

Policy Credibility and the Design of Central Banks

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IN RECENT YEARS THE PRACTICE OF CENTRAL BANKING AROUND THE WORLD HAS BEEN PROFOUNDLY AFFECTED BY TWO TRENDS. THE FIRST IS TOWARD GRANTING CENTRAL BANKS GREATER INDEPENDENCE VIS-À-VIS OTHER BRANCHES OF THEIR GOVERNMENTS. THIS TREND IS CLEARLY EXPRESSED IN THE BRITISH GOVERNMENT'S MAY 1997 MOVE GRANTING THE BANK OF ENGLAND THE POWER TO SET SHORT-TERM INTEREST RATES. IT IS ALSO EVIDENT IN THE CURRENT EUROPEAN UNION'S PLAN FOR A SINGLE CURRENCY: THE 1992 TREATY OF MAASTRICHT PRESCRIBES THE CREATION OF A MONETARY AUTHORITY, THE EUROPEAN SYSTEM OF CENTRAL BANKS (ESCB), THAT WOULD BE FORMALLY INDEPENDENT OF ANY OTHER EUROPEAN GOVERNMENT OR INSTITUTION.¹ IN ADDITION, MANY LATIN AMERICAN COUNTRIES, INCLUDING MEXICO, ARGENTINA, CHILE, AND PERU, HAVE ENHANCED THE INDEPENDENCE OF THEIR CENTRAL BANKS IN THE CONTEXT OF BROAD STRUCTURAL REFORMS. SOUTH AFRICA'S POSTAPARTHEID GOVERNMENT ALSO AGREED TO AN INDEPENDENT MONETARY AUTHORITY.²

The second trend influencing the nature of central banking is for countries to formally state that a central bank's sole objective should be to ensure price stability. New Zealand, for example, in its Reserve Bank Act of 1989, stated that the Bank's monetary policy should be "directed to the economic objective of achieving and maintaining stability in the general level of prices."³ Likewise, Article 105 of the Maastricht Treaty establishes that "the primary objective of the ESCB shall be to maintain price stability." The Bank of Canada and some other central banks are now bound to follow formal inflation targets. In many other countries there is considerable debate about whether their monetary policy should be exclusively geared toward attaining zero inflation.⁴

These two trends have an underlying unity: they can be seen as social responses to a more fundamental problem of central bank credibility called the time inconsistency of monetary policy. To aid in understanding this connection, this article discusses the nature of the time inconsistency problem and its economic implications.

The theory of time inconsistency stresses that monetary authorities are often tempted to promise low inflation now and to try to surprise the public with unexpectedly higher inflation later. However, such promises will not be believed because economic agents, understanding the authorities' incentives, realize that the promises will not be honored. Instead, economically plausible outcomes have the property that monetary authorities are not able to systematically surprise the

public. As this discussion will show, this property implies that the monetary authority cannot profit from renegeing on its announcements. In fact, it can only lose by doing so: expected and realized inflation will often be higher than if the monetary authorities had made a binding promise. This consequence is known as inflation bias.

This article explains how the creation of some institutions can be interpreted as social responses to time inconsistency. A society may try to ameliorate inflation bias by providing appropriate incentives for its monetary authorities to adhere to promises; institutional arrangements may be designed to reduce the gains to the authorities from creating unexpected inflation. One approach is to structure the compensation of central bankers so as to punish them if inflation is outside some target range, as in New Zealand. Alternatively, a society may try to constrain the policy instruments available to the monetary authorities in order to make engineering inflation surprises more difficult. A country's commitment to fix its exchange rate can be understood in this way. For either approach to work, it is necessary that the monetary authorities be insulated from the rest of the government. Hence central bank independence emerges as a necessary condition for institutional solutions to time inconsistency.

Further theoretical analyses imply that such institutional mechanisms may not be necessary, however. In particular, because monetary authorities are typically engaged in a long-term relationship with the public, they can develop a reputation for honoring commitments. The fear of losing a reputation for future "honesty" is an important incentive that may deter a central bank from "cheating" today. Recent studies have shown that this incentive may be powerful enough to make socially optimal outcomes attainable, even in the absence of any institutional constraints.

Institutional approaches and reputational concerns are both plausible solutions to the time inconsistency problem, and both have weaknesses according to existing theory. To aid in understanding their relative merits, this article discusses related empirical work. Empirical studies have largely focused on testing the hypothesis that the central banks that are more independent deliver lower inflation. Evidence favoring that hypothesis has been analyzed in several studies focusing on developed countries. However, it will be seen that the relationship between central bank independence and inflation seems fragile, and it does not hold for less developed countries.

Although the empirical findings provide little support that central bank independence helps lower inflation, it is too early to discard existing theory. According to the theory, central bank independence is only one aspect of institutional solutions to inflation bias. It cannot by itself eliminate inflation bias, so its emergence will not necessarily yield lower inflation. In addition, reputation-based approaches imply that inflation bias may be addressed by noninstitutional means; hence, low inflation need not require central bank independence. Both arguments imply that there need not be a negative relation between central bank independence and inflation even if current theory is valid.

An Economic Theory of Credibility

Although the role of credibility in monetary policy has been recognized for a very long time, modern research on credi-

bility started only in the late 1970s with the publication of seminal papers by Calvo (1978) and Kydland and Prescott (1977). These two papers showed that the then-novel hypothesis of rational expectations had profound implications for the credibility of macroeconomic policy in general and monetary policy in particular. Before focusing on these implications, it may be helpful to illustrate the basic nature of Calvo's and Kydland and Prescott's ideas with a simple example.

The example is about a fictional father, Federico, and his adolescent son, Pablo, at the start of some week. Pablo is at that age when he dislikes hard work and loves to be extravagant. Federico wants to teach Pablo the value of hard work, of course, and to that end he has convinced the neighbors to let Pablo mow their lawn for money. Federico's problem is that he cannot force Pablo to do the job. Instead, Pablo must be induced to mow the lawn, and the way to convince him is to allow him to get a tattoo in exchange for his effort. Federico would like to prevent Pablo from being tattooed, although this objective is not as important to him as inducing Pablo to mow the neighbors' lawn. Federico would rather have Pablo mow the neighbors' lawn and use the corresponding payment to

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1. See specifically Article 107 of the Maastricht Treaty.

2. See "Role Shifts for Central Bankers," in the New York Times, November 15, 1994, sec. D.

3. Section 8, Reserve Bank of New Zealand Act of 1989, quoted in Walsh (1995b).

4. For debate about U.S. policy, see, for instance, "A Matter of Demeanor," Wall Street Journal, May 20, 1994, sec. A, and "Time for an Economic Summit," Wall Street Journal, September 28, 1994, sec. A.

pay for, say, a good book. The prospect of reading a good book is not enough to induce Pablo to do the lawn, though.

To make the example interesting, assume that the neighbors, mindful of Federico's dilemma, will give the money to Federico and not Pablo. Finally, let us push the fictional nature of the example and assume that it is the only interaction that Federico and Pablo will have.

What is the likely outcome of this father-son example?

Federico cannot convince Pablo to mow the neighbors'

lawn without promising him a tattoo. It seems that it should be enough for Federico to tell Pablo, "If you mow the neighbors' lawn, you will be allowed to use their payment for whatever you want." If Pablo believes this offer and Federico honors his word, then Pablo will mow the lawn, get the money, and run to the tattoo shop.

However, after Pablo mows the lawn, it is no longer in Federico's inter-

est to allow Pablo to be tattooed. Hence, instead of giving the lawn-mowing money to Pablo, Federico will go to a bookstore and buy Pablo a good book. Then he will just tell Pablo, "Sorry, Son, a tattoo will leave an indelible mark on your body, and I cannot let you have one. Here is a good book for your effort." By breaking his promise in this fashion, Federico would have obtained his most preferred outcome: he will have induced Pablo to mow the neighbors' lawn and also prevented him from being tattooed.

The paradox is that Federico's ability to renege on his promise and surprise Pablo turns out to be counterproductive. If Pablo is intelligent enough to understand his father's decisions, he will not believe Federico's promise and, consequently, he will not mow the neighbors' lawn. Federico's promise is "incredible."

Importantly, Federico ends up worse off than if he could bind himself to honor his word. If he could, he would be able to convince Pablo to mow the lawn. Although he would have to allow Pablo to get a tattoo in order to achieve this goal, Federico would avoid his least preferred outcome.

Simple as it is, the father-son example illustrates the crucial elements of Calvo's and Kydland and Prescott's analysis of credibility. Often, the interaction between a policymaker and the public is similar to that of Federico and Pablo. Like Pablo, the public makes some decisions whose value depends on subsequent policy actions of the policymaker. Like Federico, the monetary authority may have an incentive to announce policy actions in order to

affect the public's decisions and to break its promises once these decisions are made. If the public understands the policymaker's incentives, it will disregard its promises. And this interaction will often result in a bad outcome for society. This is the essence of what Calvo and Kydland and Prescott call the time-inconsistency problem.

Although time inconsistency pervades all aspects of government policy, its application to monetary policy has attracted the most research. A monetary authority, such as the Federal Reserve, typically has as a major objective to deliver low inflation. It may also have other objectives that can be accomplished by creating surprise inflation, that is, inflation rates over and above those previously anticipated by the public. A case in point occurs if one objective is to fight unemployment, as in the studies by Kydland and Prescott (1977) and Barro and Gordon (1983a). These studies assume that firms and workers write contracts before production and sales take place; these contracts stipulate a fixed nominal wage at which workers agree to supply labor at the firms' demand. Then the monetary authority has an incentive to create unexpected inflation that would reduce the real value of wages and induce firms to employ more workers.

If, like Federico, the monetary authority is not bound by its promises, then it will have a credibility problem. The monetary authority would like to promise low inflation but has an ex post incentive to engineer surprise inflation, using whatever policies it has at its disposal, and expand employment.

Can the monetary authority succeed? Arguably, the public is intelligent enough to understand the monetary authority's credibility problem. This premise is, in fact, implied by the more general hypothesis of rational expectations, which was gaining acceptance in macroeconomics when Calvo's and Kydland and Prescott's contributions were published. Rational expectations theory maintains that individuals use efficiently all available information when making decisions. Under the plausible assumption that their information includes knowledge about how monetary policy is chosen, individuals may not believe a promise of low inflation by the monetary authority, just as Pablo discounted Federico's promise in the father-son example. Rather, understanding correctly that the monetary authority will attempt to engineer surprise inflation, individuals will adjust their inflation forecasts upward.

If individuals know that the monetary authority may try to surprise them, what is the outcome, or equilibrium, that will be observed? The answer, first advanced by Barro and Gordon (1983a), is somewhat tricky. The key observation is that a plausible outcome must have the property that the monetary authority does not profit, at the end, from surprising the public. This property must hold because individuals know that the monetary authority will try to create surprise inflation if it can gain from doing so. Therefore, in an equilibrium, expected inflation

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must equal actual inflation, and both have to be such that there is no incentive for the monetary authority to create unanticipated inflation.

Since expected and actual inflation must coincide in equilibrium, the monetary authority cannot succeed in its effort to expand employment. Given this restriction, it seems plausible that the monetary authority would choose to keep inflation low. However, time inconsistency means that expectations of low inflation provide an incentive for the monetary authority to create unexpected inflation, which would be incompatible with an equilibrium. Instead, in an equilibrium both expected and actual inflation must be such that that incentive is eliminated. Under plausible conditions the result is inflation that is inefficiently high.⁵

The result is very bad from a social perspective: not only is the monetary authority unable to expand employment, but expectations of high inflation end up being accommodated by monetary policy. In short, monetary policy suffers from an inflation bias because of the time-inconsistency problem.

Like Federico, the monetary authority would be better off if it could somehow bind itself to honor its promises. If that were possible, then the monetary authority would achieve a better outcome by promising to deliver low inflation. Making such a promise would imply giving up on the employment objective, but it would at least succeed in keeping inflation low.

The emergence of a time inconsistency problem when a central bank is concerned with both inflation and employment has been one focus of the literature, and because of its importance the rest of the article will explore this scenario as well. However, the reader should keep in mind that a monetary authority may have to deal with time inconsistency and a resulting inflation bias when it has objectives other than fighting unemployment. For instance, a central bank forced to finance government expenditures through money creation may have an incentive to promise low inflation to maximize the demand for money, which forms the base of the inflation tax, and then to break that promise to increase inflationary revenue. Other examples are not hard to find, suggesting that time inconsistency may be a pervasive feature of monetary policy.

Dealing with Inflation Bias: Delegation and Incentives

It is clear that, in the presence of time inconsistency, a monetary authority would benefit from tying its hands behind its back to enhance its credibility. However, doing so is not so simple. The monetary authority may try

to promise or even enact a rule that it will behave “honestly.” Such announcements would presumably be no more believable, though, than a promise of low inflation.

What else could be tried? To explore some possibilities, let us return to the father-son example. Obviously, Federico would not suffer from lack of credibility if he did not dislike tattoos. Even with the assumption that Federico hates tattoos, he might obtain desirable results if he were to give up dealing with Pablo directly and delegate Pablo’s education to a tutor. In pursuing this solution, Federico should be careful that the tutor’s incentives are such that he does not have a credibility problem himself. To ensure the tutor’s credibility, Federico has two options. One is to hire a tutor who likes tattoos, on the premise that such a tutor would not be tempted to buy a book rather than paying Pablo for mowing the lawn. The other option is to pay the tutor only according to whether Pablo mows lawns and not according to what he does with the money earned.

Analogously, a society may try to deal with the time inconsistency of monetary policy by delegating the execution of monetary policy to agents with appropriate incentives. This point was first developed in an important paper by Rogoff (1985). Rogoff studied an idealized economy in which there were well-defined social preferences on inflation-employment combinations. In such an economy, a central banker with the same preferences as those of society would suffer from a credibility problem, as discussed in the previous section. Given this problem, Rogoff’s key insight was that this society may not be constrained to choose an individual with the same preferences as itself to conduct monetary policy. Instead, it should choose a person whose distaste for inflation is greater than the social one.

The appointment of a “conservative” central banker mitigates the inflation bias because the public would know that such a person would refrain from using unexpected inflation to expand employment. Accordingly, individuals would reduce their inflation forecasts, and they would turn out to be correct because of the central banker’s distaste for inflation. The conservative central banker would not attempt to stimulate employment but

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5. One such condition is that the marginal cost of creating inflation increases the level of inflation while the marginal effect on employment is constant.

would be able to promise and deliver low inflation. Hence delegating monetary policy to a conservative central banker would improve matters, just as hiring a tutor who likes tattoos would help Federico ensure that Pablo will mow the neighbors' lawn.

Rogoff's analysis may explain why central bankers are often known to be "hawkish" on inflation: according to Rogoff's theory, this position would be a social response to the credibility problem in central banking. More

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subtly, Rogoff's prescription requires that central bankers be independent of other branches of the government. This independence is needed because the policy choices of a central banker whose preferences are different from those of society must, *ex post*, be suboptimal from a social perspective. Society therefore would have an incentive to dismiss the conservative central banker when he is about

to implement policy, just like Federico would have an incentive to fire the tutor after the lawn is mowed and then buy Pablo a book. This incentive must be held in check for the conservative central banker to be effective.

Another option discussed for Federico is that, instead of hiring a tutor who likes tattoos, he may solve his credibility problem by paying the tutor only according to the execution of Pablo's job. Likewise, rather than choosing a conservative central banker, a society may deal with a monetary policy credibility problem by appropriately structuring the rewards and compensation of its central banker, that is, by designing an efficient "contract." What would such a contract look like? Recall that the key implication of time inconsistency is that it induces an inflation bias. Eliminating that bias would seem to require that the central banker be penalized when inflation is high and rewarded when inflation is low. In addition, the contract might stipulate additional rewards or penalties to the central banker depending on other variables such as employment growth.

These questions were first investigated in an influential paper by Walsh (1995a). Walsh obtained several interesting results in the context of the monetary policy model of Barro and Gordon (1983a). He showed that an optimal contract for a central banker would make his compensation depend only on the realized rate of inflation or, alternatively, on the realized rate of money growth. This finding is surprising because one could have conjectured, as in the previous paragraph, that optimal rewards would depend

on other variables in addition to inflation or money growth.⁶ Also, Walsh showed that the optimal reward structure may resemble an inflation-targeting rule in that the central banker would be rewarded according to how close inflation turned out to be relative to some given values or targets.

Hence Walsh's theory provides a formal justification for inflation targeting and for the recent trend toward assigning central banks the sole objective of maintaining low inflation. That justification is based on the incentives that inflation-based compensation schemes would provide to central bankers. This argument contrasts with others in favor of inflation-based rules for monetary policy, which have emphasized the implications for the distribution of macroeconomic outcomes assuming that the rules will be followed.⁷

As with Rogoff's approach, a necessary condition for Walsh's approach is that the central banker must be independent, in the sense that his contract with society must be respected even if it is beneficial, *ex post*, to rescind it. In order to deal with time inconsistency, the central banker's contract must induce him not to create unanticipated inflation even if inflationary surprises may be beneficial. If the central banker's contract could be repealed at no cost, the contract would itself become incredible and its effects on the public's expectations would disappear.

Summarizing, the inflation bias caused by time inconsistency may be ameliorated if society can change the incentives of its central banker. This change can be accomplished by choosing a very inflation-averse individual to head the central bank or by designing his contract to discourage him from creating inflationary surprises. The latter approach may resemble a regime of inflation targeting. In both cases, central bank independence emerges as a necessary ingredient to ensure that the change in incentives is effective.

It has been emphasized that incentive-based approaches are feasible provided that society can affect the incentives of its central banker. But doing so may not be possible. If, for example, a government can commit to a particular contract with the head of its central bank, why is it impossible for that government to commit to honor promises of low inflation? The question has no fully satisfactory answer. In the end, the incentives approach depends crucially on the assumption that a society can make some commitments (such as honoring the contract of its central banker) and not others. Such an assumption must ultimately be justified on institutional or political grounds, but on this point theory remains to be developed.⁸

Dealing with Inflation Bias: Rules

Instead of imposing constraints on incentives, a different approach to solving the credibility problem imposes external constraints on the instruments that central bankers can use. The consequences would be

trivial if society could force its central bankers always to honor promises, but research along these lines assumes that imposing such a stringent constraint is not feasible. Instead, it is assumed to be feasible to impose other, less than perfect rules. Then the interesting question is to investigate the implications of those rules for equilibrium outcomes.

Consider again the father-son problem, assuming that Federico deals directly with Pablo. It may be impossible for Federico to credibly promise that he will give Pablo money to pay for a tattoo as his reward for mowing the neighbors' lawn. Nevertheless, Federico may instruct the neighbors to pay Pablo directly; this approach would prevent Federico from using the money to buy books instead. This arrangement may be a good idea in spite of, or precisely because, everyone knows that Pablo will get a tattoo if he gets the money.

Analogously, a society may be able to restrict the actions of its monetary authorities so as to alleviate the inflation bias caused by time inconsistency. The commitment to fixed exchange rates in European countries has been justified in this fashion (see Giavazzi and Pagano 1988). If a country is committed to a fixed exchange rate, it becomes difficult for the central bank to engineer inflation surprises, as they are likely to put downward pressure on the country's currency. This constraint tends to reduce the inflation bias since the public understands its consequences for monetary policy.

This kind of reasoning also provides a justification for simple monetary rules, such as a constant money growth rule. These procedures are interpreted as constraints on the choices available to central bankers, designed with the purpose of ameliorating inflation bias by preventing inflation surprises.

The conclusion is that, provided society can commit to at least some rules, the imposition of rules may help deal with credibility. This view may help justify some rules, such as fixed exchange rates, that would otherwise be irrelevant or even counterproductive.

As with incentive-based approaches, a key question is what policy choices can and cannot be ruled out. In justifying a fixed exchange rate regime, the implicit assumption is that the monetary authority can commit to fixing exchange rates but not to honoring promises of low inflation. Why is there a difference? One answer is that, because of institutional reasons, some commitments are harder to break than others. This argument carries some force for fixed exchange rate regimes, which may require

international agreements that are costly to ignore. However, even in the case of fixed exchange rates the argument is grounded on an institutional factor and not completely satisfying.

An alternative answer holds that society can in fact commit to rules, but only imperfect ones. This limitation exists because there is incomplete knowledge about the nature of shocks that may hit the economy. In this view, espoused most prominently by Flood and Garber (1989), the assumption that society can commit to some rules but not to honoring its promises approximates the fact that no rule can be written that takes into account every possible kind of disturbance to the economy. Is this argument convincing? That all rules are imperfect is not controversial. However, Flood and Garber's interpretation amounts to assuming that policymakers cannot use standard probability theory to

describe the likelihood of some relevant macroeconomic shocks. This assumption is problematic, for it makes it very hard to solve the model in a convincing way. In particular, how are individuals supposed to make investment and portfolio decisions in such an environment? Flood and Garber assume that agents' choices are based on rational expectations, that is, on full knowledge of the structure of the economy. But such knowledge must include the probabilities of all the shocks, and therefore its availability is inconsistent with Flood and Garber's interpretation of the limitations of policy rules.

The discussion in this article implies that there is no satisfactory justification for assuming that a society can commit to some rules but not to others. Such an assumption makes the theory interesting but may also be its main weakness.

The Role of Reputation

So far the emphasis has been on institutional responses to the problem of policy credibility. Since the creation and enforcement of appropriate institutions may be difficult and costly, one should ask whether

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6. As Walsh noted, this result depends on the assumption that the central banker cares about not only his compensation but also social welfare. Also, the result hinges on a particular property of the Barro-Gordon model—that the magnitude of the inflation bias is not affected by macroeconomic shocks. Whether the result holds under more general assumptions is the subject of current research.

7. For an example of this kind of argument, see Taylor (1993).

8. And, indeed, this point has been identified as a major weakness of the incentives approach (see McCallum 1995).

there are other ways to deal with the credibility problem. One alternative exists provided that the monetary authorities and the public interact for sufficiently long periods. In such cases, the monetary authority may eliminate the inflation bias by developing a reputation for honoring its announcements of low inflation, as discussed briefly above.

In the father-son example, it is unlikely that Federico would be left unpunished if he breaks a promise to Pablo.

In real life Federico and Pablo would have to face each other for many years. Federico may therefore be deterred from renegeing on his promises by the fear that Pablo will not believe subsequent promises. Somewhat paradoxically, Federico's fear of losing his reputation vis-à-vis Pablo is in fact useful. Federico may be able to credibly promise Pablo a tattoo in exchange for mowing the neighbors'

lawn if Pablo believes that Federico wants strongly enough to be able to make credible promises in the future.

The same considerations apply to monetary policy. It is likely that a monetary authority that today makes and breaks a promise of low inflation will be unable to credibly promise low inflation in the future. This incentive may be powerful enough to deter the authority from renegeing on its current promise because, as the discussion has shown, the ability of making credible promises is socially valuable.

These ideas were first discussed in the context of monetary policy by Barro and Gordon (1983b). They analyzed a simple version of the monetary model in Kydland and Prescott (1977), the main difference being the assumption that the monetary authority and the public interacted for many periods. One of the outcomes of that interaction, Barro and Gordon found, was that the monetary authority acted as if it were able to make binding promises in every period, provided it were patient enough.⁹

In spite of its importance, further study of the role of reputation was hindered for several years by the technical issues involved in analyzing the long-term relationship between a central bank and the public. The main problem is that such analysis quickly leads to a problem of infinite regress. Describing an outcome of a long-term interaction requires specifying not only what happens if the central bank breaks a promise of low inflation but also what happens if it breaks another promise after the

first one and then a third promise, and so forth. In fact, even the very concept of equilibrium, that is, of the plausible outcomes of a model, is not obvious.

Very recently, however, new methods have appeared that promise a drastic reconsideration of models of reputation. Chari and Kehoe (1990) and Stokey (1991) provide a convincing definition of equilibria in macroeconomic models of long-term relationships. In addition, these two papers present a general method for identifying the complete set of equilibrium outcomes of many such models. Although that method turns out to be difficult to apply, recent studies by Chang (1998) and Phelan and Stachetti (1997) have shown how the solution of such models can be drastically simplified, thus greatly broadening the scope of the theory of reputation.

Chang and Phelan-Stachetti exploit the fact that, in some sense, tomorrow will be very similar to today. To see this concept, recall that an outcome of the long-term relationship between the central bank and the public involves a description of what will happen if the central bank breaks a promise today, tomorrow, or the day after tomorrow, and thus ad infinitum. This kind of analysis can be exceedingly complex. However, Chang and Phelan-Stachetti show that an equivalent description can be obtained by focusing on the central bank's decision problem today, after any possible history of (possibly broken) promises, with the understanding that tomorrow's problem will be just like today's (except that the relevant history will be a little different). This approach effectively reduces the analysis to a two-period problem, involving only today and tomorrow, and hence eliminates the infinite regress problem.

The papers by Chang (1998) and Phelan and Stachetti (1997) discuss in detail the theoretical advantages of their formulation. Interestingly, they find that in any equilibrium monetary policy must follow "rules," even in the absence of external mechanisms to enforce them. The intuition is as follows. A crucial part of Chang's and Phelan-Stachetti's method is that, at any point in time, the whole history of the economy can be summarized by a small number of "state" variables. An implication is that any equilibrium has the property that monetary policy and market outcomes depend only on those variables and not on calendar time. Since monetary policy is, in any equilibrium, optimally chosen by the monetary authority, this reasoning reveals that monetary policy is governed by a relatively simple relationship between the state variables and policy instruments, that is, by a rule. Although the nature and properties of the resulting rules remain to be investigated, this finding is important because it means that observing that monetary policy follows rules should be the norm and not the exception.

In addition, Chang's and Phelan-Stachetti's studies imply that models of reputation in monetary policy can be analyzed by computational methods that many others

Central bank independence plays a role in dealing with time inconsistency but only as a complement to more fundamental arrangements intended to bind central bankers to honor their promises.

thought were inapplicable. Chang's study, in particular, analyzes the model of Calvo's (1978) original contribution and shows that reputational considerations may imply that one of the model's outcomes is indistinguishable from the best the central bank can do when it can commit perfectly to its promises. That is, the time-inconsistency problem may not prevent the attainment of socially optimal outcomes.

While the results just described are suggestive, it is too early to conclude that the long-term nature of the interaction between a central bank and the public implies a solution to the credibility problem. Other, more realistic models of monetary policy need to be investigated. More importantly, that the central bank can implement its most preferred policy is only one of many possible outcomes. In most models it remains possible that reputational considerations will not be enough to convince the public that a central bank will, in fact, honor its promises. Consider, for example, what would happen if the central bank were to assume that reputation will never matter for the public's behavior. In such a case, the central bank might behave myopically and, in general, try to cheat on the public at all times. This behavior may in turn validate the public's belief that the central bank will not attempt to develop a "good" reputation. The outcome would be that the role of reputation would not solve the time-inconsistency problem, even if the central bank and the public face each other indefinitely.

Since the theory of reputation implies that the central bank interaction with the public may have multiple outcomes, determining which outcome will occur becomes a key issue. Unfortunately, existing studies do not provide a satisfactory answer, and at this point the presumption that reputational effects eliminate the inflation bias caused by time inconsistency is based on optimism rather than theory.

Some Comments on the Empirical Evidence

A natural reaction to the theoretical discussion above is to turn to empirical evidence to check whether the credibility problem of central banks is, in fact, a problem. Unfortunately, testing the various theories described in this article has proved to be very difficult.

One of the sources of difficulty is that it is impossible to measure credibility directly. To see this problem, consider testing the key proposition that more credible central banks deliver lower inflation. What dimension identifies a central bank as "more credible"? In the theoretical discussion, credibility is a central bank's ability to make binding promises. How can such ability be observed, let alone measured, in the real world?

Because of these difficulties, existing empirical studies have by and large focused on testing a different but related proposition: that more independent central banks deliver lower inflation. This approach can be seen as an indirect test of the theory since, as the discussion noted earlier, central bank independence may emerge as part of society's attempt to eliminate the inflation bias caused by lack of policy credibility. If such an attempt is successful, one should expect a high degree of central bank independence to be associated with low inflation.

The change of focus from central bank credibility to central bank independence is useful because independence is typically expressed in many indicators found in legal documents and central bank statutes. In some cases, there is little disagreement on when such indicators signal more or less independence; for instance, most people would agree that a central bank whose chairman can be fired at the will of the president of the country is less independent than one whose chairman cannot be so easily dismissed.

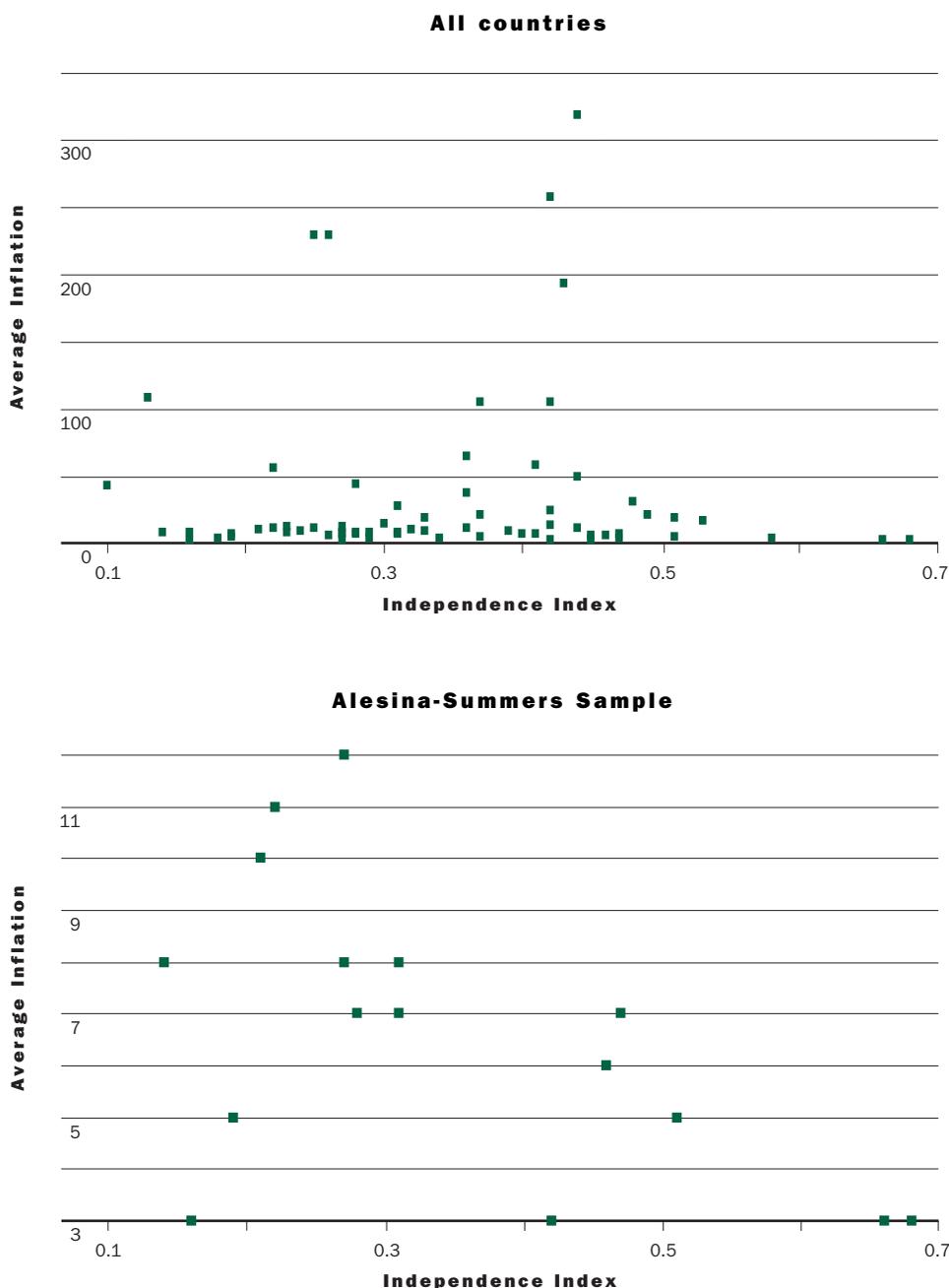
The most comprehensive attempt to quantify central bank independence is given by Cukierman (1992). He rates the central banks of several countries in different decades according to four measurable dimensions of central bank independence. The first concerns the procedures governing the appointment, tenure, or dismissal of central bankers. For example, Cukierman rates a central bank whose head is appointed by the executive branch of the government as less independent than one whose chairperson is appointed by the legislature, which in turn is rated less independent than one whose head is chosen by the central bank's board. Likewise, he considers a central bank to be more independent the longer its chairperson's statutory tenure is.

The second dimension is related to the formulation of monetary and fiscal policy. Cukierman gives a high independence rating to central banks that can decide on monetary policy without interference from the executive or legislative branches. In contrast, he gives lower ratings to central banks that must obey their government's decisions about the formulation and execution of monetary policy.

It is likely that a monetary authority that today makes and breaks a promise of low inflation will be unable to credibly promise low inflation in the future.

9. The monetary authority's degree of impatience is important in Barro and Gordon's analysis because the punishment they considered for a government that reneges on today's promise is the loss of reputation in the future; this punishment carries less force if the future is discounted more heavily.

CHART 1 Central Bank Independence and Inflation, 1980–89



A third dimension of independence has to do with the goals that a central bank is instructed to pursue. Central banks whose sole objective is to ensure low inflation are given high independence ratings. If the central bank's mandate includes other objectives, such as pursuing full employment, that bank is given a lower rating. It can be argued that whether price stability is the central bank's only objective has little to do with the usual meaning of independence. Cukierman's rationale

is that the preeminence of price stability among a central bank's possible objectives measures society's willingness to have a conservative central banker.

The fourth and final dimension of independence lies in the extent to which a central bank is required to finance government deficits. The easier the terms are under which a central bank is required by law to finance government deficits, the lower its independence rating is.

Since each available indicator is likely to convey some information about central bank independence, it is useful to include all of them in empirical work. Cukierman (1992) and others do so by constructing indices of central bank independence. Each index is essentially a weighted average of many indicators. Since the weights can vary from study to study, the construction of an independence index involves some subjectivity. However, the conclusions obtained in the existing literature do not seem to depend on the use of a particular index. Those conclusions, therefore, merit attention.

Recent research has underscored the difficulty of obtaining a tight relationship between measures of central bank independence and inflation, as the top panel of Chart 1 illustrates. Each point in the chart represents a country's central bank independence, measured along the horizontal axis, against its long-term inflation, measured along the vertical axis. Cukierman's index is a proxy for central bank independence, and the annual percentage change in the consumer price index is used for long-term inflation; both variables refer to the 1980–89 decade.

A glance at the top panel of Chart 1 suggests the absence of a systematic link between central bank independence and inflation. This conjecture is confirmed by formal statistical tests, which reveal that increases in the Cukierman index are associated with mild increases in inflation, although the association is not significant. Ordinary least squares applied to the data in the top panel of Chart 1 yields the following estimated equation: $INF = 30.27 + 15.05 CBI$, where INF denotes 1980–89 average inflation and CBI denotes Cukierman's index for each country. The t -statistic associated with the CBI coefficient is 0.23, which is quite consistent with the hypothesis that the CBI coefficient is zero. Since an increase of Cukierman's index expresses a higher degree of central bank independence, the data in the top panel of Chart 1 suggest that the empirical relationship between independence and inflation is the opposite of that predicted by the theory of time inconsistency.

The above finding seems to contradict the hypothesis that central bank independence translates into lower inflation. Belief in that hypothesis has become widespread after the publication of news stories discussing

studies that seem to confirm it.¹⁰ The difference between those studies and the results reported here can be explained easily. For a small subset of developed countries, greater central bank independence seems to be associated with lower inflation, as the theory predicts. To illustrate the point, the bottom panel of Chart 1 plots the same data as in the top panel but for only a subset of developed countries. In fact, the countries included in the bottom panel are the ones studied in an influential paper by Alesina and Summers (1993). For this subset of countries, the bottom panel of Chart 1 suggests the existence of a negative relation between Cukierman's index and inflation, a conjecture that is confirmed by formal statistical tests. For the sample of the bottom panel, ordinary least squares yields the following equation: $INF = 9.79 - 9.11 CBI$. The t -statistic associated with the CBI coefficient is -2.36 , which is inconsistent with the hypothesis of a zero CBI coefficient at conventional significance levels.¹¹

The conclusion is that greater central bank independence seems to have no beneficial impact on inflation, except perhaps for a small group of developed countries. How should these findings be interpreted? A possible reaction is to keep believing that independence is conducive to lower inflation, blaming shortcomings in empirical procedures for failing to confirm that belief. It has been argued—for example, by Cukierman (1992)—that the problem is one of poor measurement. The independence indices used in Chart 1, as well as in most of the literature, capture only the legal aspects of central bank independence. The real degree of independence may depend on other, nonlegal variables that are hard to quantify. The solution seems to lie in finding alternative, more accurate measures of central bank independence; research on that front is still under way.¹²

At this point the presumption that reputational effects eliminate the inflation bias caused by time inconsistency is based on optimism rather than theory.

10. Examples are "Role Shifts for Central Bankers," *New York Times*, November 15, 1994, sec. D, and "Divorcing Central Banks and Politics: Independence Helps in Inflation Fight," *New York Times*, May 7, 1997, sec. D.

11. This finding need not imply that central bank independence helps lower inflation. An alternative explanation is that countries that have stronger anti-inflationary postures tend to be more conservative with their central bank arrangements. This "reverse causality" view is proposed by Posen (1995).

12. Cukierman (1992) observes, for instance, that in some countries the average tenure of central bank presidents is much shorter than the legal tenure period, which is one of the variables summarized in independence indices. Accordingly, Cukierman argues that central bank independence can be measured more accurately in less developed countries by the turnover ratio of their central bank heads.

An alternative reaction to the empirical findings summarized by Chart 1 is that the theory implies that central bank independence is associated with lower inflation only under narrow conditions that may not hold in practice. As was discussed earlier, the inflation bias problem associated with time inconsistency may be solved if central bankers develop a good reputation with the public. If reputation does in fact work, one should not expect to find any systematic relationship between central bank independence and inflation, and hence the empirical facts reported earlier are not a puzzle.

A more pessimistic view is that central bank independence is only a necessary but not a sufficient condition for eliminating the inflation bias caused by time inconsistency. According to the theory discussed earlier in this article, central bank independence plays a role in dealing with time inconsistency but only as a complement to more fundamental arrangements intended to bind central bankers to honor their promises. It may be the case that central bank independence emerges for reasons not related to those institutions, but in and of itself it does not help solve the time-inconsistency problem and, therefore, does not result in lower inflation.

Conclusion

This article has reviewed the problem of time inconsistency of monetary policy and its possible solutions. The theory of time inconsistency emphasizes that, if a central bank cannot credibly commit to honor announcements of low inflation, expected and actual inflation will be larger than if such a commitment could be made. In other words, time inconsistency leads to an inflation bias.

The discussion considers how some currently fashionable institutions such as central bank independence and price stability rules may emerge as attempts to minimize the inflationary consequences of time inconsistency. But it also argues that there may be no need for such institutions. The empirical evidence reviewed here did not provide strong confirmation of the hypothesis that central bank independence lowers inflation. This empirical failure may reflect that the time inconsistency bias has been solved by reputational considerations, as suggested by recent theoretical advances. Alternatively, it may be the case that the degree of central bank independence is determined by reasons other than eliminating inflation bias.

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