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# A Model of Conflict, Appropriation and Production in a two-sector economy

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# **A MODEL OF CONFLICT, APPROPRIATION AND PRODUCTION**

## **IN A TWO-SECTOR ECONOMY**

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**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 a 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:** 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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## I. INTRODUCTION

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* ». In many general equilibrium models following Hirshleifer (1988/1991),<sup>1</sup> a contestable output falls into a common pool available for seizure and appropriation. The chosen levels of resources invested exclusively in productive or unproductive activities determine the social outcome of a conflict. Hirshleifer's seminal work and following contributions 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 an extremely 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 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, there could be institutional factors protecting contracts and

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<sup>1</sup> In more recent years several studies extended Hirshleifer basic model. See among others: Grossman (1991), Grossman and Kim (1995), Skaperdas (1992), Neary (1997a), Anderton et al. (1999), Noh (1999), Garfinkel (2004), Dixit (2004), Caruso (2006/2007), Hausken (2004/2006), Munster (2007), Spolaore (2007). The literature on the economics of conflict has been recently surveyed in Garfinkel and Skaperdas (2007).

property rights. In fact, there could be sectors where enforcement of property rights can be more effective than others. However, the protection of property rights can exist without a government with a monopoly of violence. Even stateless societies have developed informal institutions able to enforce property rights assignments. These informal structures were related to some specific factors as kin-ties, cheap and available information, reputation and social capital. These institutions in many cases are able to cope with the problem of management of common resources avoiding the “tragedy of commons”, as noted in Collier and Gunning (1999). In brief, a first fruitful source to distinguish contested and uncontested sectors, can be referred to the separation between governance and government. Such a distinction has been recently emphasized in Dixit (2009).

Secondly, there could be geographical factors 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. Finally, there are economic reasons shaping the preferences set of actors involved and spontaneously identifying a boundary between contested and uncontested sectors. Some activities can become relatively more attractive than others so that unproductive efforts can be devoted to them. Whenever the expected

returns from appropriation and bloody rent-seeking are assumed to be greater than those attainable through investments in ordinary entrepreneurial businesses, a rational agent may divert its efforts and resources to them. Therefore, in such a scenario, some entrepreneurial activities can be interpreted as non-attractive from rational agents. Paradoxically, being less profitable and non-attractive some activities are more secure from appropriation.

A simple fitting example could be drawn from reality of many African developing countries which experience the sadly famous 'resource curse'. In particular, according to a paradigmatic sketch, 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 sectors (see among others Collier and Hoeffler 1998, Le Billon 2001a, De Soysa 2002, Fearon and Laitin 2003). 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.

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. Ross (2003/2007) compares the cases of Nigeria and Indonesia in this way, though his work lacks strong theoretical underpinnings. Among other factors, the author

maintains that in Indonesia the governments have been committed to support agricultural and manufacturing sectors. Instead Nigerian governments<sup>2</sup> 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.

The reliance upon some contested sectors is the case of other African developing countries descended to civil wars as – among others – Chad, Liberia, Uganda and Angola. (see respectively Johnston 2004, Deininger 2003, Le Billon 2001b, Malaquias 2001). To simply illustrate the point, table 1 reports sectoral contributions to gross domestic product (GDP) for Angola, Chad, and Nigeria. which are resource-dependent economies and are commonly included among countries affected by the *resource curse*. All of them are dependent upon oil, whereas Angola is also dependent upon diamonds. All of them experienced violent internal conflicts. In 2002, Angola’s long-running internal conflict between the ruling party the MPLA and UNITA ended (on Angola’s war economy see among others Ferreira, 2006). Chad, which is listed among the poorest countries in the world, experienced two civil war onsets, the first in 1965 and the second in 1994. Therefore, for sake of the argument, Though by no means a perfect proxy, consider the mining (Oil) sector as a first candidate to be the contested sector, and the manufacturing sector to be the uncontested sector. In the

**Table 1 – about here**

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<sup>2</sup> See also the account given by Omeje (2004).

These examples drawn from reality led easily to 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). For instance, the economies presented in Table 1 are characterized by dominance of contested butter, namely the Oil (or mining) sector, whereas a small manufacturing sector could be defined as the ‘ice-cream’.

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 very 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.

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 simply designed. In a first section, a basic model is presented. In a second section, the impact of different variables and parameters upon total production and total welfare are studied. In a third section, under some simplifying assumptions, 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.

## II. 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  $R_i \in (0, \infty), i = 1, 2$ . 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:

$$(1) \quad R_i = y_i + x_i + G_i, i = 1, 2$$

where  $G_i$  denotes the level of ‘guns’, and  $y$  and  $x$  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  $CY$  - can be described as a simple linear additive function:

$$(2) \quad CY = x_1 + x_2 = TR - G_1 - y_1 - G_2 - y_2$$

where  $TR = R_1 + R_2$  and  $TR \in [1, \infty)$ . 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 Function<sup>3</sup> (henceforth CSF for brevity) in its ratio form:

$$(3) \quad p_i(G_1, G_2) = G_i / (G_1 + G_2), i = 1, 2$$

The functional form adopted for CSF is a special case of the general ratio form of CSF  $b_i G_i^m / (b_1 G_1^m + b_2 G_2^m)$ ,  $m > 0, b_i > 0, i = 1, 2$  which is extensively adopted in literature. In our context, firstly agents are identical in fighting abilities ( $b_1 = b_2 = 1$ ). Moreover, the parameter  $m$  is set to unity,  $m = 1$ . This is a crucial assumption. In fact, the parameter  $m$  which is commonly referred as ‘decisiveness parameter’ or ‘mass effect parameter’ does capture to which degree fighting efforts are translated into probability of success. That is, whenever  $m < 1$ , it could be said that the CSF does exhibit decreasing returns in the technology of conflict. Whenever  $m > 1$ . Thus with  $m = 1$  it exhibits increasing returns to fighting. it could be said the CSF exhibits constant returns to fighting. Such assumption appears to be particularly fitting in our context.

Equation (3) is differentiable and follows the conditions below:

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

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<sup>3</sup>Selective 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).

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

$$(4) \quad S_i = p_i(G_1, G_2)\theta CY$$

Where  $\theta \in (0,1)$  denotes a physical destruction parameter. It can be interpreted as an ex-ante perception of destructiveness of conflict. That is, a conflict is twice costly. On one hand the amount resources allocated to ‘guns’ do constitute a deadweight loss for society because the same amount of resources could be allocated to more productive activities. On the other hand, in the case of actual violent conflicts there is a fraction of resources physically destroyed. In other words, the loss is not only what can be physically destroyed; it is also what agents could have produced in the way of useful goods and services. Given the analytical complexity, I shall assume for sake of simplicity that it is equal for both agents. As  $\theta$  increases, the conflict is perceived less and less destructive.

Equation (4) At the same time, the functional form of CSF adopted is also crucial with regard to the positivity assumption for guns. In fact, the ratio form of the CSF implies that if one of the two contestants does not allocate any resource to ‘guns’, the other party does appropriate all the contested output, namely  $p_i(G_i, 0) = 1, \forall G_i \in (0, \infty)$ . Then, either party would be likely to defect and invest any small positive magnitude in order to raise its fraction of the aggregate output from 50% to 100%, in order to appropriate all the joint contested output<sup>4</sup> defined by (2). Thus, if one agent chooses not to invest in ‘guns’, it will receive a zero payoff, while player 2 will receive the payoff full and *viceversa*. If ‘peace’ can be

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<sup>4</sup> Hirshleifer (1989, p. 105) also notes that the contested ‘prize’ must be larger than zero. “Then , assuming only that  $V > 0$  [where  $V$  is the value of the prize], under the Cournot assumption either player would be motivated to defect, since even the smallest finite commitment of resources makes the defector’s relative success jump from 50% to 100%.”.

defined as the condition in which  $G_1 = G_2 = 0$ , peace can never occur as an equilibrium under the ratio form of CSF. This is confirmed in Neary (1997b) which states “as long as a player cannot physically exclude her consumption expenditure from being part of the overall prize, this expenditure is at risk of loss to the other players, and the player is, however unwillingly, a part of the game”<sup>5</sup> That is, given the ratio form adopted for CSF, the positivity assumption for guns does capture the coerced participation in the conflict.

Given conditions (3.1) the fraction of contestable output accruing to agent  $i$  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. Therefore, the production function is a standard intensive production function which exhibits decreasing returns to scale:

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

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. It is trivial to say that  $Y(0) = 0, Y(\infty) = \infty, \partial Y / \partial y > 0, \partial^2 Y / \partial^2 y_i < 0$ , that

$$\partial Y_1 / \partial a > 0 \Leftrightarrow y_1 > 1, \partial Y_2 / \partial b > 0 \Leftrightarrow y_2 > 1.$$

The level of production in the uncontested sector can be simply denoted through  $UY = Y_1 + Y_2$ .

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<sup>5</sup> Neary (1997b) p. 378

Therefore, the final income of each agent can be described as a function of contributions of both sectors as  $W_i = f(Y_i, S_i)$ . Eventually, each agent maximizes an objective function as:

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

This kind of function can lead to ambiguous results. On one hand, 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 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:

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

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

The equilibrium level of ‘ice-cream’ is increasing in the degree of returns to scale,  $\partial y_1^* / \partial a > 0, \partial y_2^* / \partial b > 0$ . 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  $\partial y_i^* / \partial \theta < 0, i = 1, 2$ . A smaller degree of destruction implies fewer resources allocated to production in the uncontested sector. The equilibrium level of ‘guns’ is given by:

$$(8) \quad G_1^* = G_2^* = G^* = (TR / 4) - 2^{(2a-1)/(1-a)} (a / \theta)^{1/(1-a)} - 2^{(2b-1)/(1-b)} (b / \theta)^{1/(1-b)}$$

A necessary and sufficient condition to have an equilibrium for the solutions shown in (7.1), (7.2) and (8) is  $TR > (2a / \theta)^{1/(1-a)} + (2b / \theta)^{1/(1-b)}$ , namely  $TR > y_1^* + y_2^*$ . Note

that the level of guns is increasing in the destruction parameter,  $\partial G^* / \partial \theta > 0$ . Namely, the lower is the perceived potential destruction the higher is the investment in guns. Moreover it is clear that  $\partial G^* / \partial a < 0, \partial G^* / \partial b < 0$ . At the equilibrium the level of ‘butter’ is:

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

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

And it is possible to show that 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  $a \in (0,1)$ . The same applies with  $b$ , in fact  $\partial x_2^* / \partial b < 0$  and  $\partial x_1^* / \partial b > 0$  if and only if  $(1/\theta) > e^{1-(1/b)}/2b$ . This means that 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.

The level of butter of agent  $i$  is increasing in its own initial endowment and decreasing in the endowment of the opponent, namely  $\partial x_i^* / \partial R_i > 0, \partial x_i^* / \partial R_j < 0, i = 1, 2, i \neq j$ . Final incomes of both agents are given by:

$$(10.1) W_1^* = (\theta/4)TR + 2^{(2a-1)/(1-a)}(2-a)(a/\theta)^{a/(1-a)} - 2^{(2b-1)/(1-b)}b^{1/(1-b)}\theta^{b/(b-1)}$$

$$(10.2) W_2^* = (\theta/4)TR + 2^{(2b-1)/(1-b)}(2-b)(b/\theta)^{b/(1-b)} - 2^{(2a-1)/(1-a)}a^{1/(1-a)}\theta^{a/(a-1)}$$

Eventually, note that incomes of both agents are decreasing in both degrees of returns to scale under some conditions. Verify for agent 1 that  $\partial W_1^* / \partial a < 0 \Leftrightarrow (a-2)\ln(2a/\theta) + a - 1 > 0$ ,  $\partial W_2^* / \partial b < 0 \Leftrightarrow (b-2)\ln(2b/\theta) + b - 1 > 0$ , and  $\partial W_1^* / \partial b < 0, \partial W_2^* / \partial a < 0$ . Then, there is a combination of  $a$  and  $\theta$  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  $\partial W_1^* / \partial a < 0 \Leftrightarrow 0 < a < .24$ . That is, when the uncontested sectors exhibits a sufficiently low degree of returns, each agent would interpret the unproductive activities of conflict and appropriation as more profitable than ordinary business activity in the uncontested sector. In other words, 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 appears to be lower. This result opens 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.

To summarise, more precisely, 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; and its collateral (a.1) whenever the production of ice-cream exhibits sufficiently low productivity each agent will prefer to allocate fewer resources to the uncontested sector; (b) when the conflict is perceived to be non-destructive each agent has fewer incentives to allocate resources to the uncontested sector. Results (a) and its collateral (a.1) 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 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).

### III. 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:

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

First, the level of uncontested production is unambiguously larger than zero. Eventually it is worth noting that  $\partial UY^* / \partial a > 0 \Leftrightarrow \ln(2a/\theta) - a + 1 > 0$  and  $\partial UY^* / \partial b > 0 \Leftrightarrow \ln(2b/\theta) - b + 1 > 0$ . 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, the level of 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 arbitrarily  $\theta = .75$ , 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:

$$(12) \quad CY^* = x_1^* + x_2^* = (TR/2) - 2^{a/(1-a)} (a/\theta)^{1/(1-a)} - 2^{b/(1-b)} (b/\theta)^{1/(1-b)}$$

The level of contested production of butter is increasing in both the level of resources ( $\partial CY^* / \partial TR > 0$ ) and in the destruction parameter ( $\partial CY^* / \partial \theta > 0$ ). At

the same time it is decreasing in both  $a$  and  $b$ ,  $\partial CY^* / \partial a < 0$ ,  $\partial CY^* / \partial b < 0$ . The higher are the returns in the uncontested sector within the bounds  $(0,1)$  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 in the economy is simply given by the sum of (9.1) and (9.2)

$$(13) \quad TY^* = CY^* + UY^* = (TR/2) + \theta^{1/(a-1)}(\theta - a)2a^{a/(1-a)} + \theta^{1/(b-1)}(\theta - b)2b^{b/(1-b)}$$

Also in this case it is clear that  $\partial TY^* / \partial \theta > 0$ ,  $\partial TY^* / \partial TR > 0$ . Given the results presented above, it appears to be 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:

$$\partial TY^* / \partial a < 0 \Leftrightarrow (a - \theta) \ln(2a / \theta) + (a - 1)(\theta - 1) > 0 \text{ and}$$

$$\partial TY^* / \partial b < 0 \Leftrightarrow (b - \theta) \ln(2b / \theta) + (b - 1)(\theta - 1) > 0.$$

In fact, 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  $\theta$ . Total welfare is computed as the sum of attainable incomes:

$$(14) \quad TW^* = W_1^* + W_2^* = \theta(TR/2) + (1 - a)(2a / \theta)^{a/(1-a)} + (1 - b)(2b / \theta)^{b/(1-b)}$$

The level of total welfare is increasing in the level of resources  $\partial TW^* / \partial TR > 0$ .

Note also that  $\partial TW^* / \partial a > 0 \Leftrightarrow \ln(2a / \theta) > 0$  and  $\partial TW^* / \partial b > 0 \Leftrightarrow \ln(2b / \theta) > 0$ .

Therefore, as the conflict becomes less destructive the degrees of returns in the uncontested sector must be sufficiently high. Moreover, the level of total welfare is

increasing in  $\theta$  , unless the degrees of returns in the uncontested sector are large enough.

#### IV. 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 the previous section such a government clearly retains limited authority. The environment is quasi-anarchic. There is no monopoly of coercive power. In fact, both government and rival group are involved in a continuous conflict. By the use of force both agents shape the distribution of a contestable output. In fact, there is an uncontested sector where each agent can invest in the production of ice-cream which is secure from appropriation. The economy is somehow ‘dual’. The duality here is an asymmetry in the effectiveness of institutional settings. The government is ineffective in providing full contract enforcement in both sectors. As noted earlier, 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.

What is a point of interest here is whether or not there could be welfare-enhancing policies able to cope with such a scenario. Are there economic policies able to influence allocation of resources to butter, guns and ice-cream in the economy? In particular, given the results of the previous section, is subsidization of

ice-cream production to be suggested? In fact, since it has been maintained that higher returns in the production of ice-cream can offset the incentives to conflict, it is reasonable to study whether or not a public-funded subsidy can be beneficial in this respect.

Hence, consider the existence of a redistributive government. That is, in this economy the government can also impose a tax burden on the rival group. Then, assume that the government can impose a proportional tax rate on production in the uncontested sector. At the same time, the government can behave as a redistributive government and subsidize the rival group by means of redistribution of public funds. The government can be either benevolent or kleptocratic. This depends to what extent it does redistribute the tax burden to the rival group. Both the tax burden and the redistribution of income to favour the rival group do 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). In the first, the author shows that a too high tax rate imposed by the ruler would increase the probability of a successful insurrection. Albeit with a different technical approach and with no distinction between butter and guns, in the latter, the authors – under different scenarios - 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.

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  $a = b$ . Then, only notation  $b$  will be used. Furthermore, assume that both agents perceive the conflict as non-destructive, namely  $\theta = 1$ . 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. Moreover the redistribution is assumed to be proportional to the production of ice-cream of the rival group. The income functions for both agents become:

$$(15.1) \quad W_1^g = y_1^b + p_1(G_1, G_2)CY + ty_2^b - wy_2^b$$

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

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:

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

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

The second order conditions dictate the condition  $2^{b/(b-1)} TR(b-1)[b(1-q)]^{1/(b-1)} + (3-2b)(1-q)^{1/(b-1)} - 2b < -2$  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  $2^{b/(b-1)}(b-1)[b(1-q)]^{1/(b-1)} + (3-2b)(1-q)^{1/(b-1)} - 2b < -2$ .

It is clear that  $y_1^{g^*} > y_2^{g^*}$  for  $q > 0$ . 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, the rival group. The total production of ice cream is given by:  $UY^{g^*} = ((1-q)^{1/(b-1)} + 1)(2b(1-q))^{1/(1-b)}$ . The production of ice cream is decreasing in  $q$  and increasing in  $b$ . The equilibrium choices of guns are:

$$(17) \quad G_1^{g^*} = G_2^{g^*} = G^{g^*} = (TR/4) - b^{1/(1-b)}(B \cdot (1-q)^{1/(1-b)} + B)$$

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

$$(18) \quad TG^{g^*} = (TR/2) - b^{1/(1-b)}(2^{b/(1-b)}(1-q)^{1/(1-b)} + 2^{b/(1-b)})$$

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

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

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

Then the total contested production of butter is:

$$(20) \quad CY^{g^*} = (TR/2) - b^{1/(1-b)}(2B(1-q)^{1/(1-b)} + 2B)$$

Total contested production is increasing in  $q$ . By contrast, total contested production is decreasing in  $b$ ,

$$\partial CY^{g^*} / \partial b < 0 \Leftrightarrow b \ln(b(1-q)) + (1-q)^{1/(b-1)} (b \ln(b) - b + 1) - b + 1 < 0.$$

That is, there are combinations of  $b$  and  $q$  that make the total contested production increasing in the degree of returns to scale. Figure 1 depicts a parameter space  $(b, q)$  to show these combinations. 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.

**FIGURE 1 – ABOUT HERE**

Note that  $CY^{g^*} = UY^{g^*} \Leftrightarrow TR = b^{1/(1-b)} \left[ 3(2(1-q))^{1/(1-b)} + 3 \times 2^{1/(1-b)} \right]$ . 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:

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

Total production is increasing in  $b$  and it is decreasing in  $q$ . The latter states that 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:

$$(22.1)$$

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

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

The total welfare is the sum of (24.1) and (24.2):

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

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.

## V. COMPARATIVE STATICS

In this brief section, a comparison between the two scenarios is presented. By means of a traditional comparative statics, 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:

$$(24) TG^* = (TR/2) - (2b)^{1/(1-b)}$$

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:-

$$(25) TY^* = (TR/2) + 2^{1/(1-b)} b^{b/(1-b)} (1-b)$$

Comparing (25) and (21) it is possible to say that  $TY^* > TY^{g^*} \Leftrightarrow (1-q)^{1/(b-1)}(3b-2)+b < 0$ . In figure 2 all the points on the left of the curve denote the combinations of  $b$  and  $q$  that make total production higher in the first scenario. Note that 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.

**FIGURE 2 – ABOUT HERE**

Total welfare is given by:

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

Whereas in the first scenario total welfare is given by (14) with  $\theta = 1$  and  $a = b$ , and then by:

$$(27) \quad TW^* = (TR/2) + 2^{1/(1-b)} b^{b/(1-b)} (1-b)$$

Hence, using (28) and (29) it is possible to write that  $TW^{g^*} > TW^*$  if and only if:

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

That is, there are combinations of  $b, q$  and  $t$  that make total welfare higher in the presence of a redistributive government. In particular, for sake of simplicity, consider some arbitrary values for  $t$  in order to highlight the combination of  $b$  and  $q$  allowing for  $TW^{g^*} > TW^*$ . Figure 3 depicts a parameter space  $(b, q)$  to show these combinations for different arbitrary values of  $t$ .

### FIGURE 3 - ABOUT HERE

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 (30) 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.

It appears that when the degree of returns is low a scenario characterized by no government committed to redistribution could be considered desirable. Results show that it appears to be more peaceful (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 appears to occur 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 (30) 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 an scenario characterized by no taxation and no redistribution; (b) total production is higher in the first scenario whenever 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 first scenario, i.e. 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.*

## VI. DISCUSSION AND CONCLUSION

This paper was an attempt to examine the conflictual 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. This partly contrasts with the argument expounded in Tornell and Lane (1999) that analyses 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.

The emphasis on the impact of a superior productivity marks a difference with the argument developed in Baland and Francois (2000) where the authors 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.

Therefore, 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 affects 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, captured through the degree of returns to scale, this result unambiguously holds. This seems to recall the results expounded in Bates et al. (2002) whereas the authors maintain that violence albeit intrinsically unproductive and destructive can be organized and rendered a source of welfare. However, also in this case it is clear that the degree of returns to scale has a significant impact of

total production and total welfare. Whenever both agents are low-productivity agents total production is higher in the first scenario presented. 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 a crucial point and needs further investigation.

Consider a dynamic framework. It is commonly 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 this model 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 first the objective

function of agent 1 evaluated at critical points  $G_2^{s*}$  and  $y_2^{s*}$ , namely (omitting superscripts):

$$W_2^{gs}(G_1^{gs}, G_2^{gs}, y_1^{gs}, y_2^{gs}) = - \frac{[G_1(4G_1 - 3TR + 4y_1) - y_1^2(4G_1 + TR)](2b(1-q))^{b+1(1-b)} - ((1-q)^{b+1(1-b)}(2bG_1 - 2by_1^2) + 2by_1^2(q-1) + 2b(1-q)(G_1(4t-3) + TRt) - w(4G_1 + TR)(2b(1-q))^{(1-b)} - ((1-q)^{1(b-1)} + 1)(2bt(q-1) + w)]}{(4G_1 + TR)(2b(1-q))^{(1-b)} - (1-q)^{1(b-1)} - 1} \times (2b(1-q))^{(1-b)}$$

and the Hessian matrix for agent 1 after substituting also the critical values  $G_1^{gs*}$  and  $y_1^{gs*}$  is given by:

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

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:

$$(A.1) \quad |H_{11}| < 0 \Leftrightarrow TR > ((1-q)^{1/(b-1)} + 1)(2b(1-q))^{1/(1-b)}$$

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

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

$$2^{b/(b-1)}(b-1)[b(1-q)]^{1/(b-1)} + (3-2b)(1-q)^{1/(b-1)} - 2b < -2.$$

The Hessian matrix for agent 2 is given by:

$$H_2 = \begin{pmatrix} \frac{\partial W_2^{gs}}{\partial G_2 G_2} & \frac{\partial W_2^{gs}}{\partial y_2 G_2} \\ \frac{\partial W_1^{gs}}{\partial G_2 y_2} & \frac{\partial W_2^{gs}}{\partial y_2 y_2} \end{pmatrix} = \begin{pmatrix} -\frac{2^{(2b-1)/(b-1)}(b(1-q))^{1/(b-1)}}{TR(2b(1-q))^{1/(b-1)} - (1-q)^{1/(b-1)} - 1} & -\frac{(2b(1-q))^{1/(b-1)}}{TR(2b(1-q))^{1/(b-1)} - (1-q)^{1/(b-1)} - 1} \\ -\frac{(2b(1-q))^{1/(b-1)}}{TR(2b(1-q))^{1/(b-1)} - (1-q)^{1/(b-1)} - 1} & 2^{(b-2)/(1-b)}(b-1)(b(1-q))^{1/(b-1)} \end{pmatrix}$$

The leading principal minors alternate signs as follows:

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

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

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  $(b-1)(2b(1-q))^{1/(b-1)} + (1-b)(1-q)^{1/(b-1)} - b < -(3/2)$ .

That is, 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 its lower bound ( $TR = 1$ ) conditions (A.2) and (A.4) must hold.

Since A.2 is stricter than A.4 the condition for a Nash equilibrium becomes

$$2^{b/(b-1)}(b-1)[b(1-q)]^{1/(b-1)} + (3-2b)(1-q)^{1/(b-1)} - 2b < -2.$$

That is, as the whole resources endowment decreases the room for a stable Nash equilibrium shrinks.

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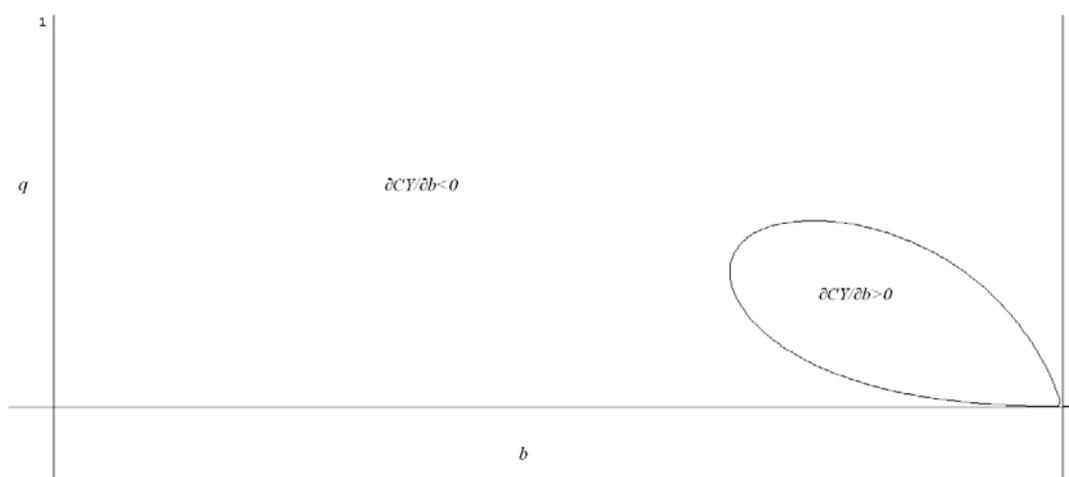
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**TABLE 1 - CONTRIBUTIONS TO GDP IN SELECTED COUNTRIES - VALUES EXPRESSED IN % -**

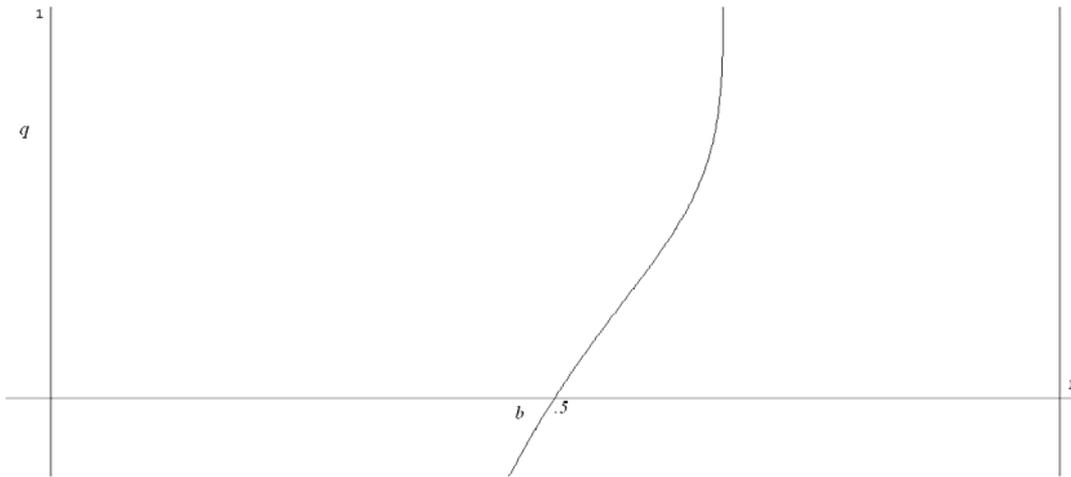
	Year	Agriculture	Manufacturing	Mining
<b>Angola</b>	<b>1995</b>	7.4	4.05	59.9
	<b>2006</b>	8	3.7	58.8
<b>Nigeria</b>	<b>1995</b>	32.34	10.2	40.2
	<b>2006</b>	33.11	3.52	39.5
<b>Chad</b>	<b>1995</b>	36.8	11.9	0.6
	<b>2006</b>	21.3	6.7	46.2

Source: Unctad

**Figure 1 – Contested Production and Return to Scale**



**Figure 2 - Comparative Statics in Total Production**



**Figure 3 - Total Welfare, Tax Burden and Redistribution**

