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Differentials in Property Rights in a two sector-economy

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**DIFFERENTIALS IN PROPERTY RIGHTS
IN A TWO-SECTOR ECONOMY**

Raul Caruso¹

ABSTRACT: *This paper presents a two-sector economy. In a **contested sector** two agents struggle to appropriate the maximum possible fraction of a contestable output. In an **uncontested sector**, they hold secure property rights over the production of some goods. Agents split their resource endowment between ‘butter’, ‘guns’ and ‘ice-cream’. The latter denote productive activities secure from appropriation. It is shown how improvements in productivity can countervail destructive impact of continuous conflicts. Eventually, the basic model is extended to consider a government and a rival group. A redistributive government can boost production in the uncontested sector, but at a higher level of ‘guns’.*

Keywords: *property rights, conflict, productive and unproductive Activities, Butter, Guns and Ice-cream, appropriation, entrepreneurship, redistribution, kleptocracy.*

JEL CLASSIFICATION: D74, D20, F51, H56, O17.

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1. Introduction

This paper is intended to model a two-sector economy characterized by differentials in property rights. That is, the point of departure is that a fraction of economic activity may take shape outside a shared institutional framework. In such a case, there is no fully enforcement of property rights and economic interactions are shaped by the existence of violence and predation. Thus, in the absence of a shared set of rules, agents are assumed to use violence and coercion to ensure positive income. A conflict takes shape on the redistribution of potential income. In this respect, this paper is intended to be a contribution to the theoretical economic analysis of conflict. A conflict can be described as « *a destructive interaction which involves strategic interdependent decisions in the presence of coercion and anarchy* ».

This paper is based on general equilibrium models of conflict as introduced by Hirshleifer [1988], Grossman [1991], and Skaperdas [1992], The basic idea is that rational agents at a given point in time, are endowed with some positive resources endowments and some technological capabilities for both productive ('butter') and unproductive activities (denoted by 'guns'). Then, they struggle over the distribution of a joint output, so that they also make a choice in the allocation of a positive endowment of resources between butter and guns. The resulting social state is then shaped by the existence of conflict and it is pareto-inferior to a social state with no conflict. Put differently, a contestable output falls into a common pool available for appropriation. The chosen levels of resources invested by rational agents exclusively in productive or unproductive activities determine the social outcome of the conflict. In particular, positive investments in unproductive activities determine also the redistribution of a contested joint output.

Most contributions of a growing literature² analyse a simplified economy where all productive activities are under the threat of violent appropriation. However, in reality, agents involved in a conflict have some income and wealth secure from appropriation. Hence, there must be a relationship between the choice of resources to be allocated to conflict and the choice of resources to be allocated in a secure production. In a simplified economy, we can consider two sectors. In a first sector, each agent holds secure property rights over the production of some goods. Such secure property rights assure the holder of a secure level of production and income stream. In a second sector, agents struggle in

² See among others: Grossman and Kim [1995], Neary [1997a], Anderton et al. [1999], Noh [1999], Anderson and Marcouiller [2002], Baker [2003], Garfinkel [2004], Dixit [2004], Anderson and Bandiera [2005], Caruso [2006/2007/2010], Hausken [2004/2006], Munster [2007], Hoffman [2010], De Luca and Sekeris [2011] Munster and Staal [2011]. The literature on the economics of conflict has been surveyed in Garfinkel and Skaperdas [2007].

order to appropriate the maximum possible fraction of a contestable output. In the continuation of this work, I shall label the first sector as *uncontested sector* and the latter as *contested sector*.

Several reasons can be advanced to distinguish between uncontested and contested sectors. First and foremost, there could be institutional factors protecting contracts and property rights. In fact, there could be sectors where enforcement of property rights can be more effective than others. This may take place in particular in weak societies where the legitimate government has not the capacity to enforce property rights neither in all sectors nor in all territories. Namely, there is no monopoly of coercive power. This recalls the separation between governance and government as emphasized in Dixit [2004/2009].

Secondly, there could be geographical factors also shielding some sectors from destructive conflicts and violent appropriation. On one hand, there could be geographical obstacles making the struggle for appropriation less feasible. Instead, there are some fractions of territory more attractive than others because of their resources endowments and productive structures. This is verifiable when different warlords [or states and rebel groups] fight over the appropriation and the control of a territory. On one hand they fight and expend resources in an identified fraction of territory to appropriate a contested resource. On the other hand, they can be involved in productive activities on the fraction of territory whose government is completely secure. A simple example could be drawn from reality of many African developing countries which experience the sadly famous 'resource curse'. In many regions, the government and different warlords compete over the appropriation of rents flourishing from exports of natural resources. This leads to social unrest and violent competition. In fact, it is now fully acknowledged that emergence of civil wars is positively related with the exploitation of rents flourishing in some 'contested' sectors [see among others Collier and Hoeffler [1998], Le Billon [2001], De Soysa [2002], Fearon and Laitin [2003], Lujala et al. [2005],]. In particular, as shown in Buhaug and Gates [2002], localization of civil wars is positively related with the presence of natural resources. In particular, the authors studied the location of all battles thereby identifying the geographic extent of 265 civil conflicts over the period 1946-2000 and finding a robust positive association between the occurrence of violent conflicts and natural resources location.

Thus, the distinction between contested and uncontested sectors opens questions about the design of economic policies able to cope with both the persistence of bloody conflicts and the emergence of welfare-enhancing institutions. In this vein, Ross [2003], for example, compares the cases of Nigeria and Indonesia. The author maintains that in Indonesia the governments have supported agricultural and manufacturing sectors. Instead Nigerian governments focused upon

exploitation of Oil sector thus undermining entrepreneurial activities in small manufacturing sector and agriculture. Yet, Nigeria is plagued by an endless war in the oil-rich Niger Delta. Instead, Indonesia avoided the crowding-out of productive sectors as manufacturing and agriculture. In brief, Indonesian governments favored uncontested productive sectors whereas Nigerian governments invested in contested sectors. In fact, the reliance and the emphasis of governments upon some contested sectors is the case of other African developing countries descended to civil wars as – among others – Chad, Liberia, Uganda and Angola. Thus, the study and the design of public policies favouring productive uncontested sector is therefore a pillar of broader strategies to cope with actual and potential conflicts. This is particularly significant in the light of a growing evidence that entrepreneurship and small business survive even in the shadow of actual conflicts. For example, McDougal [2008], using the data of a fieldwork in Liberia, shows how firms adapt and survive to war.

These examples suggest a further assumption. Namely it is reasonable to assume that there is a productive asymmetry between contested and uncontested sectors. In fact, contested production within the mining sector could be assumed to exhibit constant returns to scale whereas small-scale manufacturing firms and rural units could exhibit decreasing returns to scale. When distinguishing between contested and uncontested sectors, therefore, it is also reasonable to assume a productive asymmetry between them.

Hence, in the continuation of this work, I shall present a simplified economy characterized by two sectors labelled respectively as *contested* and *uncontested*. Two rational agents split their own positive resource endowment between two kinds of productive activities and unproductive activities. Beyond the classical ‘butter’ and ‘guns’ I shall label the productive investments in the uncontested sector ‘ice cream’. Moreover, there is a productive asymmetry between the two sectors. That is, there is an uncontested sector characterized by decreasing returns to scale (DRS) and a contested sector characterized by constant returns to scale (CRS).

In such a context, the final allocation of resources between ‘butter’, ‘guns’ and ‘ice cream’ will depend upon exploitation of force. To the best of my knowledge, within a growing literature on conflict theory there are few papers analysing two sectors with three activities as two kinds of productive activities [secure production, contested production] and unproductive activities. Garfinkel and Skaperdas [2007] introduced the argument in a section of their survey on economics of conflict. In a two-agent world, the authors assumed that agents can produce butter, guns and an inferior substitute for butter, called ‘margarine’. The latter is assumed to be secure from appropriation. In the presence of perfectly enforced property rights over the production of butter, both agents would

not have any incentive to produce margarine. Then, their model allows for two types of equilibria. In the first equilibrium agents only produce 'margarine' thus implying no allocation of resources to both 'butter' and 'guns'. In a second kind of equilibrium, both parties produce positive quantities of guns and butter but no margarine. Different equilibria emerge in the presence of particular combination of a degree of decisiveness of the conflict and a productivity parameter. Whenever the degree of productivity for margarine is relatively high with respect to the decisiveness of violent conflict, agents are likely to invest only in the secure production of margarine. Garfinkel, Skaperdas and Syropoulos [2008] consider a model where identical groups are in conflict and are endowed with labor and secure land. They produce two consumption goods, Oil and Butter. In particular, Oil is produced in the secure land, whereas the butter is produced by means of labor. However, labor can be also distorted to the production of guns. In fact, Oil is contested by means of positive investment in guns. Both consumption goods are traded domestically and internationally. The authors compare autarky and free trade. Analytical findings show: [i] importers of contested Oil gain unambiguously; [ii] exporters gain in the presence of free trade if and only if the world price is sufficiently high enough; [iii] given the existence of conflict welfare decreases in the world price of the contested Oil.

However, there are only few articles analysing different kinds of productive activities. More attention has been paid to economies characterized by two kinds of unproductive activities [defence and offence] and productive activities. This is the case of Grossman and Kim [1995], Rider [1999], and Panagariya and Shibata [2000], among others. The latter models an arms rivalry between two small countries facing a constant probability of war. Countries produce arms and a consumption good that can be traded internationally whilst a defence good interpreted as a public good is non-traded. The main result is that a subsidy flowing from one country to another can boost consumption and then increase total welfare. Rider [1999], develops a model with two goods and three activities [production, predation and defence] to show the impossibility of pure and uncontested exchange. In such a framework each agent is assumed to produce only one good.

This paper is designed as follows: In a first section, I present a general model which enriches a basic model produced in Caruso [2010]. In a second section, the impact of different variables and parameters upon total production and total welfare are studied. In a third section, the model is enriched in order to analyse the interaction between a government and a rival group. Eventually, a brief comparison between the two scenarios is presented. In the last section, results are summarized and some conclusions are presented.

2. A basic model

The world is made of two risk-neutral agents indexed by $i = 1, 2$. They interact simultaneously. Both agents have a positive resources endowment denoted by $R_i \in (0, \infty)$. It can be divided into ‘guns’, ‘butter’ and ‘ice-cream’. By ‘guns’ I indicate any positive investments in unproductive activities of fighting. By ‘butter’ I indicate any positive investment in productive activities in the contested sector, whilst by ‘ice-cream’ I indicate any positive investments in productive activities in the uncontested sector. The interaction between the two agents generates an equilibrium allocation of resources endowment to ‘guns’, ‘butter’ and ‘ice-cream’. To summarise formally it is possible to write the resources constraint as:

$$R_i = y_i + x_i + G_i, i = 1, 2 \quad [1]$$

where G_i denotes the level of ‘guns’, and y_i and x_i denote ‘ice-cream’ and ‘butter’ respectively. They are all assumed to be positive: $G_i \in (0, \infty), y_i \in (0, \infty), x_i \in (0, \infty), i = 1, 2$. In the contested sector, the contested joint product – indicated by CX – can be described as a simple linear additive function:

$$CX = x_1 + x_2 = TR - G_1 - y_1 - G_2 - y_2 \quad [2]$$

Where $TR = R_1 + R_2$. This aggregate production function is characterized by constant returns to scale and constant elasticity of substitution. The outcome of the struggle is determined by means of an ordinary Contest Success Function³ [henceforth CSF for brevity] in its ratio form:

$$p_i(G_1, G_2) = \frac{G_i}{(G_1 + G_2)}, i = 1, 2 \quad [3]$$

Equation [3] is differentiable and follows the conditions below:

$$\begin{cases} p_1 + p_2 = 1, & p_i = .5 \text{ at } G_1 = G_2 \\ \partial p_i / \partial G_i > 0 & \partial p_i / \partial G_j < 0 \\ \partial^2 p_i / \partial G_i < 0 & \partial^2 p_i / \partial G_j > 0 \end{cases} \quad [3.1]$$

and then the outcome in the contested sector is given by:

³Selective seminal contributions on CSF are by Tullock [1980], O’Keeffe et al. [1984], Rosen [1986], Dixit [1987] and Hirshleifer [1989]. See then Skaperdas [1996] and Clark and Riis [1998] for a basic axiomatization. See also Amegashie [2006] and Peng [2006].

$$S_i = p_i (G_1, G_2) \theta C X \quad [4]$$

Where $\theta \in (0,1)$ denotes a physical destruction parameter. It is a shared ex-ante perception of destructiveness of conflict. In the case of actual violent conflicts there is a fraction of resources which is physically destroyed. As θ increases, the conflict is perceived less and less destructive. According to [3.1] the fraction of contestable output accruing to agent is increasing in its own level of guns whereas it is decreasing in the opponent's level of guns.

The uncontested sector is modelled as a traditional sector exhibiting decreasing returns to scale. The production function is a standard intensive production function which exhibits decreasing returns to scale:

$$Y_1(y_1) = y_1^a; Y_2(y_2) = y_2^b \quad [5]$$

where y_i denotes the level of resources devoted to the uncontested production by agent i and $a \in (0,1)$ and $b \in (0,1)$ are the parameters capturing the degree of returns of scale for agent 1 and agent 2 respectively. The level of production in the uncontested sector is denoted as $UY = Y_1 + Y_2$. Eventually, the final income of each agent can be described as a function of contributions of both sectors. Hence, each agent maximizes the following objective function:

$$W_i(Y_i, S_i) = Y_i + S_i, i = 1,2 \quad [6]$$

Evidently, an increase in the amount of guns lowers the level of production. On the other hand, final wealth of each agent could be raised through positive investments in productive activities but also through positive investments in appropriative activities. Agents are assumed to be rational and to interact simultaneously à la Nash-Cournot. Therefore, treating the opponent's choice as given each agent i maximizes [6] with respect to G_i and y_i . Under an ordinary process of maximization the Nash equilibrium choices of 'ice-cream' are:

$$y_1^* = (2a/\theta)^{\frac{1}{(1-a)}} \quad [7.1]$$

$$y_2^* = (2b/\theta)^{\frac{1}{(1-b)}} \quad [7.2]$$

The equilibrium level of 'ice-cream' is increasing in the degree of returns to scale, $y_1^*/\partial a > 0$, $\partial y_2^*/\partial b > 0$. Trivial to say that $y_1^* = y_2^*$ for $a = b$. Note also that the level of 'ice-cream' is decreasing in the destruction parameter $\frac{\partial y_i^*}{\partial \theta} < 0, i = 1,2$. A smaller degree of destruction implies fewer resources allocated to production in the uncontested sector. The equilibrium level of 'guns' is given by:

$$G_1^* = G_2^* = G^* = \left(\frac{TR}{4}\right) - 2^{\frac{(2a-1)}{(1-a)}} \left(\frac{a}{\theta}\right)^{\frac{1}{(1-a)}} - 2^{\frac{(2b-1)}{(1-b)}} \left(\frac{b}{\theta}\right)^{\frac{1}{(1-b)}} \quad [8]$$

A necessary and sufficient condition to have an equilibrium for the solutions shown in [7.1], [7.2] and [8] is $TR > \left(\frac{2a}{\theta}\right)^{\frac{1}{(1-a)}} + \left(\frac{2b}{\theta}\right)^{\frac{1}{(1-b)}}$, namely $TR > y_1^* + y_2^*$. Note that the level of guns is increasing in the destruction parameter $\frac{\partial G^*}{\partial \theta} > 0$. Namely, the lower is the perceived potential destruction the higher is the investment in guns. Moreover it is clear that $\frac{\partial G^*}{\partial a} < 0, \frac{\partial G^*}{\partial b} < 0$. At the equilibrium the level of 'butter' is:

$$x_1^* = R_1 - y_1^* - G_1^* = ((3R_1 - R_2)/4) - 3 \times \left(2^{\frac{(2a-1)}{(1-a)}} \left(\frac{a}{\theta}\right)^{\frac{1}{(1-a)}}\right) + 2^{\frac{(2b-1)}{(1-b)}} \left(\frac{b}{\theta}\right)^{\frac{1}{(1-b)}} \quad [9.1]$$

$$x_2^* = R_2 - y_2^* - G_2^* = ((3R_2 - R_1)/4) - 3 \times \left(2^{\frac{(2b-1)}{(1-b)}} \left(\frac{b}{\theta}\right)^{\frac{1}{(1-b)}}\right) + 2^{\frac{(2a-1)}{(1-a)}} \left(\frac{a}{\theta}\right)^{\frac{1}{(1-a)}} \quad [9.2]$$

The level of butter of each agent is decreasing in its degree of returns to scale and increasing in rival's degree of return to scale. This holds in the presence of DRS in the uncontested sector. In fact, $\partial x_1^*/\partial a < 0$ and $\partial x_2^*/\partial a > 0$ if and only if $(1 - \theta) > e^{1-(1/a)}/2a$. The latter condition holds given the DRS assumption. The same applies with b , namely $\partial x_2^*/\partial b < 0$ and $\partial x_1^*/\partial b > 0$ if and only if $(1 - \theta) > e^{1-(1/b)}/2b$. As the degree of returns to scale increases each agent will prefer to allocate resources to the uncontested sector. That is, as the secure and uncontested sector becomes more productive [albeit still in the range of the DRS] the level of contested 'butter' decreases. It is interesting to note that the level of butter of each party is increasing in the degree of returns to scale of the opponent. In other words, the higher is the productivity of one party, the higher is the positive investments in butter undertaken by the opponent. In fact, as productivity of agent 2 increases, agent 1 is aware that agent 2 would invest less in guns so making the butter of agent 1 less subject to appropriation. In other words, the higher is the productivity of one party, the more secure is the butter of the opponent. The level of butter of agent i is increasing in its own initial endowment and decreasing in the endowment of the opponent, namely $\frac{\partial x_i^*}{\partial R_i} > 0, \frac{\partial x_i^*}{\partial R_j} < 0, i = 1, 2, i \neq j$. The behaviour of x_i^* with respect to θ is not clear. It depends on combination of all parameters considered. To summarise, table 1 reports the relation between main variables x_i^*, y_i^*, G with respect to θ, a, b and R_i .

Table 1. Behavior of main variables

θ	a	b	R_1	R_2
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Ice Cream	y_1^*	-	+			
	y_2^*	-		+		
Guns	G	+	-	-	+	+
Butter	x_1^*	?	-	+	+	-
	x_2^*	?	+	-	-	+

Final incomes of agents are given by:

$$W_1^* = \left(\frac{\theta}{4}\right) TR + 2^{\frac{2a-1}{(1-a)}}(2-a) \left(\frac{a}{\theta}\right)^{\frac{a}{(1-a)}} - 2^{\frac{(2b-1)}{(1-b)}} b^{\frac{1}{(1-b)}} \theta^{\frac{b}{(b-1)}} \quad [10.1]$$

$$W_2^* = \left(\frac{\theta}{4}\right) TR + 2^{\frac{(2b-1)}{(1-b)}}(2-b) \left(\frac{b}{\theta}\right)^{\frac{b}{(1-b)}} - 2^{\frac{2a-1}{(1-a)}} a^{\frac{1}{(1-a)}} \theta^{\frac{a}{(a-1)}} \quad [10.2]$$

Final income of agents is decreasing in their own degree of returns to scale under some conditions, namely $\frac{\partial W_1^*}{\partial a} < 0 \Leftrightarrow (a-2)\ln\left(\frac{2a}{\theta}\right) + a - 1 > 0$, $\frac{\partial W_2^*}{\partial b} < 0 \Leftrightarrow (b-2)\ln\left(\frac{2b}{\theta}\right) + b - 1 > 0$ and $\frac{\partial W_1^*}{\partial b} < 0, \frac{\partial W_2^*}{\partial a} < 0$. Then, there is a combination of a and θ that makes the income of each agent decreasing in its own degree of returns to scale. In particular, the first condition states that as $\theta \rightarrow 1$ there are positive values for a allowing for a negative impact of the degree of returns upon the level of income. For example if $\theta = .75$, then $\frac{\partial W_1^*}{\partial a} < 0 \Leftrightarrow 0 < a < .24$. That is, when each agent does not retain a high degree of returns in the uncontested sector and interprets the conflict as non-destructive, it will have fewer incentives to invest in the secure and uncontested sector. In such a case, the income of each agent can decrease in any investment in ‘ice-cream’. That is, the opportunity cost of conflict is lower.

These predictions open the room for theoretical deepening about implementation of economic policies able to cope with the conflict. Namely, economic policies which increase the opportunity cost of conflict. In fact, it is not only the conflict which affects negatively welfare but it is also the absence of an adequate level of productivity which can guarantee a sufficiently high degree of returns in the production of ice-cream.

In sum, when agents are identical in their fighting abilities and asymmetric in their degrees of returns to scale in the uncontested sector, a combination of the destruction parameter and the degree of returns also affect the allocation of resources shaping the social outcome. It is clear that: (a) as the degree of returns to scale in the production of ice-cream increases each agent will prefer to allocate more resources to the uncontested sector. Corollaries are: (a.1) whenever the production of ice-cream exhibits sufficiently low productivity each agent will prefer to

allocate fewer resources to the uncontested sector; (a.2) when one agent allocate more resources to the uncontested sector (so reducing its investment in guns), induces a higher investment by the rival in the contested sector.

These results are akin with results presented in Garfinkel and Skaperdas [2007]. Shortly, productivity of secure and uncontested sectors matters. The main difference relies upon two factors [i] the production of margarine in the Garfinkel and Skaperdas model is assumed to be an inferior good whereas this is not the case with ice-cream; [ii] the allocation of resources is driven by a combination of technology of conflict and the degree of inferiority of margarine with respect to butter. Whenever the margarine is not so inferior compared to butter, agents invest only in the secure production of margarine and investments in both butter and guns. In our context, the technology of conflict does not matter because it has been ruled out with the functional form of CSF adopted in [3].

3. Production and welfare

As tools for ‘measurement’ I analyse hereafter the level of production and the total welfare. I shall consider the impact of the different variables and parameters on them. First, Using [5], [7.1] and [7.2] it is possible to compute the level of production emerging in the uncontested sector. Then we have:

$$UY^* = (2(a/\theta))^{\frac{a}{(1-a)}} + (2(b/\theta))^{\frac{b}{(1-b)}} \quad [11]$$

First, the level of uncontested production is unambiguously larger than zero. Eventually it is worth noting that $\frac{\partial UY^*}{\partial a} > 0 \Leftrightarrow \ln\left(\frac{2a}{\theta}\right) - a + 1 > 0$ and $\frac{\partial UY^*}{\partial b} > 0 \Leftrightarrow \ln\left(\frac{2b}{\theta}\right) - b + 1 > 0$. That is, as the conflict is perceived to be less and less destructive the degree of returns in the uncontested sector must be sufficiently high. Otherwise, in the presence of low returns to scale both agents would be better off by allocating resources into the contested sector. In such a case, production in the uncontested sector would decrease. In other words, when the returns in the uncontested sector are extremely low the level of uncontested production would decrease. For instance, setting $\theta = .75$, in order to have a level of UY^* increasing in a and b it is necessary to have $a, b > .16$. By contrast, as $\theta \rightarrow 0$ a very low degree of returns would even suffice to satisfy the positive relationship between total production in the uncontested sector and the degree of returns. Using [9.1] and [9.2] the level of production in the contested sector – namely the contested output - is given by:

$$CX^* = x_1^* + x_2^* = \left(\frac{TR}{2}\right) - 2\frac{a}{(1-a)}\left(\frac{a}{\theta}\right)^{\frac{1}{(1-a)}} - 2\frac{b}{(1-b)}\left(\frac{b}{\theta}\right)^{\frac{1}{(1-b)}} [12]$$

The level of contested production of butter is increasing in both the level of resources $\left(\frac{\partial CY^*}{\partial TR} > 0\right)$ and in the destruction parameter $\left(\frac{\partial CY^*}{\partial \theta} > 0\right)$. At the same time it is decreasing in both a and b , $\frac{\partial CY^*}{\partial a} < 0$, $\frac{\partial CY^*}{\partial b} < 0$. The higher are the returns in the uncontested sector, the lower would be the level of production in the contested sector. That is, as the production of ice cream becomes more attractive both agents are likely to allocate resources to it. Total production is given by the sum of [9.1] and [9.2]

$$TY^* = CX^* + UY^* = \left(\frac{TR}{2}\right) + \theta^{\frac{1}{(a-1)}}(\theta - a)2a^{\frac{a}{(1-a)}} + \theta^{\frac{1}{(b-1)}}(\theta - b)2b^{\frac{b}{(1-b)}} [13]$$

Also in this case it is clear that $\frac{\partial TY^*}{\partial \theta} > 0$ $\frac{\partial TY^*}{\partial TR} > 0$. Given the results presented above, it is predictable that the degree of returns can have an ambiguous impact on the level of total production. In particular, the partial derivatives with respect to a and b show that: $\frac{\partial TY^*}{\partial a} < 0 \Leftrightarrow (a - \theta)\ln\left(\frac{2a}{\theta}\right) + (a - 1)(\theta - 1) > 0$ and $\frac{\partial TY^*}{\partial b} < 0 \Leftrightarrow (b - \theta)\ln\left(\frac{2b}{\theta}\right) + (b - 1)(\theta - 1) > 0$. When the conflict is perceived to be more destructive both agents allocate more resources to the uncontested sector. This can decrease the level of production in the contested sector. This would depend upon specific combinations of a, b and θ . Total welfare is computed as the sum of attainable incomes:

$$TW^* = W_1^* + W_2^* = \theta\left(\frac{TR}{2}\right) + (1 - a)\left(\frac{2a}{\theta}\right)^{\frac{a}{(1-a)}} + (1 - b)\left(\frac{2b}{\theta}\right)^{\frac{b}{(1-b)}} [14]$$

The level of total welfare is increasing in the level of resources $\frac{\partial TW^*}{\partial TR} > 0$. Note also that $\frac{\partial TW^*}{\partial a} > 0 \Leftrightarrow \ln(2a/\theta) > 0$ and $\frac{\partial TW^*}{\partial b} > 0 \Leftrightarrow \ln(2b/\theta) > 0$. Total welfare is increasing in returns to scale of both agents if and only if a specific combination of returns to scale and destruction parameter holds.

4. Redistributive government and rival group

Up to this point the analysis focused on a scenario characterized by two risk-neutral agents holding secure property rights in the production of ice-cream while contesting a joint output in a contested sector. No specific assumptions have been made about the characteristics of these agents. Hereafter, assume that agent 1 and agent 2 can be interpreted as

a government and a rival group respectively. In spite of the existence of a government, the environment here is quasi-anarchic. There is no clear-cut monopoly of coercive power. The government is ineffective in providing full contract enforcement in some sectors. That is, a government may retain full enforcement of contracts in some productive sectors whilst it could be contested by a rival group in some other sectors. Therefore, the government and the rival group are involved in a continuous conflict. By the use of force they shape the distribution of a contestable output in contested sectors and, as in the previous section, there is an uncontested sector where each agent can invest in the production of ice-cream which is secure from appropriation. The economy is 'dual'. The duality here is an asymmetry in the effectiveness of institutional settings.

The point of interest here is whether the structure of taxation influences allocation of resources to butter, guns and ice-cream in the economy. Evidently, the government can be either benevolent or kleptocratic. This would depend to what extent it does redistribute the tax burden to the rival group. The government can impose a proportional tax rate on production in the uncontested sector, but it can also behave as a redistributive government and subsidize the rival group by means of redistribution of public funds. The tax burden and the redistribution in favour of the rival group both affect the allocation of resources between butter, guns and ice-cream.

This idea is not a novelty. In particular, the tax burden imposed upon a fraction of population by ruling elites has been interpreted as a crucial factor for the emergence of revolutions. This is the basic idea surrounding some brilliant works as Grossman [1991] and Acemoglu and Robinson [2006]. Grossman [1991] shows that a too high tax rate imposed by the ruler would increase the probability of a successful insurrection. Acemoglu and Robinson [2006], albeit with a different technical approach and with no distinction between butter and guns, interpret the tax rate as instrument of redistributive policies used by the governing elite in favour of the citizens so determining a revolution constraint. In fact, fearing a revolution the elite can make concessions and set a tax rate that redistribute some of the resources to the citizen. In such a framework, the revolution constraint is strongly affected by existing income inequality which can be modified through redistributive policies.

In the current section, the basic model will be enriched to consider the existence of a government. However, given the analytical complexity, some simplifying assumptions have to be made. First, consider that both agents retain the same degree of productivity in the uncontested sector, namely $a = b$ (henceforth only notation b will be used). This assumption fits with a scenario where technology is simple and pervasive. Furthermore, assume that both agents perceive the conflict as non-destructive, namely

$\theta = 1$. This additional limiting assumption is reasonable when considering that the focus hereafter would be only on taxation and redistribution. That is, the emphasis here is on relation between the type of government (benevolent or kleptocratic at the extremes) and the impact on the intensity of conflict. Henceforth, taxation and redistribution define the type of the government and they are treated as given parameters. The choice variables are guns and ice-cream as in the previous section. That is, in other words, the government chooses the optimal level of conflict and production given its type, namely given the structure of taxation and redistribution.

Then, let $t \in [0,1]$ denote the proportional tax rate imposed by the government on the rival group. It is imposed on the production of ice-cream. Let also $w \in [0,1]$ denote the proportional redistribution policy applied by government to the rival group. For sake of simplicity no additional elements are considered [i.e. for example, there are no costs for collecting taxes]. Note that $t \geq w$. Whenever $t = w$ the government is completely benevolent and redistributes the entire tax burden to the rival group. Albeit absolutely unrealistic, for expository reasons, I do not exclude this possibility from the start. The redistribution is proportional to the production of ice-cream of the rival group. The income functions for both agents become:

$$W_1^g = y_1^b + p_1(G_1, G_2)CX + ty_1^b - wy_1^b \quad [15.1]$$

$$W_2^g = y_2^b(1 - t + w) + p_2(G_1, G_2)CX \quad [15.2]$$

Hereafter for sake of simplicity, use $q = t - w$. Of course the higher is q the less benevolent [the more kleptocratic] is the government. Agent 1 and agent 2 maximize [15.1] and [15.2] respectively with respect to G_i and y_i with $i = 1,2$. Solving the first order conditions, the Nash equilibrium choices of 'ice-cream' are:

$$y_1^{g*} = (2b)^{\frac{1}{(1-b)}} \quad [16.1]$$

$$y_2^{g*} = [-2b(q - 1)]^{\frac{1}{(1-b)}} \quad [16.2]$$

The second order conditions dictate the condition $2^{\frac{b}{b-1}}TR(b - 1)[b(1 - q)]^{\frac{1}{b-1}} + (3 - 2b)(1 - q)^{\frac{1}{b-1}} - 2b < -2$ for the existence of an equilibrium [please see the appendix for proofs]. As $TR \rightarrow \infty$ the latter inequality always hold. For $TR = 1$ condition reduces into $2^{\frac{b}{b-1}}(b - 1)[b(1 - q)]^{\frac{1}{b-1}} + (3 - 2b)(1 - q)^{\frac{1}{b-1}} - 2b < -2$. It is clear that $y_1^{g*} > y_2^{g*}$ for any positive level of $q, q > 0$. It is not surprising that $\partial y_2^{g*} / \partial q < 0$. That is, the tax burden depresses production in the uncontested sector for

agent 2, say the rival group. The total production of ice cream is given by: $UY^{g^*} = \left((1 - q)^{\frac{1}{(b-1)}} + 1 \right) (2b(1 - q))^{\frac{1}{(1-b)}}$. The production in the uncontested sector is decreasing in q and increasing in b . The equilibrium choices of guns are:

$$G_1^{g^*} = G_2^{g^*} = G^{g^*} = \left(\frac{TR}{4} \right) - b^{\frac{1}{(1-b)}} \left(B(1 - q)^{\frac{1}{(1-b)}} + B \right) \quad [17]$$

where $2^{(2b-1)/(1-b)} = B$ for notational simplicity. The total level of guns is given by:

$$TG^{g^*} = \left(\frac{TR}{2} \right) - b^{\frac{1}{(1-b)}} \left(2^{\frac{b}{(1-b)}} (1 - q)^{\frac{1}{(1-b)}} + 2^{\frac{b}{(1-b)}} \right) \quad [18]$$

The total level of guns is decreasing in b and increasing in both q and TR . The equilibrium level of butter is:

$$x_1^{g^*} = ((3R_1 - R_2)/4) + b^{\frac{b}{(1-b)}} \left(B(1 - q)^{\frac{1}{(1-b)}} - 3B \right) \quad [19.1]$$

$$x_2^{g^*} = ((3R_1 - R_2)/4) + b^{\frac{b}{(1-b)}} \left(B - 3B(1 - q)^{\frac{1}{(1-b)}} \right) \quad [19.2]$$

Then, the total contested production of butter is:

$$CX^{g^*} = \left(\frac{TR}{2} \right) - b^{\frac{1}{(1-b)}} \left(2B(1 - q)^{\frac{1}{(1-b)}} + 2B \right) \quad [20]$$

Total contested production is increasing in q . By contrast, total contested production is decreasing in b , $\frac{\partial CX^{g^*}}{\partial b} < 0 \Leftrightarrow b \ln(b(1 - q)) + (1 - q)^{1/(b-1)} (b \ln(b) - b + 1) - b + 1 < 0$. That is, there are combinations of b and q that make the total contested production increasing in the degree of returns to scale. Whenever $b \rightarrow 1$ and q is sufficiently low the contested production is increasing in b . That is, in the presence of a degree of productivity sufficiently high, the productivity effect dominates the incentives for fighting and appropriation. Note that $CX^{g^*} = UY^{g^*} \Leftrightarrow TR = b^{\frac{b}{(1-b)}} \left[3(2(1 - q))^{\frac{1}{(1-b)}} + 3 \times 2^{\frac{1}{(1-b)}} \right]$. That is, there is a critical value for the entire resources endowment which – given b and q – allows for equal level of production in both sectors. Eventually total production in the economy is given by:

$$TY^{g^*} = UY^{g^*} + CX^{g^*} = \left(\frac{TR}{2} \right) + b^{\frac{1}{(1-b)}} \left[2^{\frac{b}{(1-b)}} (1 - q)^{\frac{1}{(1-b)}} + 2^{\frac{b}{(1-b)}} \right] \quad [21]$$

Total production is increasing in b and q . In other words, a higher tax burden leads to a lower level of production. Put differently, the more kleptocratic is the government the lower is the level of total production. Eventually final incomes of both agents are given by:

$$W_1^{g*} = \left(\frac{TR}{4}\right) + b^{\frac{b}{(1-b)}}(1-q)^{\frac{b}{(1-b)}} \left[B(2-b)(1-q)^{\frac{b}{(b-1)}} - B(b(q-1)(4t-1)) + 2w \right] \quad [22.1]$$

$$W_2^{g*} = \left(\frac{TR}{4}\right) - b^{\frac{b}{(1-b)}} \left[B(1-q)^{\frac{1}{(1-b)}}(b-2) + bB \right] \quad [22.2]$$

The total welfare is the sum of [22.1] and [22.2]:

$$TW^{g*} = \left(\frac{TR}{2}\right) + b^{\frac{b}{(1-b)}} \left[(1-b)(1-q)^{\frac{b}{(b-1)}} + b(1-2t)(q-1) - t + 1 \right] [2(1-q)]^{\frac{b}{(1-b)}} \quad [23]$$

Total welfare is decreasing in q and increasing in TR . That is, in general the higher is the government rent, the lower is the level of attainable welfare within the whole economy.

5. Comparison

In this brief section, a comparison between the two scenarios is presented. I am comparing the results of the basic model analysed in the first section with those of the latter model involving the existence of a redistributive government. In particular, I will define a scenario as more or less “peaceful” by looking at the level of guns chosen by both parties. The greater the level of guns the less peaceful is that scenario considered. Given the simplifying assumptions applied in the governmental scenario [$\theta = 1$ and $a = b$], equations [8], [13] and [15] will be reformulated. First, using [8] with $\theta = 1$ and $a = b$ the level of guns in the first scenario becomes:

$$TG^* = \left(\frac{TR}{2}\right) - (2b)^{1/(1-b)} \quad [24]$$

Then comparing [24] and [18] it is possible to verify that the level of guns in the first scenario is unambiguously lower than the level of guns chosen in the presence of a redistributive government ($TG^* < TG^{g*}$). Put differently, it could be stated that the first scenario is more ‘peaceful’. Reformulating equation [13] with $\theta = 1$ and $a = b$, the level of total production in the first scenario becomes:-

$$TY^* = \left(\frac{TR}{2}\right) + 2^{1/(1-b)} b^{\frac{b}{(1-b)}}(1-b) \quad [25]$$

Comparing [25] and [21] it is possible to say that $TY^* > TY^{g*} \Leftrightarrow (1 - q)^{1/(b-1)}(3b - 2) + b < 0$. That is, whenever b is sufficiently high, total production is unambiguously higher in the presence of a redistributive government. This also suggests that the positive impact of a superior productivity offsets the negative impact of tax burden even in the absence of redistribution, namely when q is very close to unity and the government can be defined kleptocratic. Total welfare is given by:

$$TW^{g*} = \left(\frac{TR}{2}\right) + b^{\frac{b}{(1-b)}} \left[(1-b)(1-q)^{\frac{b}{(b-1)}} + b(1-2t)(q-1) - t + 1 \right] [2(1-q)]^{\frac{b}{(1-b)}} \quad [26]$$

In the first scenario total welfare is given by [14]. By substituting $\theta = 1$ and $a = b$, it becomes:

$$TW^* = \left(\frac{TR}{2}\right) + 2^{\frac{1}{(1-b)}} b^{\frac{b}{(1-b)}} (1-b) \quad [27]$$

Hence, using [26] and [27] it is possible to write that $TW^{g*} > TW^*$ if and only if:

$$(1-b)(1-q)^{b/(b-1)} + b(q-1)(2t-1) < 1-t \quad [28]$$

That is, there are combinations of b and q that make total welfare higher in the presence of a redistributive government. It is clear that a superior productivity ($b \rightarrow 1$) can increase total welfare even under the existence of a redistributive government. Instead, as $b \rightarrow 0$ inequality [28] does not hold. Put differently, whenever the degree of returns to scale is low, total welfare would be higher with no taxation and no redistribution. By contrast, whenever b is sufficiently high there are combinations of tax burden and redistribution that allow for higher welfare under the existence of a redistributive government. In particular, it is clear that the government rent must be sufficiently low to allow for higher welfare.

When the degree of returns is low a scenario characterized by no government committed to redistribution could be considered desirable. It is a more peaceful scenario [i.e. fewer guns], leading to both higher production and welfare. By contrast, whenever the degree of returns is sufficiently high, results are ambiguous. On one hand, the existence of a redistributive government leads unambiguously to a higher level of guns that make it less 'peaceful'. On the other hand, production and welfare can be higher in the presence of a government which collects taxes and subsidizes production of ice-cream. Therefore, even in the presence of a tax burden a proportional subsidy can boost the level of production. In particular, this occurs when the degree of returns is sufficiently high.

Note also that with no redistribution [$w = 0$] to have $TW^{g^*} > TW^*$ the tax burden must be extremely low and the degree to returns must be sufficiently high. In particular, with $w = 0$, inequality [28] reduces into $(1 - b)(1 - t)^{b/(b-1)} + b(2t^2 - 3t + 1) < 1 - t$. To sum up it is possible to write the following proposition:

PROPOSITION: when the agents are identical in both their fighting abilities and in their degrees of returns to scale in the uncontested sector then [a] in the presence of a redistributive government (imposing a tax burden over a rival group), the total level of guns is larger than in a scenario characterized by no taxation and no redistribution; [b] total production is higher in the absence of redistribution policies if and only if both agents exhibit a sufficiently low degree of productivity; [c] whenever the degree of returns is sufficiently high, total production is higher in the presence of a redistributive government; [d] whenever the degree of returns to scale is low, total welfare is higher in the absence of redistribution policies. By contrast, whenever it is sufficiently high there are combinations of tax burden and redistribution that allow for higher welfare under the existence of a redistributive government.

6. Discussion and conclusion

This paper was an attempt to examine the interaction between two risk-neutral agents that can allocate their own resources both to a contested sector and an uncontested sector. The main general result I would claim for this work is that the level of productivity in the uncontested sector can be a powerful factor inducing a higher allocation of resources to ordinary entrepreneurial activity. It is shown that the higher are the returns in the uncontested sector the lower would be the level of production in the contested sector.

Hence, in general terms, the results of the paper recall the famous discussion posed by Baumol [1990] that suggested how entrepreneurs allocate their resources depending on the relative returns of productive and unproductive activities. The analysis confirms how the allocation of resources is significantly affected by the degrees of returns in the uncontested sectors. Briefly, a sufficiently high productivity in the uncontested sector does divert resources from the contested sector to the uncontested sector increasing the opportunity cost of a bloody conflict. In other words, increased entrepreneurship can also contribute to crowd out bloody rent-seeking in contested sectors. This holds even if it is assumed that the contested sector exhibit greater returns than the uncontested sector. In fact, it has been assumed that the contested sector exhibits constant returns to scale, whereas the uncontested sector exhibits decreasing returns to scale.

These findings complement with results produced by other works involving different methodologies and analytic modelling. Tornell and Lane [1999] analyse an economy with an efficient formal sector and a less efficient informal sector. The authors show that a productivity improvement in the efficient sector does not lead to an increase in welfare when there are powerful groups demanding for discretionary redistribution. By contrast, when groups are powerless or when there recognized barriers to redistribution a productivity improvement can raise welfare. That is, the redistribution of rents between groups may outweigh the direct effect of increased productivity. This has been coined 'voracity effect'. Van der Ploeg [2010], enriches the idea by analysing whether or not the Hartwick rule holds for countries where property rights are not properly enforced so determining zero saving rates. That is, the voracity effect is magnified in the presence of poor legal systems. Baland and Francois [2000], emphasize that the initial equilibrium is the most important factor shaping the distribution of income between rent-seekers and entrepreneurs. In particular, whenever an economy is characterized by a 'full entrepreneurship equilibrium' [that is, there are entrepreneurs in all sectors] a resource boom raises returns to entrepreneurship relative to rent-seeking. Whenever entrepreneurship does not dominate rent-seeking in the initial scenario, an exogenous resources boom lowers the returns to entrepreneurship relative to rent-seeking. Such emphasis upon the resources endowment is also in Torvik [2002] that shows how an increased amount of natural resources decreases total income and welfare. The driving assumption is that with rent seeking more profitable than modern production, entrepreneurs move into rent seeking. Mehlum et al. [2003], produce a dynamic model to analyse the growth of countries which are characterized by the existence of predatory sectors. First, the authors show how predation may be the cause but also the consequence of underdevelopment. Put differently, societies which are plagued by predation are likely to fall in predation/poverty trap. This has also notable implications for convergence across countries. Thus, some countries are predicted to fall in a 'predators' club' with a low long run income level whereas other countries can be predicted to fall within a 'producers' club' which do exhibit a higher long-run income level. This prediction clearly contrasts the classical hypothesis of convergence between poorer and richer countries.

This paper was an attempt to contribute to this line of research. Needless to say, this also suggests a further step in a future research agenda. That is, there is room for designing and developing novel dynamic models in order to investigate the long-run development of economies plagued by continuous conflicts with different shapes and intensities. Eventually, the study of dynamic models of growth in the presence of conflict, would also pave the way for novel normative studies

on growth. In particular, in the light of insights drawn from theory of conflicts, economic policies can be designed first in order to cope with and control unproductive conflicts within societies. This would be intended to highlight the factors leading to a sustainable and peaceful economic development in the long run.

As pointed out, in particular, enhancing productivity in the uncontested sectors ought to be a desirable economic policy. This does not seem to be case with redistributive policies in favour of uncontested productive sectors. In fact, modelling explicitly a redistributive government and a rival group leads to ambiguous results. The government collects taxes from the rival group and redistributes a fraction of tax burden through a proportional subsidy to its uncontested production. The government could be either benevolent or predatory. This would affect significantly the allocation of resources. A redistributive government can boost production in the uncontested sector, but at a higher level of 'guns'. In fact, the existence of a redistributive government induces higher investments in guns. Whatever the level of productivity, this result unambiguously holds.

However, whenever both agents are low-productivity agents total production is higher in the absence of a redistributive government. By contrast, whenever the degree of returns is sufficiently high, total production in this scenario is lower. Eventually, whenever the degree of returns to scale is low, total welfare is also higher in the absence of both taxation and redistribution. If the degree of productivity is sufficiently high there are combinations of tax burden and redistribution that allow for higher welfare under the existence of a redistributive government. The latter result is another crucial point and needs further investigation in particular for long-run dynamics. In fact, it is recognized that equilibria based upon deterrence exhibit an intrinsic instability in the long run as explained in Boulding, [1963]. Greif [2007] confirms this idea explaining the self-undermining equilibrium established in medieval Genoa between rival clans. Such equilibrium was characterized by mutual deterrence between clans which continuously increased their military strength. In the long run this equilibrium became unstable leading Genoa to social unrest and civil war. Therefore, extending the modelling of this work in a multi-period framework could help to explain whether or not and under which conditions the diversion of resources from the contested sector to the uncontested sector could also lower the investments in unproductive guns in the long run.

APPENDIX

To check whether the critical points [18] and [19] constitute a Nash equilibrium I have to compute the Hessian matrices for both agents. Consider $W_1^g(G_1^g, G_2^{g*}, y_1^g, y_2^{g*})$ and eventually the Hessian matrix for agent 1 is given by:

$$H_1 = \begin{pmatrix} \frac{\partial W_1^g}{\partial G_1 G_1} & \frac{\partial W_1^g}{\partial y_1 G_1} \\ \frac{\partial W_1^g}{\partial G_1 y_1} & \frac{\partial W_1^g}{\partial y_1 y_1} \end{pmatrix} = \begin{pmatrix} -\frac{2^{(2b-1)/(b-1)}(b(1-q))^{1/(b-1)}}{TR(2b(1-q))^{1/(b-1)} - (1-q)^{1/(b-1)} - 1} & -\frac{(2b(1-q))^{1/(b-1)}}{TR(2b(1-q))^{1/(b-1)} - (1-q)^{1/(b-1)} - 1} \\ -\frac{(2b(1-q))^{1/(b-1)}}{TR(2b(1-q))^{1/(b-1)} - (1-q)^{1/(b-1)} - 1} & \frac{\binom{b-2}{1} \frac{1}{2^{(1-b)} b^{(b-1)} (b-1)}}{2^{(1-b)} b^{(b-1)} (b-1)} \end{pmatrix}$$

Let H_{1k} denote the k_{th} order leading principal submatrix of H_1 for $k = 1, 2$. The determinant of the k_{th} order leading principal minor of H_{1k} is denoted by $|H_{2k}|$. The leading principal minors alternate signs as follows: $|H_{11}| < 0 \Leftrightarrow TR > ((1-q)^{1/(b-1)} + 1)(2b(1-q))^{1/(1-b)}$ [A.1]

$$|H_{12}| > 0 \Leftrightarrow TR(b-1)(2b(1-q))^{\frac{1}{(b-1)}} < \left[\left((1-q)^{\frac{1}{(b-1)}}(2b-3) \right) / 2 \right] + b - 1 \quad [A.2]$$

As $TR \rightarrow \infty$ both A.1 and A.2 hold and $|H_1|$ is negative semidefinite. As $TR \rightarrow 1$, $|H_1|$ is negative semidefinite if and only if $2^{\frac{b}{(b-1)}}(b-1)[b(1-q)]^{1/(b-1)} + (3-2b)(1-q)^{1/(b-1)} - 2b < -2$.

Consider $W_2^g(G_1^{g*}, G_2^g, y_1^{g*}, y_2^g)$ and eventually the Hessian matrix for agent 2 is given by:

$$H_2 = \begin{pmatrix} \frac{\partial W_2^g}{\partial G_2 G_2} & \frac{\partial W_2^g}{\partial y_2 G_2} \\ \frac{\partial W_2^g}{\partial G_2 y_2} & \frac{\partial W_2^g}{\partial y_2 y_2} \end{pmatrix} = \begin{pmatrix} -\frac{2^{(2b-1)/(b-1)}(b(1-q))^{1/(b-1)}}{TR(2b(1-q))^{1/(b-1)} - (1-q)^{1/(b-1)} - 1} & -\frac{(2b(1-q))^{1/(b-1)}}{TR(2b(1-q))^{1/(b-1)} - (1-q)^{1/(b-1)} - 1} \\ -\frac{(2b(1-q))^{1/(b-1)}}{TR(2b(1-q))^{1/(b-1)} - (1-q)^{1/(b-1)} - 1} & \frac{\binom{b-2}{1} (b-1)(b(1-q))^{1/(b-1)}}{2^{(1-b)}(b-1)(b(1-q))^{1/(b-1)}} \end{pmatrix}$$

The leading principal minors alternate signs as follows:

$$|H_{21}| < 0 \Leftrightarrow TR > \left((1-q)^{\frac{1}{(b-1)}} + 1 \right) (2b(1-q))^{\frac{1}{(1-b)}} \quad [A.3]$$

$$|H_{22}| > 0 \Leftrightarrow TR > (b-1)(2b(1-q))^{\frac{1}{(b-1)}} + (1-b)(1-q)^{\frac{1}{(b-1)}} - b < -(3/2) \text{ [A.4]}$$

Also in this case, as $TR \rightarrow \infty$ A.3 and A.4 hold. As $TR \rightarrow 1$ $|H_2|$ is negative semidefinite if and only if $(b-1)(2b(1-q))^{1/(b-1)} + (1-b)(1-q)^{1/(b-1)} - b < -(3/2)$.

Finally, as the resources endowment goes to infinity the critical points $(G_1^{g^*}, G_2^{g^*}, y_1^{g^*}, y_2^{g^*})$ do constitute a Nash equilibrium. As the resources endowment goes to unity ($TR = 1$) conditions [A.2] and [A.4] must hold. Since A.2 is stricter than A.4 the condition for a Nash equilibrium becomes $\frac{b}{2(b-1)}(b-1)[b(1-q)]^{1/(b-1)} + (3-2b)(1-q)^{1/(b-1)} - 2b < -2$. That is, as the whole resources endowment decreases the room for a stable Nash equilibrium shrinks.

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