

INEFFICIENCY IN THE FACE OF RATIONALITY: HOW GAME THEORY CAN INFORM ECONOMIC POLICY

BY GRELLAN MCGRATH

Senior Sophister

‘A rational man often bases his move on fact, not emotion. Paradise Island often turns out to be volcanic as on closer inspection.’

Robert J. Ringer

In a well structured and easy to understand paper, Grellan McGrath lays out the application for Game Theory in formulating economic policy. He gives examples of quite topical issues such as debt forgiveness and Common Fisheries policies.

Introduction

It has been said of game theory that its greatest contribution to economics is its ability to give some explanation as to how intelligent people can produce ludicrous outputs. In fact, this is very close to the truth: it is precisely through game theory’s ability to show how rational players can arrive at remarkably inefficient outcomes that it can inform economic policy. The spectrum of policies which game theory can influence now is much broader than even its founding fathers could have imagined in the 1940’s and 50’s: from wage negotiations to monetary policy, the auctioning of broadcasting rights to cross-jurisdictional tax harmonisation.

This paper examines three macroeconomic examples of how the simplest games can inform even global scale economic policies. Specifically, the success of games in trade and tariff negotiations, sovereign debt, and the rationing of natural resources will be seen. In each of these models we shall see how comparing the inefficient predictions of game theory to the socially optimal outcomes can inform economic policy. Of course it would be naïve to suggest that game theory is perfect, and as such some of its current limitations will be considered.

It is the contention of this paper that through models, which explain how inefficient equilibria can arise if rational players are left to their own devices, game theory has had an increasingly integral role to play in the formulation of economic policy.

Game Theory in Trade and Tariff Negotiations

One of the simplest examples of how game theory can inform economic policy-making has broad implications in the realm of international trade negotiations. Here a non-cooperative game is examined which clearly shows the benefits of free trade and cooperation among governments.

This game has two identical countries; $i=1,2$. Each has (i) a government which chooses a tariff; t_i (ii) a firm producing output for both home consumption and export; $q_i = h_i + e_i$ and (iii) consumers who buy on the home market either from the home or foreign firm; total quantity on the market in country i is $Q_i = h_i + e_j$.

For the first move in the game the governments simultaneously choose tariffs t_1 and t_2 . These are observed by the firms who then simultaneously choose quantities (h_1, e_1) and (h_2, e_2) . The payoff to firm i is given by its profit function. The payoff to the government is given by total welfare to the country, which is the sum of consumer surplus enjoyed in i , profit earned by firm i , and tariffs collected from firm j .

Equilibrium is found for this game by backwards induction. First find firm i 's best response (h_i^*, e_i^*) in terms of chosen tariffs, then maximise the payoffs for the government with respect to t_i . The equilibrium outcome of the game is:¹

$$(t_1^* = t_2^* = \frac{(a-c)}{3}, h_1^* = h_2^* = \frac{4(a-c)}{9}, e_1^* = e_2^* = \frac{(a-c)}{9})$$

In order to evaluate this outcome it is important to see what it would have been without any government tariffs. The most suitable comparison to make is with that of Cournot equilibrium in which

$$q_1^* = q_2^* = \frac{(a-c)}{3} \text{ in each market.}^2$$

Without tariffs total quantity on each market is $\frac{2(a-c)}{3}$. With tariffs,

total quantity on each market is $\frac{5(a-c)}{9}$. So we can see that consumer surplus is reduced when governments choose their Nash Equilibrium tariffs. In fact the

¹ For a fuller mathematical derivation of this equilibrium, see Gibbons (1992). For our purposes however, it is sufficient just to know the rules and outcome of the game.

² For a complete derivation of Cournot equilibrium see Tirole (2000). Again, it is sufficient here just to know that this outcome will be reached.

socially optimal tariffs are $t_1=t_2=0$ because they solve the first order conditions for maximizing welfare across both countries.

By comparing the inefficient outcome predicted by non-cooperative game theory to the socially optimal one, we are informed that the best economic policy when it comes to trade negotiations is that of free trade. This is consistent with history, which correlates times of highly-protectionist policies with times of depression such as the period following World War I. Institutions such as the World Trade Organisation and Free Trade areas, which facilitate lowering of tariffs are also consistent with policy recommendations arising from game theory.

Sovereign Debt: An example of Credibility

Bulow and Rogoff³ use the tool of game theory to evaluate potential policy alternatives for dealing with the developing countries' debt problem. Traditional theory says a country makes repayments on its debt in order to preserve reputational "collateral" needed for future borrowing. Using a simple model however, the authors find that any contract based solely on reputation must have some state of nature in which the country will default, and by doing so they would have strictly higher consumption in each future period by using short-term "cash in advance" contracts. This means there is no punishment for default available in infinitely repeated games between debtor and creditor countries.

In order to give some credibility to their promise to repay, lending to LDC's must be supported by direct costs which lenders can impose on a country in the event of a default. This could be the ability to impede its trade or seize its financial assets abroad.

The policy implication reached is that debt forgiveness schemes will not adversely affect LDC's future access to world capital markets by hurting their reputations, since loans must be able to be re-enforced by punishments. Thus debt-forgiveness is advocated by game theory. This is an example of how the issue of credibility of threats and promises in games of incomplete information can inform policy.

Policies in the Economics of Natural Resources

One of the games with the most rustic roots has got important ramifications in international economic negotiations about the allocation of scarce resources: the

³ Bulow and Rogoff (1989)

‘problem of the commons’ which was first expressed in terms of common pastures in old English villages. A simplified two-period model of the game is as follows:

Suppose there is a common property resource of size y . Each of two players can withdraw an amount c_1 or c_2 in period 1. When combined consumption is less than y the remaining amount [$y_1 - (c_1 + c_2)$] forms the base resource for future consumption.

Since there are no more periods left after period 2, each player would like to consume as much as possible in that period, hence the total (period 2) amount is divided amongst them. Each gets

$$\frac{y - (c_1 + c_2)}{2}$$

Now for period 1 reaction functions are derived:

$$R_1(c_2) = \frac{(y - c_2)}{2} \quad \text{and} \quad R_2(c_1) = \frac{(y - c_1)}{2}$$

$c_1^* = c_2^* = \frac{y}{3}$ is the Nash equilibrium.

In order to find the socially optimal levels we shall assume (for simplicity) that the Von Neumann Morgenstern utility function is of logarithmic form, i.e. if player 1 consumes c_1 , his utility from doing so will be taken to be $\log c_1$. A pattern of consumption (\hat{c}_1, \hat{c}_2) is socially optimal if it maximises the sum of the players’ utilities:

$$\hat{c}_1 = \hat{c}_2 = \frac{y}{4}$$

If the Nash equilibrium predicted by the game is compared to the socially optimal outcome, we see that rational players can reach an inefficient outcome and have an over-extraction of the resource, known as a ‘tragedy of the commons.’

There are many examples of common property resources in the world today. Perhaps one of the most topical is that of international waters and who has the right to how many fish in them (the Common Fisheries Policy is currently under re-negotiation in the EU). Levhari and Mirman were the first to look at this issue from

a game theoretical perspective.⁴ They created a two-country dynamic model in which they reasonably assume the object of each country is to maximise the sum of discounted utilities and the welfare of its citizens. This model takes into account (i) the strategic aspect of the participants' actions and (ii) the fact that the underlying fish population is decreased by harvesting but has a limited ability to replenish.

Levhari and Mirman derive a Cournot-Nash equilibrium and the corresponding steady state quantity of fish (i.e. the equilibrium size of the fish population in a dynamic sense). They then compare this to the optimal outcome where both countries form a cooperative venture and pool their resources. They find that Cournot-Nash policies imply a greater harvest of fish and therefore a smaller steady state than socially optimal. In fact the fish population may even tend to zero. This is consistent with the predictions of our simple model. By combined management, the two countries will consume, for each level of the population of fish, smaller quantities, but will be able to achieve a higher "permanent" catch.

Thus the obvious policy implication for economics of natural resources is that international cooperation and pooling of resources will have greater long-term benefits than short-term maximisation of harvestation quotas. Again this is an example of how policy recommendations can be reached by comparing the predictions of non-cooperative game theory models to socially optimal outcomes.

Limitations

While the three games and their applications looked at are persuasive examples of how game theory can inform economic policy, it would be somewhat incomplete not to allude to the current limitations of the discipline. It's not within the scope of this paper to give a full description of the deficiencies of game theory, so instead Kreps' ⁵ limitations will be outlined. Firstly, game theorists unquestioningly accept exogenous rules, whose origins are vague at best. Secondly, in many games, multiple equilibria arise and we have no way of telling which will dominate. This is a contentious issue, which is shown in the application of the theory to time-consistent monetary policy.⁶ Thirdly, it is not often taken into account the extent to which the rules that prevail are influenced by outcomes. Are they manipulated to get the desired outcomes, or perhaps to be 'predicted' by history?

⁴ Levhari and Mirman (1980)

⁵ Kreps, (1990)

⁶ For a treatment of this issue see Rogoff, R. "Reputation, Coordination and Monetary Policy" in R. Barro, ed., *Modern Business Cycle Theory*. Cambridge, Mass.: the Harvard University Press, 1989 pp. 236-64

When looking at these and other criticisms, the relative youth of game theory must be remembered: Its formal beginnings are accredited to Von Neumann and Morgenstern in 1944, and it lay relatively idle until the 1970's. In fact when this is taken into account, it could be said that game theory has made remarkable advances in credibility and adaptability, as testified by the range of applications examined.

Conclusion

In this paper we have looked at just three of the innumerable examples of how game theory can inform economic policy. In the case of sovereign debt we saw how notions of credibility in threats and promises lead to an endorsement of debt-forgiveness schemes. In our other examples we saw how even simple models can be adapted to be useful in global economic policy contexts such as trade negotiations and the allocations of commonly owned international resources. On the basis of these models, I believe we can conclude that the most effective way in which game theory can inform economic policy is to show us how rational players can logically reach inefficient equilibria, and allow us to compare these equilibria to more socially desirable outcomes, which would arise under the correct economic policies.

References

- BULOW, J. AND ROGOFF, K.**, (March 1989), 'Sovereign Debt: Is to Forgive to Forget?' *The American Economic Review*, Vol. 79, pp. 43-50.
- DUTTA, P.K.**, (1999) *Strategies and Games* Cambridge, Mass.: The MIT Press.
- GIBBONS, R.**, (1992), *Game Theory for Applied Economists* Princeton, NJ: Princeton University Press.
- HEY, J.D.**, (1991) *Experiments in Economics* Oxford: Blackwell.
- KREPS, D.**, (1990), *Game Theory and Economic Modelling* Oxford: Oxford University Press.
- LEVHARI, D. AND MIRMAN, L. J.**, (Spring 1980) "The Great Fish War: an Example using a Dynamic Cournot-Nash Solution," *Bell Journal of Economics*, Vol.11, pp.322-334
- RASMUSEN, E.**, (1989), *Games and Information: An introduction to game theory* New York: Basil Blackwell.
- TIOLE, J.**, (2000) *The Theory of Industrial Organization*, Cambridge, Mass: The MIT Press.