A Political Economy Application of the "Tragedy of the Anticommons":

The Greek Government Debt Crisis

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Abstract

The tragedy of the anti-commons unfolds when separate social agents—be they private owners of a property who intend to use the property for their own economic benefit or political actors who pursue their political objectives—do not hold effective rights to use their economic or political power for their own purposes without consent of the other players of the economic or political game. I shall discuss the Greek government debt crisis and the Eurozone countries' policies toward Greece within the analytical framework of the tragedy of the anticommons in this paper. I do not intend to dig deep into the structure and long-term trends of public and private finances in Greece. I shall only show that the successive bail-out programs of the Eurozone countries were doomed to fail because of these countries' "competitive" and non-cooperative approach to the Greek financial problems. I shall also show that a coordinating agency, say the IMF, can foster the coordinated outcome only under strict informational conditions.

Keywords: The tragedy of the anticommons; Non-cooperative games; The Eurozone
Jel Classification: D00 Microeconomic theory; F01 Globalization; K00 Law and Economics; P60 Interdependence, Systems, Sustainability

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Introduction

The tragedy of the anti-commons unfolds when separate social agents—be they private owners of a property who intend to use the property for their own economic benefit or political actors who pursue their political objectives—do not hold effective rights to *use* their economic or political power for their own purposes without the consent of the other players of the economic or political game. Tragedy of the anticommons is conventionally contrasted with the more familiar tragedy of the commons, in which multiple owners of a common-pool resource hold effective rights of use but not of *exclusion*, resulting in systematic resource over-utilization.[1] In the tragedy of anticommons resources will be systematically under-utilized.

The first papers on the anticommons problem were published in the 1990s[2] and they reached back to Ronald Coase's work on externalities and transaction costs.[3] These papers focused on the legal aspects of property utilization and explained the anticommons problem with the players' erroneous strategy formulation and with the substantial transaction costs that multiple players face in a competitive and non-cooperative environment. But it turned out fairly soon that the tragedy of the anticommons may also unfold by assuming fully rational players and zero transaction costs if the initial property rights of the interconnected players are not clearly defined. This important result contradicts to Coase's conclusion who argued that the efficient allocation of property rights can always be attained if transaction costs are close to zero.[4] Buchanan and Yoon (2000) presented a fairly simple but convincing example of the above assertion by demonstrating that in case two (or more) fully rational

[1] See, e.g., Hardin (1968), Ostrom (1990), and Ostrom et al. (1994).

[2] See, e.g., Heller (1998), (1999), Fennell (2011).

[3] Coase (1960).

[4] About the importance of transaction costs see also Williamson (1981).

economic actors require the consent of all other players in utilizing their own product or service and they uncooperatively set their commodity's price, the total price of the commodity will be higher and demand will be lower than the Pareto efficient outcome. Schulz, Parisi and Depoorter (2002), and Parisi, Schulz and Depoorter (2004) arrived at similar conclusions.

I shall discuss the Greek government debt crisis and the Eurozone countries' policies toward Greece within the analytical framework of the tragedy of the anticommons in this paper. I do not intend to dig deep into the structure and long-term trends of public and private finances in Greece. I shall only show that the successive bail-out programs of the Eurozone countries were doomed to fail because of these countries' "competitive" and non-cooperative approach to the Greek financial problems.

The structure of the paper is as follows: Then I present the main hypothesis and the motivation of the analysis in section 2. I shall demonstrate the tragedy of the anticommons and its analytical, modeling tools with two simple games in section 3. The first one is similar to the model Buchanan and Yoon (2000). The second one is an extended application of the double marginalization problem. The application of the anticommons framework to the Greek debt crisis and to the Eurozone countries' bail-out programs is given in Section 4. Conclusion is given in section 5.

Motivation: Does Competition Always Foster Efficiency?

The essence of the anticommons approach is that competition—so much cherished by our profession—does not always reap a Pareto-efficient allocation of the economic resources. If private property owners have the right of exclusion but not the right of autonomous use, cooperation rather than competition among them will result in a more efficient outcome.

The tragedy of the anticommons can be contrasted with the tragedy of the commons. As, for instance, Garrett Hardin (1968) demonstrated, if a property is publicly owned by multiple owners they will be tempted to overuse the property that will ultimately result in the property's depletion. But private ownership cannot guarantee the efficient use of a property either if the owners have limited rights of use of their property. (See, e.g. Heller (2013). Parisi et al. (2005), Vanneste et al. (2006), and Depoorter and Vanneste (2007) contrasted the tragedy of the anticommons with the tragedy of the commons by showing that we can expect under-utilization of capacities and excessive prices of the final products with the former while the opposite will occur if a tragedy of the commons unfolds. A well-known example of the tragedy of the anticommons is the case when an investor—be him private or public—plans to construct a highway and he needs the consent of a large number of estate owners along the highway's track. Producing and introducing new drugs in the pharmaceutical market also provide us with convincing examples. Assume that a pharmaceutical company needs to use several components to produce a new medicine that fights cancer, and those components have been developed by different patent holders. Then each patent holder will strive to push up his or her price for the patent—i.e., the patent holders engage in a "price-up" competition—that will ultimately result in too little production and in an excessive price of the new drug.

The successive sovereign debt crises of the Eurozone countries or in a broader framework, those of the members of the European Union (EU) also provide us with good and insightful examples of the anti-commons approach. We have chosen the Greek financial crisis to demonstrate how the analytical framework of the tragedy of the anti-commons can be applied to better understand why the efforts of the EU countries have reaped limited results.

Two Simple Models of the Tragedy of the Anticommons

Before advancing to the main issue of this paper, I shall outline two simple models of the anticommons just to demonstrate the logic of the anticommons approach.[5] First, assume that two countries construct a cross-border railway network to speed up the transportation process between them. Each country sets a unit price for transportation on the new network independent of what the other country charges for transportation services. Country 1 charges unit price p_1 while country 2's unit price is p_2. Any user of the railway network must pay the total price $p_1 + p_2$. I assume zero marginal and fixed costs of transportation in order to simplify the analysis. Total market demand for railway transport is given by:

$$Q = 1 - p_1 - p_2, \tag{1}$$

where Q is quantity of total transportation demand.

Each country will maximize its profits:

$$\pi_1(p_1, p_2) = Q \cdot p_1 = (1 - p_1 - p_2)p_1; \quad \pi_2(p_1, p_2) = Q \cdot p_2 = (1 - p_1 - p_2)p_2. \tag{2}$$

The first order conditions of profit maximization are:

$$\frac{\partial \pi_1(p_1, p_2)}{\partial p_1} = 1 - 2p_1 - p_2 = 0; \quad \frac{\partial \pi_2(p_1, p_2)}{\partial p_2} = 1 - p_1 - 2p_2 = 0. \tag{3}$$

From the first order conditions of the countries' profit maximization problem we have:

$$p_1 = \frac{1}{3}; \quad p_2 = \frac{1}{3}; \quad p = p_1 + p_2 = \frac{2}{3}; \quad Q = 1 - (p_1 + p_2) = \frac{1}{3}; \quad \pi_1 + \pi_2 = 2/9. \tag{4}$$

As can be easily seen from equation (4), country 1 and country 2 will equally earn 1/9 in terms of profits.

Should the two countries coordinate their pricing strategies and set a uniform price for transportation services, they could arrive at higher total profits while customers would pay a lower price for the service as shown below.

[5] The example follows the logic of Buchanan and Yoon (2000).

Proposition 1: *Had the two countries coordinated their pricing strategy by setting a single price p for the transportation service, the retail price of service would have been lower while the quantity demanded at that price would have been higher in the market, resulting in larger net benefits for all the players.*

Proof: *The countries maximize total profits from transportation services by finding the optimum price:*

$$\max_p \pi(p) = \max_p \{\alpha\pi_1(p) + (1-\alpha)\pi_2(p)\} = \max_p \{Q \cdot p\} = \max_p \{(1-p)p\}. \tag{5}$$

where $\alpha \in [0;1]$ *is country 1's share from total profit.*

From the first order condition of profit maximization we have:

$$\frac{d\pi(p)}{dp} = 1 - 2p = 0 \Rightarrow p = 1/2; \quad Q = 1/2; \quad \pi(p) = 1/4. \tag{6}$$

Comparing the results in equations (4) and (6) immediately shows that transport customers pay a lower price and the countries earn a higher profit in total with than without coordination.

The above result is a special application of the well-known prisoners' dilemma game. It shows that coordination sometimes results in larger benefits to all the participants of an economic or political game than competition.

The second example is about two pharmaceutical companies and two patent holders whose components are needed for the firms to produce and sell their drug in the retail market. I shall show that in case the pharmaceutical retailers compete in the market with substitute drugs, and they both use two different components to produce their drug, and those components are owned and produced by two different patent holders, a merger of the retailers—that is, less rather than more competition—already results in lower prices for consumers. If the patent holders merge it has no effect on prices. But in case the retailers and the patent holders also merge, the price of the drug will be even further reduced.

Assume that two firms produce and sell two different but substitute drugs—one of each—in the retail market. They both use the same two components that are owned by two different patent holders in producing their drug. The retailers do not incur costs others than paying a separate royalty fee to patent holder 1 and patent holder 2 after each unit of the drug sold. We denote these royalty fees w_1 and w_2. Retailer 1 charges the price r_1, while retailer 2 sets her price at r_2 for each unit sold. Patent holders 1 and 2 incur a unit cost (constant marginal cost) of producing the components for the drugs c_1 and c_2, respectively, plus the fixed cost of R&D in component development in the amount of F_1 and F_2, respectively. The demand functions for drug 1 and drug 2 are as follows:

$$q_1 = 1 - r_1 + ar_2 \text{, and } q_2 = 1 + ar_1 - r_2 \text{, respectively,} \tag{7}$$

where q_1 and q_2 denote the quantity sold from drug 1 and drug 2, while $a < 1$ is the parameter of substitution between the two drugs. Notice that I assumed the same "strength" of substitution for the two firms. Retailers maximize their profits:

$$\max_{r_1} \pi_1(r_1, r_2) = \max_{r_1} \{(1 - r_1 + ar_2)(r_1 - w_1 - w_2)\} \text{, and} \tag{8}$$

$$\max_{r_2} \pi_2(r_1, r_2) = \max_{r_2} \{(1 + ar_1 - r_2)(r_{2_1} - w_1 - w_2)\} \text{, respectively.} \tag{9}$$

The first order conditions for profit maximum are:

$$\frac{\partial \pi_1(r_1, r_2)}{\partial r_1} = 1 - 2r_1 + ar_2 + w_1 + w_2 = 0 \text{, and} \tag{10}$$

$$\frac{\partial \pi_2(r_1, r_2)}{\partial r_2} = 1 + ar_1 - 2r_2 + w_1 + w_2 = 0 . \tag{11}$$

Solving for r_1 and for r_2 we have:

$$r_1 = r_2 = \frac{1 + w_1 + w_2}{2 - a} . \tag{12}$$

Plugging the results from (12) back into equation in (7) obtains:

$$q_1 = q_2 = 1-(1-a)\left(\frac{1+w_1+w_2}{2-a}\right) = \frac{1-(1-a)(w_1+w_2)}{2-a}. \tag{13}$$

Demand facing each of the two patent holders is given by equations (12).

Patent holders also maximize profits:

$$\max_{w_1} \Pi_1(w_1, w_2) = \max_{w_1}\left\{\left(\frac{1-(1-a)(w_1+w_2)}{2-a}\right)(w_1-c_1)\right\}, \text{ and} \tag{14}$$

$$\max_{w_2} \Pi_2(w_1, w_2) = \max_{w_2}\left\{\left(\frac{1-(1-a)(w_1+w_2)}{2-a}\right)(w_2-c_2)\right\}, \tag{15}$$

where Π_1 and Π_2 denote the patent holders' profit. The first order conditions are as follows:

$$\frac{\partial \Pi_1(w_1, w_2)}{\partial w_1} = \frac{1-2(1-a)w_1-(1-a)w_2}{2-a} + \frac{(1-a)c_1}{2-a} = 0, \text{ and} \tag{16}$$

$$\frac{\partial \Pi_2(w_1, w_2)}{\partial w_2} = \frac{1-(1-a)w_1-2(1-a)w_2}{2-a} + \frac{(1-a)c_2}{2-a} = 0. \tag{17}$$

Solving the first order conditions obtains:

$$\begin{aligned} &-1+3(1-a)w_1-2(1-a)c_1+(1-a)c_2 = 0 \Rightarrow \\ &\Rightarrow w_1 = \frac{1}{3(1-a)} + \frac{2c_1-c_2}{3} \text{ and } w_2 = \frac{1}{3(1-a)} + \frac{2c_2-c_1}{3}. \end{aligned} \tag{18}$$

Using the results from (18) we have:

$$q_1 = q_2 = \frac{1}{3(2-a)} - \frac{(1-a)(c_1+c_2)}{3(2-a)}, \text{ and} \tag{19}$$

$$r_1 = r_2 = \frac{1}{2-a} + \frac{2}{3(1-a)(2-a)} + \frac{(1-a)(c_1+c_2)}{3(2-a)} = \frac{5-3a+(1-a)(c_1+c_2)}{3(1-a)(2-a)}. \tag{20}$$

Substituting the results from (17) into equations (12) we have:

$$q_1 = q_2 = \frac{1}{3(2-a)} - \frac{(1-a)(c_1+c_2)}{3(2-a)}, \text{ and} \tag{21}$$

$$r_1 = r_2 = \frac{1}{2-a} + \frac{2}{3(1-a)(2-a)} + \frac{(1-a)(c_1+c_2)}{3(2-a)} = \frac{5-3a+(1-a)(c_1+c_2)}{3(1-a)(2-a)}. \tag{22}$$

If the two retailers merged, the new firm would face demand $q = 1 - r$; and it would maximize profits $\pi(r) = (1-r)(r - w_1 - w_2)$. The monopoly's price and quantity sold would become:

$$r = \frac{1 + w_1 + w_2}{2}; \quad q = \frac{1 - (w_1 + w_2)}{2}. \tag{23}$$

Plugging the expression of q from (23) into the patent holders' profit function obtains:

$$\Pi_1 = \left(\frac{1-(w_1 + w_2)}{2}\right)(w_1 - c_1) - F_1; \text{ and } \Pi_2 = \left(\frac{1-(w_1 + w_2)}{2}\right)(w_2 - c_2) - F_2. \tag{24}$$

From the first order conditions of profit maximum we have:

$$w_1 = \frac{1 + 2c_1 - c_2}{3}, \text{ and } w_2 = \frac{1 + 2c_2 - c_1}{3}. \tag{25}$$

Ultimately, the drug's retail price and quantity will be:

$$r = \frac{2 + c_1 + c_2}{3}, \text{ and } q = \frac{1 - (c_1 + c_2)}{3}. \tag{26}$$

Comparing r in (26) and $r_1 = r_2$ in equation (22) shows that the retail price of the merged firm will be lower than the retail prices of the two competing drugs, if:

$$\frac{2 + c_1 + c_2}{3} < \frac{5 - 3a + (1-a)(c_1 + c_2)}{3(1-a)(2-a)} \Rightarrow 1 + 3a - 2a^2 \geq (1-a)^2(c_1 + c_2). \tag{27}$$

Since the left-hand side of the equation is always non-negative for $a < 1$, and it is larger than 1 for any $0 < a < 1$, while the right-hand side will be smaller than 1 for any realistic values of $c_1 + c_2$, the equation in (27) will always hold. Consequently, the merged firm sells the drug at a lower price and it sells a larger quantity than the competing retailers.

If the merged retailer also merges with the patent holders, then the new firm's profit will be:

$$\Pi = (1-r)(r - c_1 - c_2) - F_1 - F_2. \tag{28}$$

The first order condition of profit maximum immediately yields:

$$r = \frac{1 + c_1 + c_2}{2}, \text{ and } q = \frac{1 - (c_1 + c_2)}{2}. \quad (29)$$

The fully merged firm's price will be lower and the quantity sold will be larger than with separate patent holders if: $c_1 + c_2 < 1$, a condition that will always be satisfied. We can summarize the above results in proposition 2.

Proposition 2: I*f firms compete in a* "*downstream*" *and also in an* "*upstream*" *market their profit maximizing outcome will be less efficient than in case the firms in both markets cooperated.*

Proof: *The proof of Proposition 2 is given in equations* (27) *and* (29) *above.*

Now we turn to our main question about the Greek government debt crisis and the bail-out program of the Eurozone countries: could it have reaped better results than what actually occurred?

The Greek Government Debt Crisis as Tragedy of the Anticommons

The literature on the Greek financial crisis would fill libraries so we do not discuss its reasons and potential impacts on the EU in this paper.[6] We focus on one issue only: how much does it cost to the Eurozone countries to save Greece from total financial collapse if they can agree on a joint bail-out plan or in case they cannot.

Greece accumulated a substantial government debt that amounted to 130% relative to GDP in 2010, to 148% in 2011, and its debt relative to GDP hiked to 177% in 2012. It decreased then to 156.9% in 2013, due to the government's effort to meet the conditions of the IMF and the EC.[7] The remaining sixteen member countries of the Eurozone agreed to contribute to a financial assistance package for Greece in 2010. The Eurozone countries demanded that Greece implemented an austerity program along with a comprehensive structural reform of its government finances. Two additional bail-out plans have followed since, without great success. Greece obviously strived for receiving maximum financial assistance for the "price" (effort) it had to pay in terms of austerity measures, while the donor countries had two options to choose from: they could either cooperate in designing a bail-out plan, or they could individually decide how much they were willing to contribute to the Greek financial assistance package and under what conditions. We exclude the possibility that the Eurozone countries would let Greece down, for the risk of the European Union's disintegration would largely increase and that would be too high a cost for them to pay.

[6] See, for instance, Haidar, J. I. (2012), Krugman, P. (2011), *Financial Times* (2012), OECD (2012).

[7] Source: *Eurostat* (2014).

First, we discuss the case when the donor countries set the effort level they demand from Greece in return to their assistance separately, without coordination. We can safely assume that Greece's demand for the amount of financial assistance is a decreasing function of the effort it has to pay for the Eurozone countries' help. We also assume that the donor countries maximize the net benefit of helping Greece. Finally, we assume that the lower the amount of financial assistance the larger the risk of future disintegration of the EU becomes. We can model the "game" among the donor countries under the above conditions.

Let F^{NC} denote the amount of total financial assistance from the donor countries with no coordination, and e_i the "price" (effort) country *k* charges for its contribution. Let Greece's demand for assistance from country *k* be:

$$f_k^{NC} = a_k - b_k e_k \tag{30}$$

where f_k^{NC} is the financial assistance from country *k* when the donor countries do not coordinate the assistance program, and a_k and b_k are parameters. (a_k may denote a fraction of Greece's total government debt, while b_k can be a country specific indicator, for instance, the country's size, or another indicator of its "economic and political strength", with $\sum_{k=1}^{n} b_k = 1$.)

Then Greece's total demand for assistance facing the donor countries is:

$$F^{NC} = A - \sum_{k=1}^{n} b_k e_k \tag{31}$$

where $A = \sum_{k=1}^{n} a_k$ is Greece's total government debt.

If country *i*'s net benefit from helping Greece is given by:

$$w_i^{NC} = F^{NC} e_i - C_i(f_i^{NC}) = \left(A - \sum_{k=1}^{n} b_k e_k \right) e_i - C_i\left(a_i - b_i e_i\right), \tag{32}$$

where w_i^{NC} is a welfare function of country *i* and $C_i(f_i) = C_i\left(a_i - b_i e_i\right)$ is the country's cost of extending financial assistance to Greece. In order to avoid tedious algebra I assume that the cost function is linear in e_i and given as $c_i\left(a_i - b_i e_i\right)$. The donor countries maximize their net benefit, thus the effort level each donor country can get from Greece can be derived from:

$$\max_{e_i}\left\{w_i^{NC}\right\} = \max_{e_i}\left\{\left(A - \sum_{k=1}^{n} b_k e_k \right) e_i - C_i\left(a_i - b_i e_i\right)\right\}. \tag{33}$$

The first order conditions of the system of equations in (33) yield:

$$e_i = \frac{F^{NC}}{b_i} + c_i, \quad i = 1,\ldots,n. \tag{34}$$

Substituting the above result back into Greece's demand function for assistance given by equation (31) we have:

$$F^{NC} = \frac{A}{n+1} - \frac{\sum_{k=1}^{n} b_k c_k}{n+1}. \tag{35}$$

The "price" (effort) Greece must pay for assistance will be as follows:

$$E^{NC} = \sum_{k=1}^{n} b_k e_k = \frac{n}{n+1} A + \frac{\sum_{k=1}^{n} b_k c_k}{n+1} \tag{36}$$

where the left hand side denotes the total (weighted) effort required from Greece.

If we assume that the donor country's "investment costs" with regard to Greece's bail-out program are non-linear[8], say, the cost functions are quadratic in f_i^{NC}:

[8] The reviewer of my manuscript suggested that I should use non-linear cost functions in the analysis of the Greek bail-out program. I shall show below that assuming a non-linear rather than linear cost function would not alter the main conclusions of the paper.

$$C_i\left(f_i^{NC}\right)=\frac{\left(a_i-b_ie_i\right)^2}{2}, \qquad (37)$$

the first order conditions of welfare maximization would become:

$$e_i=\frac{F^{NC}+a_ib_i}{b_i\left(1+b_i\right)}, \quad i=1,\ldots,n, \qquad (38)$$

while the Eurozone countries' total financial assistance, and Greece's total effort would be:

$$F^{NC}=\frac{A-\sum_{k=1}^{n}\frac{a_kb_k}{\left(1+b_k\right)}}{1+\sum_{k=1}^{n}\frac{1}{\left(1+b_k\right)}}, \qquad (39)$$

$$E^{NC}=\sum_{k=1}^{n}b_ke_k=\frac{A\left(\sum_{k=1}^{n}\frac{1}{\left(1+b_k\right)}\right)+\sum_{k=1}^{n}\frac{a_kb_k}{\left(1+b_k\right)}}{1+\sum_{k=1}^{n}\frac{1}{\left(1+b_k\right)}}. \qquad (40)$$

Comparing the Results of the Eurozone Countries' Non-Coordinated Actions to a Coordinated Approach

Now we turn to the case when the Eurozone countries coordinate their assistance program. The effort level they require from Greece will be identical across countries and we shall denote it E^C. Greece's demand for assistance then becomes:

$$\sum_{k=1}^{n}f_k^C=F^C=\sum_{k=1}^{n}\left(a_k-b_kE^C\right)=A-E^C \qquad (41)$$

where f_k^C and F^C denote country *k*'s financial assistance and total financial assistance, respectively, with coordination among the donor countries.

From the welfare maximization problem of the donor countries—that act now as a "monopoly"—we have:

$$E^C = \frac{A}{2} + \frac{\bar{c}}{2n} \tag{42}$$

where $\bar{c} = \sum_{k=1}^{n} b_k c_k$ denotes the donor countries' average cost of granting financial assistance to Greece. Plugging the above result back to Greece's demand for the total amount of financial assistance yields:

$$F^C = \frac{A}{2} - \frac{\sum_{k=1}^{n} b_k c_k}{2n}. \tag{43}$$

We shall derive the results with the countries' non-linear cost function as before. Now the net benefit from coordinated assistance will be:

$$W(E^C) = (A - E^C)E^C - \frac{(A - E^C)^2}{2}. \tag{44}$$

From the first order condition of maximizing $W(E^C)$ we immediately have:

$$E^C = \frac{2A}{3}, \text{ and } F^C = \frac{A}{3}. \tag{45}$$

Based on the above results we can formulate the following proposition.

Proposition 3: *If the Eurozone countries unilaterally and non-cooperatively decide about their contribution to the Greek assistance program, Greece must pay a higher price for a smaller amount of assistance than in case the donor countries cooperated in designing the Greek bail-out plan. The donor countries would also have attained higher welfare with than without cooperation. These results hold under general conditions, too, for instance, when the donor countries have non-linear cost functions.*

Proof: *It can be immediately seen from comparing* F^{NC} *in equations* (35) *and* (39), *and* F^{C} *in equations* (43) *and* (45), *moreover* $E^{NC} = \sum_{k=1}^{n} b_k e_k$ *in equations* (36) *and* (40), *moreover* E^{C} *in equations* (42) *and* (45) *that total financial assistance will be smaller, while the price Greece must pay for the assistance will by higher without than with cooperation among the donor countries if* $n > 1$. *By substituting these results in the donor countries' welfare maximization problem yields lower welfare to these countries without than with cooperation. Q.e.d.*

Finally, we need to address the question how would the donor countries' behavior change if a coordinating agency – say, the International Monetary Fund (IMF) – became a part of the negotiations on the Greek bail-out program among the countries.[9] The answer to this question is far from being obvious. We need to consider two options. Assume that the coordinating agency is capable of and it actually does calculate the optimal level of total financial assistance to Greece, also each donor country's individual contribution, and Greece's optimum level of effort. In the first case we need to assume that the coordinating agency is capable of negotiating with all the donor countries and with Greece so that all information of the negotiations immediately becomes common knowledge among all participating countries. Then we can expect that the coordinated outcome of the countries' game will occur.

In the second case, however, when all the countries have complete information about the negotiations but their information is not common knowledge among the participants, the donor countries will be tempted to free-ride on one another. Notice that the efficient level of Greece's effort is a "public good" for the donor countries now. To demonstrate this hypothesis assume that a coordinator signs an agreement with Greece how much effort that

[9] The reviewer of my paper suggested that I should address this case, too, for which and I am grateful to her/him.

country will exert (“supply”) at different levels of the donor countries’ financial assistance. Greece’s supply of effort is given by:

$$E = \sum_{i=1}^{n} f_i \tag{46}$$

The donor countries will individually find the optimum level of their financial support by solving

$$\max_{f_i} \left\{ \frac{\sum_{i=1}^{n} f_i}{n} - \left(\sum_{i=1}^{n} f_i \right) f_i - c_i f_i \right\} \tag{47}$$

where $\frac{\sum_{i=1}^{n} f_i}{n}$ is country i’s valuation of Greece’s effort and $\left(\sum_{i=1}^{n} f_i \right) f_i + c_i f_i$ is the country’s cost of extending financial support. From the first order conditions of (47) we get:

$$F = \sum_{i=1}^{n} f_i = \frac{1 - \sum_{i=1}^{n} c_i}{n+1} = E \text{, and } f_k = \frac{1}{n(n+1)} + \frac{\sum_{i=1}^{n} c_i - (n+1)c_k}{n+1} \quad k = 1,\ldots,n\,. \tag{48}$$

Comparing the results in equation (48) and in equations (42) and (43) it immediately obtains that both financial support and Greece’s effort will be lower now than if the donor countries coordinated. If Greece’s effort is a public good we face a “tragedy of the commons”.

Conclusions

We can conclude the above analysis that by applying simple tools of economics and game theory we were able to demonstrate the strength and applicability of the tragedy of the anticommons’ analytical framework: the bail-out programs of the Eurozone countries can easily fail if the countries pursue their own, uncoordinated strategies in assisting Greece or other troubled countries. The donor countries will require too high an effort from, and provide insufficient financial help to the recipient country that just maintains and exacerbates the problem of its government debt.

In case, a coordinating agency joins the negotiations among Greece and the donor countries the outcome of their “game” will strongly depend on the information structure of the game. If all information of the negotiations is common knowledge among the participants and the coordinating agency can enforce their agreement we can expect that the coordinated solution will unfold that I demonstrated above. However, should the participants possess only complete information but no common knowledge about their negotiations the outcome of their game will easily become a “tragedy of the commons”.

The analysis can be extended in several directions. We can incorporate the issues of moral hazard with regard to financial assistance, and we can transform the above model into a dynamic one that analyses the effects of uncoordinated or coordinated efforts of the donor countries on a longer time horizon.

With moral hazard, the donor countries possess only imperfect information about Greece’s effort to implement its economic reform program. They may be able to induce high effort from Greece but external conditions may undermine its endeavor. If we take moral hazard into account, it exacerbates the negative effects of the donor countries’ uncoordinated actions: Greece and the donor countries would be even worse off than with perfect information among the “players”.

The outcome of the game would considerably change if the countries played it in a dynamic framework. Then both the donors and Greece could learn from previous experience and send signals to each other about expected future behavior. As in a dynamic prisoners’ dilemma, donor countries would opt for coordinated action that would result in higher payoffs for everyone.

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