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Russell W. Cooper

Dans Revue d'économie politique 2005/4 (Vol. 115), pages 379 à 390
Éditions Dalloz

ISSN 0373-2630
DOI 10.3917/redp.154.0379

Article disponible en ligne à l'adresse
https://www.cairn.info/revue-d-economie-politique-2005-4-page-379.htm

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Economic Policy in the Presence of Coordination Problems

Russell W. Cooper*

This paper discusses the conduct of government policy in coordination games. In economic situations with multiple equilibria, government intervention may be valuable to overcome coordination problems and to internalize externalities. Yet, the design of optimal interventions is made more difficult by the presence of strategic complementarities and multiple equilibria.

coordination games - economic policy - multiple equilibria

Politique économique en présence de problèmes de coordination

Cet article analyse la politique gouvernementale en présence des jeux de coordination. Dans les situations économiques avec équilibres multiples, l'intervention du gouvernement peut être nécessaire pour dépasser les problèmes de coordination et internaliser les externalités. Cependant, la définition des interventions optimales est rendue plus difficile par la présence des complémentarités stratégiques et des équilibres multiples.

jeux de coordination - politique économique - équilibres multiples

Classification JEL : C71, H11, E12

1. Motivation

This paper considers the conduct of economic policy in the presence of strategic complementarities and multiple equilibria. As highlighted in Cooper and John [1988], the existence of strategic complementarities in the choices of individual agents is present in many interactions. The presence of complementarities can lead to inefficiencies and, in the extreme, coordination failures and thus a rationale for intervention. The actions of a government may influence the selection of an equilibrium and the level of economic activity as well. So, it is natural to consider economic policy and multiplicity jointly.

But, determining optimal government policy in the presence of multiple equilibria is quite difficult due to problems in identifying structural para-

* Department of Economics, University of Texas, Austin, TX 78712, cooper@eco.utexas.edu. The research assistance of Shutao Cao is gratefully acknowledged as is support from the National Science Foundation.

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meters and in designing optimal policy when there are multiple Nash equilibria for a given policy. Here we formalize these issues and problems. In the context of the example of bank runs, we argue that policy interventions may allow researchers to resolve an important identification problem and thus distinguish shocks to fundamentals from variations in confidence.

To many economists, strategic complementarities are present in many economic and social interactions\(^1\). On the social side, the languages we speak, our driving conventions, the bars, beaches and restaurants we choose to frequent, fashions, etc. are all driven by the presence of complementarities which lead us all, in effect, to “do what others are doing”. In economics, the demand for fiat money, returns to effort and education, return to investment, the decision on bank deposits, the expectations we hold, the tax rates we face, the prices we set, the structure of markets have all been viewed from the perspective of strategic complementarities\(^2\).

All of these interactions seem to generate plausible environments where complementarities exist and multiple, Pareto-ranked equilibria become possible. Further, ample experimental evidence of coordination games suggests that in the presence of multiple equilibria, it is not the case that the Pareto-superior Nash equilibrium is naturally selected. Thus the potential for coordination failure, defined as the selection of the Pareto-inferior equilibrium, is certainly quite real. If so, there are clearly social gains to coordinating on the Pareto-superior equilibrium and to other interventions needed to internalize external effects.

To formalize these ideas, the next section of the paper provides a brief review of coordination games. We then turn to the design of government policy in this environment with particular emphasis on estimation of structural parameters and identification problems.

### 2. Coordination Games: An Overview

To fix the terminology, consider the following game in which there are two players and each can choose either a high or low level of effort.

<table>
<thead>
<tr>
<th>Coordination Game</th>
</tr>
</thead>
<tbody>
<tr>
<td>high effort</td>
</tr>
<tr>
<td>high effort</td>
</tr>
<tr>
<td>low effort</td>
</tr>
</tbody>
</table>

Assume that \(x \in \{0,1\}\) and \(y \in \{1,2\}\). With these restrictions, this game exhibits strategic complementarity in that the gains from high effort, say by

\(^1\) The next section briefly reviews these concepts.
\(^2\) Numerous examples along these lines with references are provided in Cooper [1999].

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the row player, are increasing in the effort level of the column play: \(2 - y > 0 > x - 1\). Further, there are two pure strategy Nash equilibria: one in which both agents choose high effort and a second in which both choose low effort. Further, these equilibria are Pareto-ranked. The outcome in which all agents select low effort is termed a coordination failure. While both agents realize that the outcome with low effort is socially undesirable, neither, acting alone, can do anything about it.

Though variations in the parameters \((x, y)\) within the limits set above have no effect on the set of equilibria, there are some arguments that link \((x, y)\) to the selection of an equilibrium. Carlsson and van Damme [1993] consider an incomplete information version of a coordination game in which the values of \((x, y)\) influence which of the Nash equilibria of the game with complete information is the unique equilibrium of the game with incomplete information.

A final comment on the number of players is in order. There is a more general version of the basic coordination game in which there are \(N\) players, where \(N\) can be very large. In one interpretation, all of the players are selecting low or high effort levels as in the game above. In that case, one can think of the columns as indicating the choice of \(N - 1\) players and the row showing the choices of a single player. The outcomes in which all players choose high effort and all choose low effort are clearly Nash equilibria of the game with \(N\) players.

An alternative setting is one in which there are many interlinked games between pairs or small numbers of players. These small groups can be linked by the presence of some players in multiple groups with payoffs which are additive across the groups. These players choose a single action which is their strategy for each of the games in which they are involved. Here there is again the possibility of coordination failure.

Not surprisingly, coordination games have been studied in experimental economics. This experimental evidence, summarized in Cooper [1999], indicates that play does ultimately evolve to one of the Nash equilibria. But, the Nash equilibrium selected is not necessarily the Pareto-dominant Nash equilibrium. Instead, coordination failures appear.

### 3. Economic Policy

This section consider government interventions in economies with multiple equilibria. What does the presence of multiple equilibria imply for economic policy? How can policy interventions be used to internalize the externalities inherent in coordination games?

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3. To be more precise, they consider a class of 2x2 coordination games and introduce incomplete information about payoffs. They argue that as the amount of noise about payoffs vanishes, the equilibrium outcome in the game of incomplete information is the risk dominant equilibrium of the game with complete information.
Intuitively, there are two rationales for interventions in coordination games. First, there is the selection issue: government can help to overcome coordination problems by taking actions which support play at the Pareto-superior Nash equilibrium. Second, government actions may help to internalize external effects and thus increase social welfare. This is easier said than done since the design of economic policy in an environment with multiple equilibria can be quite challenging.

To study these issues, we first introduce government policy into the coordination game. We then study the design of government policy.

3.1. Government Policy in a Coordination Game

We study a more general version of a coordination game and then add in government intervention. Let the payoff of an individual agent be given by $$\sigma(e, E; X, \Theta)$$ where $$e$$ is the agent’s action, $$E$$ is the common action of others and $$X$$ is common shock. Let $$\theta$$ represent the vector of parameters characterizing payoffs.

Given the actions of others and the realized value of $$X$$, denote the (assumed) unique optimal response of a player by $$e = \phi(E; X, \Theta)$$. The derivative $$\partial e / \partial E = \phi'_E (E; X, \theta)$$ characterizes the response of a single agent to a change in the common action of the others. In this example, $$\phi'_E (E; X, \theta) > 0$$ is the case of strategic complementarity.

The set of symmetric Nash equilibria is defined by $$\xi(X, \Theta) = \{e | e = \phi(e; X, \Theta)\}$$.

This set may not be unique due to strategic complementarity.

To consider government policy in this model, we assume that the government can commit to an intervention denoted $$\Pi(E, X)$$. By assumption, there is no commitment problem here as the government moves before private agents. Further, note that the government’s action depend on $$E$$ rather than $$e$$. Thus the government’s behavior reflects the aggregate effort variable and not the choice of a single agent.

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4. This section draws upon Chari, Kehoe, and Prescott [1989] and Chapter 7 of Cooper [1999].

5. For simplicity, all actions are scalars and payoffs are given only for the case of a common action by all others, denoted $$E$$. More generally, $$E$$ would be a vector of actions of the other players.

6. See Cooper and John [1988] for a discussion of the link between strategic complementarity and multiplicity. If there is strategic substitutability, $$\phi'_E (E; X, \theta) < 0$$ then multiple symmetric Nash equilibria will not arise though there may be multiple asymmetric Nash equilibria.

7. So, by assumption, we can focus on the interaction of the players through $$\sigma(e, E; X, \Theta)$$ rather than on a commitment problem of the government.

8. Here we are focusing on symmetric outcomes by private agents. More generally, the government rule depends in general on the fractions of agent’s choosing different actions. The key is that an individual cannot influence the government’s choices.

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Given the government policy, we can define the set of Nash equilibria as

$$\xi(\mathcal{X}; \Theta, \Pi(\cdot)) = \{e | e = \phi(e; \mathcal{X}, \Theta), \Pi(\cdot)\}.$$ 

Here the government’s policy rule is indicated explicitly as part of the best response function of the private agent and in the set of equilibria. Note that the set of equilibria reflects two types of interactions. First, there are the interactions between private agents which were present in the initial game. Second, the form of the government policy introduces another dependence of $e$ on $E$.

The government intervention may take two forms. First, in equilibrium the government might be actively involved through taxation, subsidies, spending, etc. Second, the government may be indirect through various forms of guarantees and promised actions. In this case, the government may be inactive in equilibrium though its policy may have real effects by influencing payoffs out of equilibrium.

Recall the bi-matrix game. Suppose that the government wishes to support the equilibrium in which all agents supply high effort. To do so, it might subsidize effort levels so as to increase the return to high effort. Of course, these subsidies would have to be financed by some form of taxation and this would be taken into account in the welfare analysis of the policy. This is a type of direct intervention in that, in equilibrium, the government would be taxing and subsidizing.

Alternatively, suppose that the government had a policy in which it offered a subsidy to a group agents who chose high effort when other agents chose low effort. The policy could be structured so that in the event all agents chose high effort, the government had no obligation. If the subsidy was larger than $1 - x$, then high effort is a dominant strategy for each agent. In this case, the low effort equilibrium is eliminated as high effort becomes a dominant strategy. Yet, in the high effort equilibrium, the government is inactive.

This second type of government policy is a type of confidence building measure. These policies can have real effects in coordination games as these interventions influence payoffs that agents receive off of the equilibrium path. So in equilibrium the government appears to be doing nothing even though its policies matter.

### 3.2. Optimal Government Policy

We can now state the optimization problem faced by the government. Denote the payoff of the representative agent as $V(\mathcal{X}; \Pi(\cdot), \Theta) = \mathbb{E}_{\pi \in \xi(\mathcal{X}; \Pi(\cdot), \Theta)} \sigma(e, e; \mathcal{X}, \Pi(\cdot), \Theta)$. Here the expectation is over the set of equilibria induced by the policy.

9. Alternatively, the function $\Pi(\mathcal{E}, \mathcal{X})$ could be implicit in $\phi(e; \mathcal{E}, \Theta)$.

10. This is the source of the idea that in some cases government policy can itself induce strategic complementarity.

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The government sets $\Pi(\cdot)$ to max $V(X; \Pi(\cdot), \Theta)$. This optimization problem is not trivial for a number of reasons.

First, as with any government policy decision, knowing the underlying parameters of the economy is necessary. That is, what is $\Theta$? The estimation of $\Theta$ is made more difficult by the presence of multiple equilibria.

Second, as is clear from the definition of $V(X; \Pi(\cdot), \Theta)$, for a given government policy, there may be multiple equilibria. In this case, the government is assumed to impose a distribution on the equilibrium outcomes given its policy. This may be viewed as a sunspot process which is imposed on the set $\xi(X; \Pi(\cdot), \Theta)^{11}$.

Importantly, with this formulation the government may choose a policy which induces multiple equilibria. Whether it wishes to or not depends on the severity of the coordination problem and the costs of obtaining a unique equilibrium. Looking again at the bi-matrix coordination game. If the government can costlessly remove the low effort equilibrium, then clearly it will choose to do so. But if elimination of the low effort equilibrium is costly, thus reducing the payoffs in the remaining equilibrium, then the government may in fact allow the multiplicity to remain as long as the probability of the low effort equilibrium is sufficiently low$^{12}$.

The next sections discuss these issues in turn. Here we draw on specific examples in the literature on coordination games$^{13}$.

4. Estimation of $\Theta$

In this section, we discuss the estimation of $\Theta$ when complementarities are present and can be strong enough to create multiple equilibria. We illustrate this by discussing two areas of applied research on complementarities, one related to social interactions and the second associated with technological complementarities.

The main message here is that structural parameters can be identified. In fact, it might even be that identification is helped along by the presence of non-linearities which underlie the multiplicity of equilibria.

4.1. Social Interactions: The Reflection Problem

In many settings, we can imagine that the behavior of individuals depends on the actions of others. The nature and strength of those interactions are

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11. Part of the government policy may itself try to influence this selection process through cheap talk.
12. More concretely, deposit insurance may eliminate bank runs but the adverse incentive effects on banks and depositors may outweigh the gains to eliminating strategic uncertainty.
13. Some of this discussion draws heavily on Cooper [2002]
important for how we think about social outcomes and give advice on various forms of social policy.

For example, school performance by one student may well depend on the behavior of a reference group of other students, as well as observable variables (such as school characteristics, the characteristics of the reference group, individual income, parent's education). Or, the likelihood that an individual may engage in criminal activity could depend on the choices made by his friends (reference group) as well as other social and income variables characterizing the individual and the reference group.

In formalizing these types of interactions, Manski [1993] assumes that individual behavior is given by:

$$y = \alpha + \beta E(y|x) + z\eta + \mu. \tag{1}$$

Here $y$ is an individual outcome and $E(y|x)$ is the outcome for the reference group where $x$ refers to the group of agents who influence the individual. This statement of the problem ignores the influence of exogenous aspects of a reference group on individual behavior. As discussed in Manski [1993] and Brock and Durlauf [2004], inclusion of these interactions exacerbates the identification problem. The exogenous variables are represented by $z$ and $\mu$ is a shock to the individual outcome. The issue here is identification of the interaction between the group and the individual. This interaction is parameterized by $\beta$. Can we identify this parameter?

To solve for the equilibrium of the interactions between the agents, one can compute $E(y|x)$ yielding

$$E(y|x) = \frac{\alpha}{1 - \beta} + E(z'|x) \frac{\eta}{1 - \beta} \tag{2}$$

using $E(\mu|x) = 0$. Substitution into (1) implies

$$y = \frac{\alpha}{1 - \beta} + E(z'|x) \frac{\beta\eta}{1 - \beta} + z\eta + \mu. \tag{3}$$

From this regression, there are three parameters to estimate ($\alpha, \beta, \eta$) and three reduced form coefficients are estimated. Thus we can identify $\beta$ if the regressors, $(E(z'|x), z')$, are linearly independent. This means that there must be sufficient individual variation relative to the group.

This depends, in turn, on group formation. To gain information about interactions, there must be some variations in individuals within a reference group. Thus the formation of reference groups becomes an important element of the identification discussion.

Section 6 of Durlauf [2000] contains a lengthy discussion of this and related identification issues. As discussed there, it may be possible to identify interactions if there are other sources of exogenous variation. Further, the above formulation is linear yet many models of interactions rely on nonlinearities as a basis for the multiplicity of equilibria. Durlauf [2000] and Brock and Durlauf [2000] argue that these nonlinearities may actually help identification of model parameters.
4.2. Technological Complementarities

In macroeconomics, one of the more convenient specifications for interaction between agents is through the production technology\(^{14}\). This formulation can easily be placed inside of the standard stochastic growth model.

Here we start with a production function (in logs) for an individual production site augmented by the aggregate level of output.

\[
y_t = \alpha_n n_t + \alpha_k k_t + \phi Y_t + a_t
\]  

[4]

Here \(Y_t\) is output of "reference group", \(y_t\) is the output of an individual producer and \((n_t, k_t)\) are the inputs of labor and capital. The parameter \(\phi\) here is like the \(\beta\) in (1) as it parameterizes the interaction between a single producer and the aggregate economy. If \(\phi > 0\), then the high levels of aggregate activity increase the productivity of an individual producer.

Assuming that the technology shocks \((a_t)\) are common to the producers, it is natural to look at a symmetric equilibrium in which \(y_t = Y_t\). Using this condition, (4) becomes

\[
y_t = \frac{\alpha_n}{1 - \phi} n_t + \frac{\alpha_k}{1 - \phi} k_t + a_t
\]  

[5]

This expression is analogous to (3). But, there are two important differences. First, in (5) there are only two reduced form coefficients to identify three parameters. Second, there is good reason to think that the regressors are correlated with the productivity shock, \(a_t\).

As in Baxter and King [1991] and Cooper and Johri [1997], one way to overcome the identification problem is to impose constant returns to scale in the producers own inputs, \(\alpha_n + \alpha_k = 1\). With this restriction, all the structural parameters are identified.

As for the correlation of inputs with \(a_t\), the usual approach is to find instruments which imply movement along the production surface for fixed technology. Instruments, such as monetary policy innovations as well as sectoral variations, have been used.

There seems to be some evidence of technological complementarities. For example, Cooper and Johri [1997] estimate contemporaneous and dynamic complementarities and find significant interactions of both forms\(^{15}\).

Alternatively, if the null model has sunspot driven fluctuations, then these variations are enough to identify the production function parameters. In this

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\(^{15}\) Dynamic complementarities link the productivity at a plant in period \(t\) with lagged aggregated economic activity. Cooper and Johri [1997] impose CRS and estimate the contemporaneous complementarity at 0.24 and the dynamic effect at 0.32.
sense, the multiplicity may aid rather than impede identification if these sunspots can be used as instruments.

5. Government Policy: Source or Solution to Multiplicity?

Suppose that we have identified $\Theta$. The issue for the government is then to formulate an optimal policy given that for some choices of $\Pi(\cdot)$ there may be multiple equilibria. So the government is interested in choosing $\Pi(\cdot)$ to maximize $V(X; \Pi(\cdot), \Theta)$.

5.1. A Selection Process

Recall that the $V(\cdot)$ function includes an expectation over the equilibrium set. Where does this expectation come from?

One approach which has been used in the literature is to assume there is a process which assigns non-negative probabilities to each element of the equilibrium set. This assignment of probabilities might reflect the view, for example, that the selection of an equilibrium reflects the theme of Pareto-dominance. In that case, only the Pareto-dominant Nash equilibrium would have a positive probability associated with it. Or the assignment of probabilities might reflect the concept of risk dominance which, as discussed by Carlsson and van Damme [1993], has some attractive properties.

Once a selection principle has been established, then a sunspot variable with the required distribution can be used to represent the uncertainty over the equilibrium outcomes. So, for each choice of $\Pi(\cdot)$, social welfare, represented by $V(X; \Pi(\cdot), \Theta)$ is well defined.

5.2. Creating or Destroying Multiplicity

The interaction between policy and multiplicity is complicated by the fact that the set of equilibria reflects $\Pi(\cdot)$ in a couple of ways. The government’s policy may create multiple equilibria or destroy some of the equilibria.

16. The reader though might object as this begs the question of identifying sunspots. On this point, there is a sense that distinguishing sunspots from real shocks may be difficult, as discussed in Kamihigashi [1996].
First, as noted earlier, some economic policies actually create a basis for multiplicity. A well-known example arises from the Laffer curve in which a government seeks to raise a fixed amount of revenue.

As a simple example, suppose the government has to raise per capita revenues of \( G \) from a tax on output \( \tau \). Private agents have access to a technology which allows them to produce consumption goods from labor time. The utility function is given by \( U(c) - g(n) \) where \( U(.) \) is strictly increasing and strictly concave and \( g(.) \) is strictly increasing and strictly convex. In the presence of government taxation, the budget constraint of an agent is \( c = A(n(1 - \tau)) \) where \( A \) is a productivity parameter. The first order condition for the agent is \( A(1 - \tau) U'(A(1 - \tau)n) = g'(n) \) implying a decision rule of \( n(\tau) \). Assuming that substitution effects dominate, \( n(\tau) \) is a decreasing function.

The government's budget constraint is \( G = A\tau N \) where \( N \) is the level of labor input by the representative agent. In equilibrium \( n(\tau) = N \) so that the condition for equilibrium becomes

\[
G = A\tau n(\tau) \quad [6]
\]

This equation can have multiple solutions; i.e. there may exist multiple values of \( \tau \) which solve (6). For example, if \( U(c) = c \) and \( g(n) = \frac{n^2}{2} \) then \( n(\tau) = A(1 - \tau) \) and (6) becomes \( G = A^2 \tau (1 - \tau) \). So one possible equilibrium has high tax rates and low economic activity and another has low tax rates and high economic activity. Absent a commitment by the government, there are multiple equilibria in this interaction between private agents. In a similar vein, some monetary policy rules have been shown to be the source of multiplicity as well.

Second, the government could take actions which would eliminate the multiplicity. These interventions often take the form of government guarantees.

A leading example of this is deposit insurance. Absent incentive problems, deposit insurance provides a guaranteed return to agents and thus eliminates bank runs. In this case, the government can have huge effects by acting on agents beliefs without being active in equilibrium. Of course, the government policy must be credible for it to have these effects.

18. In this example, if \( G = 0 \) so that \( \tau = 0 \), there is no interaction between agents.
19. On this important consideration, see Benhabib, Schmitt-Grohe, and Uribe [2001].
20. It is not obvious this is always the best policy. At least in principle, the actions which eliminate the multiplicity may be so distortionary that private agents are better off dealing with strategic uncertainty.
5.3. Government Policy and Identification Revisited

A final view of government policy and multiplicity comes from the challenge in distinguishing models driven by fundamental shocks from those driven by expectations alone. An example is the study of the Great Depression by Cooper and Corbae [2001] where sunspot driven variations of beliefs by private agents on the returns to intermediation are the source of fluctuations in aggregate activity. Yet, another model might generate similar fluctuations in activity from fundamental shocks to the intermediation process.

So, are the fluctuations driven by expectations or fundamentals? This becomes an identification problem since there is a problem estimating the variance of the fundamental shock and the parameters determining the complementarity between agents and the sunspot process\(^{21}\).

One resolution of this identification problem might rest in examining the response of economy to certain forms of government intervention. Consider the effects of deposit insurance. To a large degree, the deposit insurance eliminates the runs equilibrium, leaving the no-runs equilibrium intact. So, in equilibrium, there are no runs and the government is inactive. Yet, there was an effect through confidence of the government policy.

Contrast this with a model in which fluctuations are driven by fundamentals. In that case, it seems that the effects of the deposit insurance will be different since the fundamental shocks do not disappear when deposit insurance is introduced. Instead, the influence of these shocks reappear in other aspects of the economy.

To be sure, working this out requires a model of fundamentals and deposit insurance. The point of the discussion is simply to say that perhaps the response of the economy to some forms of government intervention may be quite revealing about the underlying sources of fluctuations.

6. Conclusion

This paper studies government policy in a world of multiple equilibria. From the outset, it is quite natural to study government interventions in a setting with coordination failures since there are welfare gains from well-formulated policy.

Yet, the existence of multiplicity produces additional problems for the design of optimal policy. These range from the difficulty of identifying parameters in the presence of complementarities to the selection of an equilibrium given government policy.

\(^{21}\) Kamihigashi [1996] discusses this point in the context of the stochastic growth model.
There is a positive side to the discussion here as well. For researchers studying models with complementarities, there is also the possibility that government policy interventions may actually help identification.

References


COOPER, R. [1999], Coordination Games: Complementarities and Macroeconomics. Cambridge University Press.


KAMHIHIGASHI, T. [1996], “Real Business Cycles and Sunspot Fluctuations are Observationally Equivalent”, Journal of Monetary Economics, 37, 105-17.


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