explicitly,

$$y_{t+1}^M = h_{t+1}\theta\, K_{t+1}^{\alpha}(\delta_{t+1}^M h_{t+1})^{\theta-1}N^{\beta(1-\alpha-\theta)}\,(\delta_{t+1}^N h_{t+1})^{(1-\beta)(1-\alpha-\theta)} + (1 - \tau_t^M)b_t^M[\alpha K_{t+1}^{\alpha-1}(\delta_{t+1}^M h_{t+1})^{\theta}N^{\beta(1-\alpha-\theta)}\,(\delta_{t+1}^N h_{t+1})^{(1-\beta)(1-\alpha-\theta)}]$$

The cost of increasing human capital is the increase in the tax rate. Following from (15), we can express the second period physical capital investment as;

$$K_{t+1} = (1-\tau_t^M)\, aQ_t$$

Since $h_{t+1} = h(e_t)$ and as follows from (16), the efficiency units of human capital function can be written as

$$h_{t+1} = h(e_t) = h(\tau_t^M aQ_t)$$

Now we can rewrite the second period income function of the manufacturers as

$$y_{t+1}^M = \left[\theta(1-\tau_t^M)^{\alpha}(aQ_t)^{\alpha}[h(\tau_t^M aQ_t)]^{(1-\alpha-\beta+\alpha\beta+\theta\beta)}(\delta_{t+1}^M)^{\theta-1}N^{\beta(1-\alpha-\theta)}\,(\delta_{t+1}^N)^{(1-\beta)(1-\alpha-\theta)}\right] + [\alpha b_t^M(1-\tau_t^M)^{\alpha}(aQ_t)^{\alpha-1}[h(\tau_t^M aQ_t)]^{(1-\alpha-\beta+\alpha\beta+\theta\beta)}(\delta_{t+1}^M)^{\theta}N^{\beta(1-\alpha-\theta)}\,(\delta_{t+1}^N)^{(1-\beta)(1-\alpha-\theta)}]$$

Simplifying this expression further;

$$y_{t+1}^M = (1-\tau_t^M)^{\alpha}(aQ_t)^{\alpha}[h(\tau_t^M aQ_t)]^{(1-\alpha-\beta+\alpha\beta+\theta\beta)}(\delta_{t+1}^M)^{\theta}N^{\beta(1-\alpha-\theta)}\,(\delta_{t+1}^N)^{(1-\beta)(1-\alpha-\theta)}[(\theta(\delta_{t+1}^M)^{-1}) + (\alpha b_t^M(\,aQ_t)^{-1})]$$

Now, we can take the derivative of the second period income function with respect to the preferred tax rate of the manufacturers, τ_t^M, and get both the benefit and the cost of supporting human capital accumulation for the manufacturers.

$$\frac{\partial y_{t+1}^M}{\partial \tau_t^M} =$$

$$(1 - \tau_t^M)^\alpha (aQ_t)^\alpha [h(\tau_t^M aQ_t)]^{(1-\alpha-\beta+\alpha\beta+\theta\beta)} (\delta_{t+1}^M)^\theta N^{\beta(1-\alpha-\theta)} (\delta_{t+1}^N)^{(1-\beta)(1-\alpha-\theta)} \Big\{\Big\{[(1 - \alpha - \beta + \alpha\beta + \theta\beta) h'(\tau_t^M aQ_t)[h(\tau_t^M aQ_t)]^{-1}] - [\alpha(1-\tau_t^M)^{-1}] + \left[\theta(\delta_{t+1}^M)^{-1} \frac{\partial \delta^M(Q_t,\tau_t^M,N,Z)}{\partial \tau_t^M}\right] + \left[(1-\beta)(1-\alpha-\theta)(\delta_{t+1}^N)^{-1} \frac{\partial \delta^N(Q_t,\tau_t^M,N,Z)}{\partial \tau_t^M}\right]\Big\} [(\theta(\delta_{t+1}^M)^{-1}) + (\alpha b_t^M (aQ_t)^{-1})] - \left[\theta(\delta_{t+1}^M)^{-2} \frac{\partial \delta^M(Q_t,\tau_t^M,N,Z)}{\partial \tau_t^M}\right]\}$$

Therefore,

$\frac{\partial y_{t+1}^M}{\partial \tau_t^M} = 0$ implies that in the following equation,

$$\Big\{\Big\{[(1 - \alpha - \beta + \alpha\beta + \theta\beta) h'(\tau_t^M aQ_t)[h(\tau_t^M aQ_t)]^{-1}] - [\alpha(1-\tau_t^M)^{-1}] + \left[\theta(\delta_{t+1}^M)^{-1} \frac{\partial \delta^M(Q_t,\tau_t^M,N,Z)}{\partial \tau_t^M}\right] + \left[(1-\beta)(1-\alpha-\theta)(\delta_{t+1}^N)^{-1} \frac{\partial \delta^N(Q_t,\tau_t^M,N,Z)}{\partial \tau_t^M}\right]\Big\} [(\theta(\delta_{t+1}^M)^{-1}) + (\alpha b_t^M (aQ_t)^{-1})] - \left[\theta(\delta_{t+1}^M)^{-2} \frac{\partial \delta^M(Q_t,\tau_t^M,N,Z)}{\partial \tau_t^M}\right]\Big\} = 0$$

Hence the tax rate preferred by the manufacturers satisfies the following equation,

$$\left\{[(1-\alpha-\beta+\alpha\beta+\theta\beta)h'(\tau_t^M aQ_t)[h(\tau_t^M aQ_t)]^{-1}] + \left[\theta(\delta_{t+1}^M)^{-1}\frac{\partial\delta^M(Q_t,\tau_t^M,N,Z)}{\partial\tau_t^M}\right] + \right.$$

$$\left.\left[(1-\beta)(1-\alpha-\theta)(\delta_{t+1}^N)^{-1}\frac{\partial\delta^N(Q_t,\tau_t^M,N,Z)}{\partial\tau_t^M}\right]\right\}[(\theta(\delta_{t+1}^M)^{-1}) + (\alpha b_t^M(\ aQ_t)^{-1})] =$$

$$\{[\alpha(1-\tau_t^M)^{-1}]\ [(\theta(\delta_{t+1}^M)^{-1}) + (\alpha b_t^M(\ aQ_t)^{-1})]\} + \left[\theta(\delta_{t+1}^M)^{-2}\frac{\partial\delta^M(Q_t,\tau_t^M,N,Z)}{\partial\tau_t^M}\right]$$

The tax rate satisfying the above equality, τ_t^M, is the tax rate which maximizes second period income of the manufacturers. Thus,

$$\tau_t^M = argmax y_{t+1}^M$$

A.3. Preferred Tax Rate of the Landowners

Following from (22) and (29) the income function of landowners in period $t+1$ can be written as,

$$y_{t+1}^A =$$
$$\left[\theta(1-\right.$$
$$\left.\tau_t^A)^\alpha(aQ_t)^\alpha[h(\tau_t^A aQ_t)]^{(1-\alpha-\beta+\alpha\beta+\theta\beta)}(\delta_{t+1}^M)^{\theta-1}N^{\beta(1-\alpha-\theta)}\ (\delta_{t+1}^N)^{(1-\beta)(1-\alpha-\theta)}\right] +$$
$$\left[\left(\frac{1}{\mu}\right)\gamma\ Z^\gamma\ (1-\delta_{t+1}^N-\delta_{t+1}^M)^{1-\gamma}\right]$$

By taking the derivative of the income function of landowners in period $t+1$ with respect to their preferred tax rate, ${\tau_t}^A$, we can obtain both the benefit and the cost of supporting human capital accumulation for the landowners.

$\frac{\partial y_{t+1}^A}{\partial {\tau_t}^A} = 0$ implies that

$\theta(1-$

$\tau_t^A)^{\alpha}(aQ_t)^{\alpha}[h(\tau_t^A aQ_t)]^{(1-\alpha-\beta+\alpha\beta+\theta\beta)}(\delta_{t+1}^M)^{\theta-1}N^{\beta(1-\alpha-\theta)}\ (\delta_{t+1}^N)^{(1-\beta)(1-\alpha-\theta)}\Big\{[(1-$

$\alpha-\beta+\alpha\beta+\theta\beta)h'(\tau_t^A aQ_t)[h(\tau_t^A aQ_t)]^{-1}]-[\alpha(1-\tau_t^A)^{-1}]+$

$\left[(\theta-1)(\delta_{t+1}^M)^{-1}\frac{\partial\delta^M(Q_t,\tau_t^A,N,Z)}{\partial\tau_t^A}\right]+\left[(1-\beta)(1-\alpha-\theta)(\delta_{t+1}^N)^{-1}\frac{\partial\delta^N(Q_t,\tau_t^A,N,Z)}{\partial\tau_t^A}\right]\Big\}+$

$\left[\left(\frac{1}{\mu}\right)(1-\gamma)\gamma\ Z^{\gamma}(1-\delta_{t+1}^N-\delta_{t+1}^M)^{-\gamma}\frac{\partial\delta^N(Q_t,\tau_t{}^A,N,Z)}{\partial\tau_t{}^A}\ \frac{\partial\delta^M(Q_t,\tau_t{}^A,N,Z)}{\partial\tau_t{}^A}\right]=0$

The tax rate satisfying this equality, τ_t^A, is the tax rate which maximizes the second period income of the landowners. Hence,

$$\tau_t^A = argmax y_{t+1}^A$$

A.4. Preferred Tax Rate of the Natural Resource Owners

As follows from (24) and (31),

$$y_{t+1}^N = w\big(Q_{t,}\tau_t{}^N,N,Z\big)+(1-\tau_t^N)\ b_t^N\ R\big(Q_{t,}\tau_t{}^N,N,Z\big)+(N/\sigma)\ v\big(Q_{t,}\tau_t{}^N,N,Z\big)$$

Following from (15), (16), (22) and Section A.2 in the Appendix, we can write y_{t+1}^N as,

$y_{t+1}^N=$

$\left[(1-\beta)N^{\beta}(\delta_{t+1}^N)^{-\beta}\ \ [h(\tau_t^N aQ_t)]^{(1-\beta)}\right]+$

$\big[\alpha b_t^N(1-$

$\tau_t^N)^{\alpha}(aQ_t)^{\alpha-1}[h(\tau_t^N aQ_t)]^{(\theta)}(\delta_{t+1}^M)^{\theta}N^{\beta(1-\alpha-\theta)}\ (\delta_{t+1}^N)^{(1-\beta)(1-\alpha-\theta)}[h(\tau_t^N aQ_t)]^{(1-\alpha-\theta)(1-\beta)}\big]+$

$[\left(\frac{1}{\sigma}\right)\beta\ N^{\beta}(\delta_{t+1}^N)^{1-\beta}\ \ [h(\tau_t^N aQ_t)]^{(1-\beta)}]$

This expression can be simplified as in the following equation,

$y_{t+1}^{N} = \{N^{\beta}(\delta_{t+1}^{N})^{-\beta}\ [h(\tau_t^N aQ_t)]^{(1-\beta)}\left[(1-\beta)+\left(\frac{1}{\sigma}\right)\beta\delta_{t+1}^{N}\right]\} + \{\alpha b_t^N(1-$

$\tau_t^N)^{\alpha}(aQ_t)^{\alpha-1}[h(\tau_t^N aQ_t)]^{(1-\alpha-\beta+\alpha\beta+\theta\beta)}(\delta_{t+1}^{M})^{\theta}N^{\beta(1-\alpha-\theta)}\ (\delta_{t+1}^{N})^{(1-\beta)(1-\alpha-\theta)}\}$

Taking the derivative of the second period income function of the natural resource owners with respect to their preferred tax rate, τ_t^N, gives us the following equation,

$\frac{\partial y_{t+1}^{N}}{\partial \tau_t^N} = 0$ implies that

$\left\{ N^{\beta}(\delta_{t+1}^{N})^{-\beta}\ [h(\tau_t^N aQ_t)]^{(1-\beta)}\{\left[\left(-\beta\ \frac{\partial\delta^N(Q_t,\tau_t^N,N,Z)}{\partial\tau_t^N}(\delta_{t+1}^{N})^{-1}\right)+\right.\right.$

$\left.\left.\left((1-\beta)\ h'(\tau_t^N aQ_t)[h(\tau_t^N aQ_t)]^{-1}\right)\right]\left[(1-\beta)+\left(\frac{1}{\sigma}\right)\beta\delta_{t+1}^{N}\right]+[\left(\frac{1}{\sigma}\right)\beta\frac{\partial\delta^N(Q_t,\tau_t^N,N,Z)}{\partial\tau_t^N}]\right\}+$

$\{\alpha b_t^N(1-$

$\tau_t^N)^{\alpha}\ [h(\tau_t^N aQ_t)]^{(1-\alpha-\beta+\alpha\beta+\theta\beta)}\ (aQ_t)^{\alpha-1}\ N^{\beta(1-\alpha-\theta)}\ (\delta_{t+1}^{N})^{(1-\beta)(1-\alpha-\theta)}\ (\delta_{t+1}^{M})^{\theta}\ \left\{[(1-\right.$

$\alpha-\beta+\alpha\beta+\theta\beta)h'(\tau_t^N aQ_t)[h(\tau_t^N aQ_t)]^{-1}] - [\alpha(1-\tau_t^N)^{-1}\ ]+$

$\left.\left[\theta(\delta_{t+1}^{M})^{-1}\frac{\partial\delta^M(Q_t,\tau_t^N,N,Z)}{\partial\tau_t^N}\ \right]+\left[(1-\beta)(1-\alpha-\theta)(\delta_{t+1}^{N})^{-1}\frac{\partial\delta^N(Q_t,\tau_t^N,N,Z)}{\partial\tau_t^N}\ \right]\right\}\} = 0$

Hence, in order to satisfy the above equality and maximize the income of the natural resource owners in period $t+1$, it requires a tax rate, τ_t^N, higher than the tax rate preferred by the manufacturers, τ_t^M.

Then, $\tau_t^N = argmax y_{t+1}^N$

$\tau_t^N =$

$argmax\left[w\left(Q_{t,}\tau_t{}^N,N,Z\right)+(1-\tau_t^N)\ b_t^N\ R\left(Q_{t,}\tau_t{}^N,N,Z\right)+(N/\sigma)\ v\left(Q_{t,}\tau_t{}^N,N,Z\right)\right]$

Therefore, the tax rate, τ_t^N, maximizing the second period income of natural resource owners also satisfies the following condition,

$$\tau_t^N > \tau_t^M = \tau_t^* > \tau_t^A$$

A.5. Preferred Tax Policy of the Manufacturers-Natural Resource Owners Coalition

The political coalition of manufacturers and natural resource owners will prefer a tax rate, τ_t^{MN}, which maximizes their joint second period income. The simulation results imply that following from (24) and (33), the joint second period income function can be written as

$$y_{t+1}^{MN} = [w(Q_t, \tau_t^{MN}, N, Z) + (1-\tau_t^{MN}) b_t^M R(Q_t, \tau_t^{MN}, N, Z)] + [w\left(Q_{t,} \tau_t{}^{MN}, N, Z\right) +$$
$$(1-\tau_t^{MN})\, b_t^N\, R\left(Q_{t,} \tau_t{}^{MN}, N, Z\right) + \left(\frac{N}{\sigma}\right)\, v\left(Q_{t,} \tau_t{}^{MN}, N, Z\right)]$$

Taking the derivative of the second period income function of the manufacturers - natural resource owners coalition with respect to their preferred tax rate, τ_t^{MN}, gives us the following equation,

$\frac{\partial y_{t+1}^{MN}}{\partial \tau_t^{MN}} = 0$ implies that

$$\left\{ N^{\beta} (\delta_{t+1}^N)^{-\beta}\, [h(\tau_t^{MN} a Q_t)]^{(1-\beta)} \{ \left[\left(-\beta\, \frac{\partial \delta^N(Q_t, \tau_t^{MN}, N, Z)}{\partial \tau_t^{MN}} (\delta_{t+1}^N)^{-1} \right) + \right.\right.$$

$$\left. \left((1-\beta)\, h'(\tau_t^{MN} a Q_t) [h(\tau_t^{MN} a Q_t)]^{-1} \right) \right] \left[(1-\beta) + \left(\frac{1}{\sigma}\right) \beta \delta_{t+1}^N \right] +$$

$$\left. [\left(\frac{1}{\sigma}\right) \beta\, \frac{\partial \delta^N(Q_t, \tau_t^{MN}, N, Z)}{\partial \tau_t^{MN}}] \right\} +$$

$$(1 -$$

$\tau_t^{MN})^{\alpha}(aQ_t)^{\alpha}[h(\tau_t^{MN}aQ_t)]^{(1-\alpha-\beta+\alpha\beta+\theta\beta)}(\delta_{t+1}^{M})^{\theta}N^{\beta(1-\alpha-\theta)}\ (\delta_{t+1}^{N})^{(1-\beta)(1-\alpha-\theta)}\Bigg\{\Bigg\{[(1-$

$\alpha-\beta+\alpha\beta+\theta\beta)h'(\tau_t^{MN}aQ_t)[h(\tau_t^{MN}aQ_t)]^{-1}]-[\alpha(1-\tau_t^{MN})^{-1}]+$

$\left[\theta(\delta_{t+1}^{M})^{-1}\frac{\partial\delta^{M}(Q_t,\tau_t^{MN},N,Z)}{\partial\tau_t^{MN}}\right]+$

$\left[(1-\beta)(1-\alpha-\theta)(\delta_{t+1}^{N})^{-1}\frac{\partial\delta^{N}(Q_t,\tau_t^{MN},N,Z)}{\partial\tau_t^{MN}}\right]\Bigg\}[(\theta(\delta_{t+1}^{M})^{-1})+(\alpha b_t^{M}(\ aQ_t)^{-1})+$

$(\alpha b_t^{N}(\ aQ_t)^{-1})]-\left[\theta(\delta_{t+1}^{M})^{-2}\frac{\partial\delta^{M}(Q_t,\tau_t^{MN},N,Z)}{\partial\tau_t^{MN}}\right]\Bigg\}=0$

The tax rate satisfying the above equality, τ_t^{MN}, is the tax rate which maximizes second period income of the manufacturers – natural resource owners coalition members.

Then, $\tau_t^{MN}=argmaxy_{t+1}^{MN}$

A.6. Preferred Tax Policy of the Manufacturers-Landowners Coalition

The second period income function of the coalition, (35), can also be written as the following

$$y_{t+1}^{MA}=[w(Q_t,\tau_t^{MA},N,Z)+(1-\tau_t^{MA})b_t^{M}R(Q_t,\tau_t^{MA},N,Z)]+[w\big(Q_{t,}\tau_t{}^{MA},N,Z\big)+$$
$$s^{A}x(Q_t,\tau_t{}^{MA},N,Z)]$$

The political coalition of manufacturers and landowners will implement a tax policy for human capital accumulation using the tax rate, τ_t^{MA}, such as maximizing their second period income as in the following equation,

$\frac{\partial y_{t+1}^{MA}}{\partial\tau_t^{MA}}=0$ implies that

$(1 -$

$\tau_t^{MA})^{\alpha}\ [h(\tau_t^{MA} aQ_t)]^{(1-\alpha-\beta+\alpha\beta+\theta\beta)}\ (aQ_t)^{\alpha}\ N^{\beta(1-\alpha-\theta)}\ (\delta_{t+1}^{N})^{(1-\beta)(1-\alpha-\theta)}\ (\delta_{t+1}^{M})^{\theta}\{ \Big\{[(1 -$

$\alpha - \beta + \alpha\beta + \theta\beta)h'(\tau_t^{MA} aQ_t)\ [h(\tau_t^{MA} aQ_t)]^{-1}] - [\alpha(1 - \tau_t^{MA})^{-1}\ ] +$

$\left[\theta(\delta_{t+1}^{M})^{-1} \frac{\partial \delta^{M}(Q_t, \tau_t^{MA}, N, Z)}{\partial \tau_t^{MA}}\ \right] +$

$\left[(1-\beta)(1-\alpha-\theta)(\delta_{t+1}^{N})^{-1} \frac{\partial \delta^{N}(Q_t, \tau_t^{MA}, N, Z)}{\partial \tau_t^{MA}}\ \right] [(\theta(\delta_{t+1}^{M})^{-1}) + (\alpha b_t^{M}(\ aQ_t)^{-1})] -$

$\left[\theta(\delta_{t+1}^{M})^{-2} \frac{\partial \delta^{M}(Q_t, \tau_t^{M}, N, Z)}{\partial \tau_t^{M}}\ \right]\Big\} +$

$\{[\theta(\delta_{t+1}^{M})^{-1}] \Big\{[(1 - \alpha - \beta + \alpha\beta + \theta\beta)h'(\tau_t^{MA} aQ_t)[h(\tau_t^{MA} aQ_t)]^{-1}] - [\alpha(1 -$

$\tau_t^{MA})^{-1}] + \left[(\theta - 1)(\delta_{t+1}^{M})^{-1} \frac{\partial \delta^{M}(Q_t, \tau_t^{MA}, N, Z)}{\partial \tau_t^{MA}}\ \right] +$

$\left[(1-\beta)(1-\alpha-\theta)(\delta_{t+1}^{N})^{-1} \frac{\partial \delta^{N}(Q_t, \tau_t^{MA}, N, Z)}{\partial \tau_t^{MA}}\ \right]\Big\}\} + \left[\left(\frac{1}{\mu}\right)(1-\gamma)\gamma\ Z^{\gamma}(1 - \delta_{t+1}^{N} -$

$\delta_{t+1}^{M})^{-\gamma} \frac{\partial \delta^{N}(Q_t, \tau_t{}^{MA}, N, Z)}{\partial \tau_t{}^{MA}}\ \frac{\partial \delta^{M}(Q_t, \tau_t{}^{MA}, N, Z)}{\partial \tau_t{}^{MA}}\ \right] = 0$

Therefore, τ_t^{MA} is the tax rate maximizing the second period income of the manufacturers – landowners coalition members, so

$$\tau_t^{MA} = argmax y_{t+1}^{MA}$$

And, $\tau_t^{MA} = \tau_t^{M} = \tau_t^{*}$, and following (26), (27), (28)

$$\tau_t^{MA} \equiv argmax Q_{t+1} \quad \text{, and}$$

$$\tau_t^{N} > \tau_t^{MN} > \tau_t^{MA} = \tau_t^{M} = \tau_t^{*} > \tau_t^{A}$$

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