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ARBITRAGE AND POLICY RULES

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ABSTRACT

Macroeconomic policy is not a financially isolated process; markets exist that generate profits contingent on policy outcomes, including the possibility that the government reneges. This in turn influences expectations about monetary policy. We combine a game of time (in)consistent monetary rules with the no-arbitrage paradigm common to the financial analysis of markets. Commitment is shown to be facilitated through the relation between the no-arbitrage condition for markets and incentive-compatibility in games of strategy.

ARBITRAGE AND POLICY RULES

The question of rules versus discretion in macroeconomic policy games hinges on the analysis of the incentive-compatibility of rules that constrain policy-makers' actions in the presence of shocks. In particular, incentive-compatibility (truth-telling) problems are often associated with the announcement of forecasts of these shocks by policy-makers. For example, Andersen (1986) demonstrates that there exist situations in which the incentive compatibility of announcements holds for rules under asymmetric information, and is violated for announcements and rules given full information. From a game-theoretic perspective this is not surprising; results that are difficult to achieve under conditions of complete information can often be supported as equilibria when (even a little) information asymmetry is introduced into the game.[1]

At issue, then, is what kind of institution creates the type of information externality that will make announcements incentive-compatible under a rules regime? This is similar in spirit to Taylor's (1983: 125) assertion that the macroeconomic situation ought to be no different from, "other well-recognized time inconsistency situations, (where) society seems to have found ways to institute the optimal policy." The institution we posit as a natural solution to the incentive-compatibility problem is financial market-making. The general idea is that macroeconomic policy is not a financially isolated process; markets will be created to generate profits that are contingent on policy outcomes, including the possibility that the government reneges. Examples include ERM

[1] See, for example, Kreps and Wilson (1982), Roberds (1987), Petith (1988) and Osborne and Rubinstein (1994, exercise 28.2).

cross-rate options (Campa and Chang 1996) and CPI futures (Cowen 1997).

In a policy game framework these and other forms of market-making are based on the credibility of monetary policy, and in turn impose the well-known financial criteria of no-arbitrage on the policy outcomes.[2] In other words, when financial markets are built around policy outcomes, the analysis becomes intrinsically financial, in which case the no-arbitrage paradigm comes into play. The key to our analysis is the link between the no-arbitrage condition for financial markets and incentive-compatibility in games of strategy. Specifically, the no-arbitrage solution for games of strategy developed by Nau and McCardle (1990,1991) is based on incentive-compatibility conditions that are not normally present in either Nash or Stackelberg equilibria. Moreover, this theoretical orientation agrees with recent empirical tests of credibility which are based upon the existence (or lack thereof) of arbitrage opportunities in financial (or index) markets. Arbitrage-based tests have been conducted for monetary policy (King 1995) and exchange rate regimes (Campa and Chang; Holden and Vikoren 1996).

The policy game

Consider a model of policy making such as that given by Andersen (1986,1988) and Canzoneri (1985) where real output growth (q) is determined by the natural rate, $\bar{q}$, and unanticipated inflation:

(1) $q = \bar{q} + (\pi - E[\pi])$

[2] Related phenomena include 'Fed watching' and secrecy (Goodfriend 1986; Balke and Haslag 1992; Cosimano and Huyck 1993; Arce 1997a) and policy-based market making in the sense of Shiller (1993), Walsh (1997) and Wohl (1997).

The rate of inflation is given as:

(2) $\pi = g + s$

where: g is the growth rate of money, and

s is a nominal shock/state variable (e.g. velocity) that can take on two values, $s_2 > s_2$.

The private sector's wage/price strategy is structurally equivalent to the expected rate of inflation, π^e, and its reduced-form payoff function is $-(\pi-\pi^e)^2$. The analysis presented in the majority of macropolicy games typically does not differentiate between beliefs and strategies in a strict game-theoretic sense, hence, in Eq.(1) it is assumed that $E[\pi] \equiv \pi^e$. In our analysis, however, it will be important to distinguish between π^e -- the strategy formulated in the price-setting sector, and $E[\pi]$-- the mean public expectation faced by the policy-maker, because the latter includes the expectations generated in financial markets. In equilibrium they will coincide.

The policy-maker's strategy is to choose money supply growth, g, to minimize deviations from its target output rate, q*, and price stability, $\pi^* = 0$. In state 's' its payoff function is given as:

(3) $$U_s(g, \pi^e) = -\frac{\alpha_1}{2}(q-q^*)^2 - \frac{\alpha_2}{2}\cdot\pi^2 \; ; \; \alpha_1,\alpha_2 > 0; \; s \in \{s_1,s_2\}$$

Consider the case where there is full information about shock term 's,' and the policy-maker operates under the following rule:

(4) $g = \pi - \sigma$

where σ is the policy-maker's declaration of the shock.

This setup allows for ex-post verification of adherence to the state-contingent rule, but not ex-post control of the policy-maker. In this context, Andersen (1986) provides the following result:

Proposition: Given the assumption $E[\pi] \equiv \pi^e$, truthful information disclosure is not incentive-compatible for state s_2 ($\sigma_{S_2} \neq s_2$) under the growth rule in Eq.(4) if:

$$(5) \qquad s_2 - s_1 < 2 \cdot (q^{*} - \bar{q})$$

If the marginal output gains from reneging dominate the range of the shock, truthful announcements are not incentive-compatible. Indeed, the lack of incentive-compatible announcements is endemic in the literature.[3]

Arbitrage considerations

As is pointed out by Waller (1987), a conceptual problem with this and similar policy analyses is that it is not a legitimate game between the policy-maker and the private sector because the two do not actually interact strategically. As such, attempts have been made to include explicit strategy choices by the private sector. Another alternative is to introduce rational observers (Holly 1987), who do not participate directly in the game, but whose expectations are nonetheless part of the public expectations the policy-maker faces.

It is interesting to note that this latter approach is precisely the point of view taken by Nau and McCardle's (1990,1991) no-arbitrage characterization for games of strategy.

[3] See Canzoneri (1985) and Andersen (1989) for the case of asymmetric information, Stein (1989) for the case of cheap talk, and Arce (1997a) for the case of finite, but indeterminant, rounds of costless communication.

Specifically, for <u>any</u> game that can be associated with market-making on the outcome, there exists an underlying arbitrage game in which outside observers attempt to make profits off the actions of the direct participants of the game.[4] Moreover, the no-arbitrage solutions of this <u>underlying</u> game are observationally equivalent to the correlated equilibrium of the <u>original</u> game. What makes this of particular interest to our policy game analysis is that a correlated equilibrium is a set of incentive-compatibility constraints on the actions of the players in the game.

A <u>correlated equilibrium</u> is a mixture on <u>joint strategies</u>, $\rho(a) = \rho(a_i;a_{-i})$, such that given the strategies of others, a_{-i}, player 'i' has no incentive to deviate from a_i to some $\hat{a}_i \neq a_i$:

(6) $$\sum_{a_{-i}} \rho(a_i;a_{-i}) \cdot [U_i(a_i;a_{-i})-U_i(\hat{a}_i;a_{-i})] \geq 0; \;\; \forall\, a_i,\hat{a}_i \in A_i; \forall\, i.$$

Where: A is the joint strategy set, $\rho(a){:}A \rightarrow [0,1]$; $\sum_a \rho(a) = 1$.

Equivalently, in terms of a no-arbitrage condition on i's actions:

(7) $$\sum_{a_{-i}} \rho(a_i;a_{-i}) \cdot [U_i(\hat{a}_i;a_{-i})-U_i(a_i;a_{-i})] \leq 0; \;\; \forall\, a_i,\hat{a}_i \in A_i; \forall\, i.$$

A strategy for the policy-maker is a pair, (g_i,σ_i), where σ_i is its state declaration in state $i \in \{s_1,s_2\}$; $\sigma_i \in \{s_1,s_2\}$, which may be misleading relative to the optimal growth rate for true state 'i'; $g_i \in \{g_1,g_2\}$. A strategy is incentive-compatible if truth-telling occurs in state 'i': $\sigma_i = i$. The term given in brackets in Eq.(7) represents the 'arbitrage margin' to player i for deviating to some strategy $\hat{a}_i \neq a_i$ when the correlated strategy calls for a_i. For

[4] See Arce (1997a,b) for the explicit specification of the underlying arbitrage games pertaining to sender-receiver games of incomplete information and 2x2 strategic form games, respectively.

example, consider the commitment strategy for state 2, $a_{S_2} = (g_2,s_2)$, and the 'reneging' strategy, $\hat{a}_{S_2} = (g_2,s_1)$, where the policy-maker lies about the state. Reneging creates a positive arbitrage margin for the policy-maker if the benefit for reneging, $U_{S_2}(\hat{a}_{S_2},a_{-i})$, exceeds that for truth-telling, $U_{S_2}(a_{S_2},a_{-i})$. In order to rule $\hat{a}_{S_2}$ out, the no-arbitrage condition on the correlated strategy $\rho(a_{S_2},a_{-i})$ must be such that reneging yields a non-positive expected payoff (Eq.(7)).

Public expectations

The effect of the no-arbitrage condition is two-fold. First, it redefines the rationality of policy-maker actions. Specifically, if reneging on a policy declaration is profitable, then it represents an arbitrage opportunity for the policy-maker. Such an outcome is not possible in equilibrium because it violates the incentive-compatibility conditions given in Eq.(6).

The second implication of the no-arbitrage condition is that it affects public expectations about policy. The correlated equilibrium distribution applies to all players (public or private, direct or indirect). This is given in Fig.(1).[5]

Figure 1: Correlated Strategies
(for player/state $i \in \{s_1,s_2\}$)

$\downarrow g_i/\sigma_i \rightarrow$	s_1	s_2	Total
g_1	$\rho(g_1,s_1)$	$\rho(g_1,s_2)$	$\rho(g_1)$
g_2	$\rho(g_2,s_1)$	$\rho(g_2,s_2)$	$\rho(g_2)$
Total	$\rho(s_1)$	$\rho(s_2)$	1

[5] What this suggests is that the full information situation is again akin to the policy-maker playing a game against itself, where, in each state s_i, announcement σ_{S_i} is pitted against growth strategy g_{S_i}. From the perspective of the public sector's expectation formation, they know whether they are facing the payoff and correlation matrices that correspond to state s_1 or s_2.

In equilibrium if the policy-maker declares state s_2, $\sigma_{s_2}=s_2$, the public's expected inflation rate is:

$$(8) \qquad E[\pi|s_2] = \frac{\rho(g_1, s_2)}{\rho(s_2)} \cdot \pi_1 + \frac{\rho(g_2, s_2)}{\rho(s_2)} \cdot \pi_2,$$

and a similar conditional expectation is given if the policy-maker declares the state as s_1. It follows that the policy-makers' objective function must recognize that Eq.(1) becomes:

$$(9) \qquad q = \bar{q} + (\pi - E[\pi|\sigma_i]).$$

The model is closed through the following symbiotic relation: (a) incentive compatible announcements are characterized through their correlated equilibrium distributions, and (b) these same distributions determine the mean public inflation expectation.

From Andersen (1986) it is clear that there is no incentive-compatibility problem in state s_1, and in state s_2, $\rho(g_1, s_2) = 0$; the policy-maker never has an incentive to declare state s_2 and implement growth strategy g_1. The question that remains is whether $\rho(g_2,s_1) > 0$ in state s_2 -- does the government lie about state s_2 in order to derive reneging benefits from g_2 as surprise inflation? The conditions for this violation of incentive compatibility were given in Eq.(5) in the absence of the no-arbitrage conditions. In contrast, under the 'financial' policy environment, we can now present a positive result (proof in appendix):

Proposition: The no-arbitrage monetary rule equilibrium for state s_2 is incentive-compatible independent of the conditions given in Eq.(5). Specifically, $\rho(g_2,s_2)=1$ in state s_2; no randomization is required for truth-telling.

Discussion

The rules versus discretion question is inherently strategic because if policy-makers can establish a credible commitment, they can achieve a socially optimal outcome, whereas if the policy is time-inconsistent, the (re)actions of rational agents may nullify it. An example is the 'activist' rule given in Eq.(4), which, when applied under conditions of truth-telling about the state of the economy, leads to an optimal policy outcome. Our result illustrates the strategic importance of financial markets for establishing the credibility of monetary policy rules in the presence of nominal shocks. Specifically, reneging is recognized in financial markets to be an arbitrage opportunity for the policy-maker. The key is that the no-arbitrage solution generates public expectations that are related to the underlying strategic incentives of the model. This in turn creates incentive-compatible discipline through expectations that eliminate reneging as an arbitrage opportunity.

We have used a game-theoretic model to show that in the absence of arbitrage opportunities, rules can be credible. Moreover, if arbitrage opportunities exist (Eq.(7) is reversed), then the government cannot commit. Our results pertain to the Barro-Gordon (1983) model of credibility that pervades policy analysis. Moreover, as is shown by Nau (1992), no-arbitrage conditions exist and can be used for games of incomplete information. In particular, Arce (1997a) investigates the implications of arbitrage in an alternative policy environment, where a lack of credibility arises as a positive probability of policy failure (e.g. Andersen 1989; Dornbusch 1991). So the no-arbitrage approach is theoretically flexible; it is not restricted to a specific underlying market or model of credibility.

In addition, we have provided a theoretical counterpart to the empirical tests for policy credibility that are based on arbitrage measures. The no-arbitrage condition is a measure of market expectations that can be used as an empirical indicator of commitment.

Appendix

From Eq.(6), the incentive compatibility of $\rho(g_2,s_2) = 1$ requires:

(10) $\rho(g_2,s_2)\cdot[U_{S_2}(g_2,s_2) - U_{S_2}(g_2,s_1)] \geq 0 \Rightarrow U_{S_2}(g_2,s_2) \geq U_{S_2}(g_2,s_1)$

We first solve for $U_{S_2}(g_2,s_2)$ on the left-hand side of Eq.(10). Given declaration s_2 and

$\rho(g_1,s_2) = 0$, Eq.(8) yields: $E[\pi|s] = \frac{\rho(g_2,s_2)}{\rho(s_2)}\cdot\pi_2$. It follows that:

$$U_{S_2}(g_2,s_2) = -\frac{\alpha_1}{2}\cdot[\bar{q} + \{\pi_2 - \frac{\rho(g_2,s_2)}{\rho(s_2)}\cdot\pi_2\} - q^*]^2 - \frac{\alpha_2}{2}(\pi_2)^2$$

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And again by $\rho(g_1,s_2) = 0$ we have:

$$U_{S_2}(g_2,s_2) = -\frac{\alpha_1}{2}\cdot[\bar{q} - q^*]^2 - \frac{\alpha_2}{2}(\pi_2)^2$$

The payoff $U_{S_2}(g_2,s_1)$ on the right-hand side of Eq.(10) corresponds to the case where the state is s_2, but the policy-maker declares s_1 and its growth rate is g_2. Here, $E[\pi|s_1] = \frac{\rho(g_1,s_1)}{\rho(s_1)}\cdot\pi_1 + \frac{\rho(g_2,s_1)}{\rho(s_1)}\cdot\pi_2$, and $\rho(g_2,s_1) > 0$ is Andersen's source of concern because this is the type of incentive-compatibility violation that occurs under the conditions of Eq.(5) when financial markets are absent.

$$U_{S_2}(g_2,s_1) = -\frac{\alpha_1}{2}\cdot[\bar{q} + \{(g + s_2) - E[\pi|s_1]\} - q^*]^2 - \frac{\alpha_2}{2}(\pi_2)^2$$

First, accounting for the role of the monetary rule (Eq.(4)) to substitute for g:

$$U_{S_2}(g_2,s_1) = -\frac{\alpha_1}{2}\cdot[\bar{q} + \{(\pi_1 - s_1 + s_2) - E[\pi|s_1]\} - q^*]^2 - \frac{\alpha_2}{2}(\pi_2)^2$$

$$U_{S_2}(g_2,s_1) = -\frac{\alpha_1}{2}\cdot[\{\bar{q} - q^*\} + \{s_2 - s_1\} + \{\pi_1 - E[\pi|s_1]\}]^2 - \frac{\alpha_2}{2}(\pi_2)^2$$

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$$U_{S_2}(g_2,s_1) = -\frac{\alpha_1}{2}\cdot[\bar{q} + \{(g + s_2) - E[\pi|s_1]\} - q^*]^2 - \frac{\alpha_2}{2}(\pi_2)^2$$

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$$U_{S_2}(g_2,s_1) = -\frac{\alpha_1}{2}\cdot[\bar{q} + \{(\pi_1 - s_1 + s_2) - E[\pi|s_1]\} - q^*]^2 - \frac{\alpha_2}{2}(\pi_2)^2$$

$$U_{S_2}(g_2,s_1) = -\frac{\alpha_1}{2}\cdot[\{\bar{q} - q^*\} + \{s_2 - s_1\} + \{\pi_1 - E[\pi|s_1]\}]^2 - \frac{\alpha_2}{2}(\pi_2)^2$$

Now, solving for the term π_1 - E[π|s_1],

$$\pi_1 - E[\pi|s_1] = \frac{\rho(s_1)-\rho(g_1,s_1)}{\rho(s_1)}\cdot\pi_1 - \frac{\rho(g_2,s_1)}{\rho(s_1)}\cdot\pi_2 = \frac{\rho(g_2,s_1)}{\rho(s_1)}\cdot(\pi_1-\pi_2)$$

$$\pi_1 - E[\pi|s_1] = \frac{\rho(g_2,s_1)}{\rho(s_1)}\cdot(g - s_1 - g + s_2) = \frac{\rho(g_2,s_1)}{\rho(s_1)}\cdot(s_2-s_1)$$

Hence:

$$U_{S_2}(g_2,s_1) = -\frac{\alpha_1}{2}\cdot[\{\bar{q}-q^*\} + (s_2-s_1) + \frac{\rho(g_2,s_1)}{\rho(s_1)}\cdot(s_2-s_1)]^2 - \frac{\alpha_2}{2}(\pi_2)^2$$

$$U_{S_2}(g_2,s_1) = -\frac{\alpha_1}{2}\cdot[\{\bar{q}-q^*\} + \frac{\rho(g_1,s_1)}{\rho(s_1)}\cdot(s_2-s_1)]^2 - \frac{\alpha_2}{2}(\pi_2)^2$$

Substituting, Eq.(10) becomes:

$$-\frac{\alpha_1}{2}\cdot[\bar{q}-q^*]^2 \geq -\frac{\alpha_1}{2}\cdot[\{\bar{q}-q^*\} + \frac{\rho(g_1,s_1)}{\rho(s_1)}\cdot(s_2-s_1)]^2$$

$\rho(g_2,s_2) = 1$ implies $\rho(g_1,s_1) = 0$ (for state s_2), hence:

$$-\frac{\alpha_1}{2}\cdot[\bar{q}-q^*]^2 \geq -\frac{\alpha_1}{2}\cdot[\bar{q}-q^*]^2 \ \varpi$$

References

Andersen, Torben (1986). "Rules Versus Discretion in Monetary Policy. The Case of Asymmetric Information," Journal of Economic Dynamics and Control, 10(1/2)169-174.

Andersen, Torben (1988). "Rules or Discretion in Public Sector Decision-Making," Scandinavian Journal of Economics, 90(3)291-303.

Andersen, Torben (1989). "Credibility of Policy Announcements. The Output and Inflation Costs of Disinflationary Policies," European Economic Review, 33(1)13-30.

Arce M., Daniel (1997a). "Coherence and the Credibility of Convertibility Policy," Journal of International Money and Finance, 16(5)719-735.

Arce M., Daniel (1997b). "Correlated Strategies as Institutions," Theory and Decision, 42(3):271-285.

Balke, N.S. and J.Haslag (1992). "A Theory of Fed Watching in a Macroeconomic Policy Game," International Economic Review, 33(3)619-628.

Barro, R. and D. Gordon (1983). "Rules, Discretion and Reputation in a Model of Monetary Policy." Journal of Monetary Economics, 12:101-22.

Campa, J.M. and P.H.K. Chang (1996). "Arbitrage-Based Tests of Target-Zone Credibility: Evidence from ERM Cross-Rate Options," American Economic Review, 86(4)726-740.

Canzoneri, Matthew (1985). "Monetary Policy Games and the Role of Private Information," American Economic Review, 75(5)1056-1070.

Cowen, Tyler (1997). "Should Central Banks Target CPI Futures?," Journal of Money, Credit and Banking, August.

Cosimano, T.F. and J.B. Van Huyck (1993). "Central Bank Secrecy, Interest Rates, and Monetary Control," Economic Inquiry, 31(3)370-382.

Dornbusch, Rudiger (1991). "Credibility and Stabilization," Quarterly Journal of Economics, 56:837-850.

Goodfriend, Marvin (1986). "Monetary Mistique: Secrecy and Central Banking," Journal of Monetary Economics, 17(1)63-92.

Holden, S. and B. Vikoren (1996). "The Credibility of a Fixed Exchange Rate: How Repuation is Gained or Lost," Scandinavian Journal of Economics, 98(4)485-502.

Holly, Sean (1987). "Non-cooperative Dynamic Games with Rational Observers," Journal of Economic Dynamics and Control, 11:159-161.

King, Mervyn (1995). "Credibility and Monetary Policy: Theory and Evidence," Scottish Journal of Political Economy, 42(1)1-19.

Kreps, D.M. and R.B. Wilson (1982). "Reputation and Imperfect Information," Journal of Economic Theory, 27:253-279.

Nau, Robert (1992). "Joint Coherence in Games of Incomplete Information," Management Science, 38:374-387.

Nau, R.F. and K. McCardle (1990). "Coherent Behavior in Noncooperative Games," Journal of Economic Theory, 50:424-444.

Nau, R.F. and K.F. McCardle (1991). "Arbitrage, Rationality, and Equilibrium," Theory and Decision, 31:199-240.

Osborne, M.J. and A. Rubinstein (1994). A Course in Game Theory, Cambridge, MA: MIT Press.

Petith, Howard (1988). "Purposely Induced Asymmetric Information," Bulletin of Economic Research, 40(4)307-378.

Roberds, William (1987). "Models of Policy Under Stochastic Replanning," International Economic Review, 28(3)731-755.

Shiller, Robert J. (1993). Macro Markets, Oxford: Clarendon.

Stein, Jeremy (1989). "Cheap Talk and the Fed: A Theory of Imprecise Policy Announcements," American Economic Review, 79(1):32-42.

Taylor, John (1983). "Comment," Journal of Monetary Economics, 12(1)123-125..

Waller, Christopher (1987). "Reputation Building in a Monetary Policy Game," Journal of Macroeconomics, 9(3)351-371.

Walsh, Carl (1997). "Market Discipline and Monetary Policy," mimeo.

Wohl, Avner (1997). "The Feasibility of an Index-Contingent Trading Mechanism," Management Science, 43(1)112-121.