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Capacity Utilization and Prices Within Industries

Deflation and Real Economic Activity Under the Gold Standard

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CONTENTS

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Performance Contracts for Central Bankers

Christopher J. Waller

Since the end of World War II, economies around the world have been plagued by historically high and persistent inflation. This raises a question: If inflation is socially undesirable, why do policymakers produce it? One explanation is that discretionary monetary policy may lead to an inflationary bias. This explanation is based on the "time-inconsistency" problem, first outlined by Kydland and Prescott (1977) and illuminated by Barro and Gordon (1983a). The typical version of this explanation assumes that society wants the monetary authority to follow a low inflation policy, which it promises to do. Once private agents commit themselves to nominal wage contracts based on a low expected inflation rate, however, the monetary authority is assumed to have an incentive to create "surprise" inflation and inflate away the real value of the contracted nominal wage. As a result, firms hire more labor and produce more output. But, because private agents are aware of this incentive, they do not believe that the central bank will carry through with its promise to maintain inflation at a low level. Hence, workers set their nominal wages high enough so that the extra inflation created by the central bank leaves real wages at their desired levels. Consequently, no additional output or employment is created but society suffers from an inflation bias.

For the past decade, researchers have investigated an array of methods with which to reduce this inflation bias. Although most methods promise to lower the inflation bias, they usually do so at the cost of creating greater output variability. However, a recent proposal by Walsh (1995a) and Persson and Tabellini (1993)—the adoption of performance contracts for central bankers—has created a stir among economists working in this area. The purpose of this article is to survey the work on performance contracts and compare it to earlier proposals for mitigating the inflation bias. The remainder of the paper proceeds as follows: The second section contains a model describing the basic time-inconsistency problem and reviews previous suggestions for eliminating the inflationary bias. Following that is a discussion of the nature of performance contracts and how they work. The fourth section probes the principal-agent nature of central banking and its relationship to central bank independence. In the final section, I offer concluding comments.

THE TIME-INCONSISTENCY PROBLEM

A Model of Discretionary Monetary Policy

A general description of how monetary policy is determined would go something like this: Society (the principal) delegates the power to create money to the central bank (the agent). Society instructs the central bank to use its money creation powers to "do good." What is meant by doing good is often not well-defined; nevertheless, it can be interpreted to mean that the central bank should produce a policy that improves the well-being of society. The central bank then enacts policy according to some objective function. Presumably, its objective is to maximize social welfare, but it could also be to maximize something other than society's welfare. Finally, after policy is enacted, the monetary authority may be asked to account for its actions.

To illustrate the nature of the time-inconsistency problem, consider the following version of the Barro and Gordon model:

$$(1) \qquad y = y^n + (\pi - \pi^e) + u$$

$$(2) \qquad U^S = -(y - y^n - k^S)^2 - b\pi$$

$$(3) \qquad U^M = w - (y - y^n - k^M)^2 - b\pi^2 \ ,$$

where y is real output, y^n is the trend level of output, π is the inflation rate, π^e is the expected inflation rate and u is a mean zero, serially uncorrelated real output shock.

Equation 1 describes how output is influenced by inflation and inflation expectations. Workers are assumed to sign nominal wage contracts prior to the setting of monetary policy and the contracted wage is based on the expected rate of inflation. An inflation surprise reduces the real value of the contracted nominal wage, thereby inducing firms to hire more labor and produce more output.

Equation 2 is society's utility function and shows that society suffers from output and inflation fluctuations about their targeted levels. Society's target output level is $y^n + k^S$, where y^n is the natural or trend level of output and k^S is a positive constant. The parameter k^S is assumed to reflect society's belief that distortions in the economy make trend output undesirably low. Society's preferred inflation rate is assumed to be zero. The parameter b measures the relative weight society places on losses arising from inflation. The weight on losses arising from output has been set equal to 1 for notational ease.

Equation 3 is assumed to be the central banker's objective function. The parameter w is the salary or budget the central banker receives for doing the job. This term is irrelevant in the standard Barro and Gordon model and is usually ignored. But this term plays a key role in the performance-contract literature, so I will include it now for comparison later. Equation 3 looks very much like society's utility function except that the central bank is allowed to have a potentially different output target, $y^n + k^M$, than society's. If $k^M = k^S$, then the central bank's objective is identical to society's. If $k^M \neq k^S$, then the central bank uses policy to pursue an agenda that is different than that of society as a whole. The reason the central bank has a different agenda is important and is a crucial part of the performance-contract debate, as discussed later in this article. Finally, for ease of analysis, the monetary authority is assumed to control the inflation rate directly and thus chooses π to maximize equation 3 given equation 1.

Consider the case in which the central bank has only society's interests at heart, that is, $k^M = k^S = k$. Since society wants inflation to be zero (on average), suppose the central bank can pre-commit to a policy whereby it will not create systematic inflation. This implies that expected inflation is zero. Substituting equation 1 into 3 and maximizing subject to the constraint $k^M = k^S = 0$ yields what is called the *socially optimal* or *"pre-commitment"* solution for inflation and output:

$$(4) \qquad \pi = -\frac{1}{1+b}u$$

$$(5) \qquad y = y^n + \frac{b}{1+b}u \ .$$

From equation 4, the central banker partially offsets the output shock by allowing inflation to vary more. Expected inflation is zero, and expected output is y^n. In this world, pre-commitment refers to the idea that the central bank can commit itself to making the inflation rate zero *on average,* but will vary the period-by-period inflation rate to stabilize output in a way that maximizes social welfare. The central bank makes no attempt to expand output above the trend level even though it has a desire to do so. In short, even though $k > 0$, pre-commitment means the central bank is able to credibly promise to act as if $k = 0$.

Now suppose that the central bank cannot commit itself to acting as if $k = 0$. Now the central banker chooses π, taking π^e as given, to maximize its objective function. Maximizing equation 3 yields the following expression:

$$(6) \qquad \pi = \left(\frac{1}{1+b}\right)(\pi^e + k^M - u) \ .$$

Rational expectations implies that π^e must be set consistent with equation 6. This implies that

$$(7) \qquad \pi^e = \frac{k^M}{b} \ ,$$

which yields the following solutions for the *discretionary* equilibrium:

$$(8) \qquad \pi = \frac{k^M}{b} - \frac{1}{1+b}u$$

$$(9) \qquad y = y^n + \frac{b}{1+b}u \ .$$

The only difference between these expressions and those from the pre-commitment solution is that there is now an inflationary bias, given by $k^M/b > 0$; output is the same.

Why does the inflation bias arise? Because the target level of output is higher than the trend value. Once wage contracts are signed, the central bank can increase output above trend by creating an inflation surprise. The central bank does this not out of self-interest but because society wants it to. Even though society as a whole desires this, however, individual agents have no incentive to allow their wages to be inflated away. Consequently, they set expectations and nominal wage demands accordingly. In equilibrium, the economy suffers from excessive inflation with no additional gains in output. It can be shown that the loss from the discretionary equilibrium is higher than it would be in the pre-commitment case. Thus, even though the central banker does what society wants him to do, the use of discretionary policy makes society worse off in equilibrium.

There are three points to note about equations 8 and 9. First, the inflation bias is a constant—it is not a random variable nor does it vary over time. Second, the bias does not depend on the output shock. Third, the stabilization response to the output shock u is the same in both the socially optimal solution and the discretionary solution. These features all come into play when discussing the optimal design of performance contracts.

RESOLVING THE TIME-INCONSISTENCY PROBLEM

Since the publication of the Barro and Gordon (1983a) paper, research has focused on ways of eliminating this inflationary bias. There have been two distinct directions of research: the reputation-building approach and the institutional-design approach.

Reputation Building

The reputation-building approach focuses on the use of "punishment" strategies by private agents to deter the central bank from generating the inflation bias. In these models, workers believe the central bank will follow a low inflation policy as long as it has not tried to surprise workers in the past. Otherwise, they "punish" the central bank by expecting a high inflation rate, which the central bank validates to avoid creating a recession. By using this type of mechanism, the private sector is able to persuade the central banker to develop a reputation for enacting the announced policy. Barro and Gordon (1983b) showed that reputation building would generate a lower inflation bias but would not eliminate it.

Barro and Gordon's early model of reputation was done under the assumption of perfect information. Subsequent research examined how robust the reputation-building approach was to information imperfections. Canzoneri (1985) showed that the economy would suffer inflation "cycles" due to occasional breakdowns in credibility if private agents were unable to separate exogenous inflation shocks from systematic policy actions. Backus and Driffill (1985), Barro (1986) and Rogoff (1987) showed that if private agents are unsure of the central banker's type—inflation hawk or dove—then a recession will frequently occur early in a central banker's term. This is because private agents' expectations of inflation are an average of the hawk's and the dove's equilibrium inflation rates. If the central banker is a hawk, inflation is set lower than expected and a recession occurs. If the central banker is a dove, he may act like a hawk and create a recession to build a reputation as a hawk. The reason is that if the dove inflates immediately, he reveals himself as a dove and inflation expectations will be higher for the remainder of his term in office. By acting like a hawk, he manages to keep inflation expectations low. The dove, however, eventually chooses to create an inflation surprise and expand output for a short period of time. Thus, while inflation is lower on average, output and inflation are more variable.

Although reputation models are able to generate lower equilibrium inflation rates, albeit at some cost of greater output variability, they have several unappealing aspects. First, there are an infinite number of punishment strategies that could be adopted, and it is not obvious which is the correct one to use. For example, how long should the punishment last?

Second, the multiplicity of strategies suggests that private agents would have to coordinate their actions to send a clear signal to the central bank as to how they would behave in the event that they are surprised. But how is such coordination to be achieved? Large, national trade unions may be sufficient for coordinating actions in some countries, but this is not a feasible solution in the relatively atomistic labor markets that characterize the U.S. economy.

Third, the reputation approach tends to focus on the personality and reputation of *individual* central bankers. Because individuals do not serve as the central banker for long periods in the real world, this approach suggests that there will be considerable uncertainty and variability of policy as central bankers turn over. Thus, we should focus on ways of developing the *institutional* reputation of the central bank instead of the reputation of individual central bankers.

Finally, the reliance on the private sector to enforce the appropriate path of monetary policy is a bit unpleasant from a public policy perspective. The reputation–building approach does not try to change the central bank's objective function directly; rather, it alters the central bank's behavior by making the policy choice dynamic, that is, by making today's policy actions have future consequences. But if the institutional structure of the central bank provides it with the wrong policy incentives, then it would seem prudent to change the institution rather than rely on private agents to solve the problem.

To illustrate this point, consider the response to airline hijackings. One way of dealing with hijackers is to arm the passengers and let them enforce peace on the airplane. This is akin to what the reputation approach does for the inflation bias. A better idea is to change the environment for boarding a plane so that the likelihood of a hijacking is reduced—hence, the use of metal detectors.

As a result of these problems with the reputation–based approach, researchers began to investigate institutional reforms for the central bank that would mitigate the inflationary bias.

Institutional Design

The institutional–design approach focuses on using legislative means to restrain the central bank from engaging in high-inflation policies. The intent is to manipulate the central bank's objective function directly through legislative action. Some work in this area has focused on legislation that restricts the day–to–day operating procedures of the central bank; other research shows how the appointment process for central bankers can be used to elicit better inflation performance. Advocates of the latter line of research recommend making the central bank independent from elected leaders as a means of reducing the inflationary bias.

Targeting Regimes

Legislative restrictions on the central bank often take the form of imposing monetary targeting or adopting simple rules (which are actually targeting regimes with a horizon of one period). The adoption of Friedmanesque k-percent rules has been studied by Alesina (1988) and Lohmann (1992). They show that these rules eliminate not only the inflationary bias, but also stabilization of output by the monetary authority. Hence, there is a trade-off between reducing inflation and stabilizing output. Simple rules dominate discretion when output shocks are small and relatively rare.[1]

Multi-period targeting horizons have been examined by Canzoneri (1985) and Garfinkel and Oh (1993). In these models, the central bank must follow policies so that the targeted inflation rate occurs *on average* over some time interval. In this environment, the central bank creates an inflation bias early in the targeting horizon, but it is smaller than it would have been in the absence of targeting. However, it produces sub-optimally low inflation (or even deflation) at the end of the targeting horizon to hit the targeted inflation or money growth rate. Stabilization is also sacrificed in the name of inflation, since shocks early in the period are not stabilized in an optimal fashion because those actions must be reversed later in the targeting period.

An implicit assumption in these targeting models is that the central banker's worst penalty for missing the target is dismissal (shooting him is not a realistic punishment). Consequently, the central banker's self-interest plays a large but hidden role in these types of models.

Conservative Central Bankers

The appointment and reappointment of a central banker who sets policy according to his own self-interest plays a large role in other institutional schemes for dealing with the inflation bias. Thompson (1981) and Rogoff (1985) proposed appointing a "conservative" central banker who dislikes inflation more than everyone else in society. A conservative central banker generates a lower inflationary bias but does so by not stabilizing the economy in a socially optimal fashion.[2] To illustrate this point, suppose that society appoints a central banker who puts more weight on inflation than it does. The central banker would then have a larger value of the parameter b in equation 3 to use in setting policy. From equations 8 and 9, however, we see that a larger value of b reduces the inflation bias but makes output more variable.

For the conservative central banker's policies to be credible, society must believe that he cannot be removed *ex post* by the current government. Thus, the central banker must have some degree of independence to pursue policies that are not desired by the current administration (and, implicitly, the electorate). Subsequent research by Flood and Izard (1989) and Lohmann (1992) showed that complete independence was not socially optimal—for certain bad states of the world, society benefits from firing the conservative central banker and stabilizing output.

A NEW INSTITUTIONAL DESIGN: PERFORMANCE CONTRACTS

A consistent theme of both the reputation-building and institutional–design models is that the inflation bias can be reduced or eliminated, but usually at the cost of having the central bank reduce its

1 Recently, Haubrich and Ritter (1995) have argued that this comparison between simple rules and discretion is biased in favor of rules, because it assumes that the choice between adopting a simple rule over discretion is a one-time decision. In fact, monetary authority has the option of waiting before committing to a k-percent rule, and this option has value that is typically ignored in the Alesina and Lohmann analyses. Thus, they argue that discretion is more likely to be preferred than is typically shown.

2 Faust (1994) has shown that the appointment of a central banker who prefers a lower trend inflation rate than the median voter can improve social welfare if the majority of voters are net nominal debt holders. Stabilization issues, however, are not studied in Faust's model.

emphasis on stabilizing output. Thus, there appears to be a trade-off between reducing average inflation and stabilizing the real economy.[3] Debate has centered on the relative benefits and costs of this trade-off in determining the goals of monetary policy, and the types of legislative restraints to place on the central bank.

Recently, however, a new idea has surfaced in the institutional-design literature for dealing with the inflation bias. The idea is to offer the central banker a performance contract, whereby the central banker's salary or the bank's budget is tied directly to the performance of important macroeconomic variables such as GDP and the inflation rate. By giving the central banker the proper financial incentives, these researchers have shown that the central bank can be induced to generate low inflation without forsaking its stabilization responsibilities.

Performance Contracts

Walsh (1995a) suggested that the monetary policy game be viewed as a *principal-agent problem*.[4] In a principal–agent model, one individual or group (the principal) delegates control over a policy variable to another individual or group (the agent). Although the principal would like the agent to set policy so that the principal's welfare is maximized, the agent has a different objective and opts for a policy that does not give the principal its most desired outcome. The solution to this problem is for the principal to offer the agent a contract that gives the agent the incentives to enact the policy desired by the principal.

By viewing monetary policy as a principal-agent model, Walsh redirected attention to the source of the problem—the central banker is confronted with a set of preferences that do not yield the outcome that society prefers most. So rather than worry about appointing conservative central bankers or adopting appropriate reputation strategies, Walsh argued that we should provide the central banker with the incentives to "do the right thing"—even if those incentives do not appear, at first glance, to be consistent with maximizing society's well-being. The problem is determining what those incentives should be.

Following the principal-agent literature, Walsh proposed offering the central bank a performance contract. This contract ties the central banker's personal compensation or the size of the bank's budget to the performance of the economy. Once the contract is signed, society encourages the central banker to pursue his own self-interest and adopt policies that increase his income or the bank's budget. The trick is to structure the contract in such a way that by trying to increase his own resources, the central banker maximizes social welfare in the process.

This approach is a radically different way to deal with policymakers. Under this institutional design, society exploits the pursuit of self-interest by the central banker to achieve the socially desirable outcome. This differs from the traditional view of appointing a benevolent central banker and then instructing him to do good. Under the performance contract approach, society essentially says: "You can do what you want, but you will pay personally for undesirable outcomes." Making the central bank accountable for its actions is a prominent theme of performance contracts.

Designing a Performance Contract

What does a performance contract look like? Consider the following compensation contract for setting the central banker's salary (w in equation 3):

$$w = s - \lambda\pi \ , \qquad (10)$$

where s denotes the central banker's base salary or the budget of the central bank. This contract specifies that the central banker be paid a base salary s, which will be reduced if any inflation occurs. The degree of salary reduction is determined by the parameter λ. A key feature of this contract is that it is based solely on the publicly observed inflation rate; it is not based

3 Empirical evidence on this point is mixed. For example, some researchers have shown that greater central bank independence is associated with lower average inflation rates but has no relationship with the variance of GDP. Other work has shown that countries with independent central banks tend to suffer greater output losses during disinflations, which suggests that there is a trade-off between reducing inflation and stabilizing output variability.

4 Persson and Tabellini (1993), working from an early draft of Walsh's paper, extended his approach to a more general framework.

on items that are unverifiable (such as how hard the central banker works).

Once the contract is in place, society tells the central banker to set policy in any manner he sees fit; there is no mention of pursuing the public good. Therefore, given equations 1, 3 and 10, the central banker chooses π to maximize

$$(11) \quad U^M = s - \lambda\pi - (y - y^n - k^M)^2 - b\pi^2.$$

This yields the following expression for the inflation rate:

$$(12) \quad \pi = \left(\frac{1}{1+b}\right)\left[k^M + \pi^e - \lambda - u\right].$$

Imposing rational expectations yields the following equilibrium solutions for inflation and output:

$$(13) \quad \pi = \frac{k^M - \lambda}{b} - \frac{1}{1+b}u$$

$$(14) \quad y = y^n + \frac{b}{1+b}u.$$

Given these expressions for what inflation and output will be when the central banker pursues his own self-interest, society would like to set the weight λ such that the expressions in 13 and 14 are exactly the same as those given by the precommitment solutions in equations 4 and 5. This result can be accomplished by setting:

$$(15) \quad \lambda = k^M.$$

By setting $\lambda = k^M$, the reduction in salary from creating an inflation surprise just offsets any benefits that would accrue from expanding output towards $y^n + k^M$. Hence, on the margin, the loss of income for the central banker is just equal to the utility gain from creating surprise inflation and expanding output, so he chooses not to create surprise inflation and no inflation bias occurs.

Furthermore, output and inflation are stabilized in the socially optimal fashion. The reason this can be accomplished is that the inflation bias is constant and independent of the output shock u. So a simple linear penalty for inflation is sufficient to deter the central bank from inflating. But the key point is that eliminating the inflation bias through appropriate incentives does not require the central banker's stabilization response to be distorted. Therefore, there is no cost for eliminating the inflation bias. By careful construction of the central banker's compensation, society is able to eliminate the inflation bias and have output optimally stabilized. This is indeed a pleasant result.

The contract could take a variety of different forms and still generate the optimal outcome. Every contract, however, must have the feature that the central bank pays more attention to inflation (or less attention to output) than society does. This simply reflects Rogoff's (1985) notion of a conservative central banker. The only difference is that in Rogoff's framework, society carefully selects a central banker who has the "right" personal attributes to reduce inflation, whereas the contract approach gives any arbitrarily chosen central banker the appropriate incentives to produce low inflation. In general, the principle of Rogoff's idea is still relevant; the issue is how to define "conservative."

Rogoff's definition of a conservative central banker was someone who put more weight on inflation relative to stable output. But we could define a conservative central banker as someone who has a lower inflation rate target or lower output target than the rest of society. In all cases, the central banker cares relatively more about inflation than output.

For example, consider the following performance contract:

$$(16) \quad w = s - 2k^M(y - y^n) + (k^M)^2.$$

In this example, society simply offers the central banker a contract that penalizes him if output is above the natural rate, plus adds a fixed amount to the base salary according to the magnitude of k^M. Substituting 16 into 3 and rearranging yields

$$(17) \quad U^M = s - (y - y^n)^2 - b\pi^2 .$$

The contract in 16 leads to an objective function for the central banker that is equivalent to appointing a central banker with a lower output target than the rest of society, since the parameter k^M disappears. With this contract the central banker will use discretion to produce the socially optimal outcome.

Alternatively, Svensson (1995) proposes a contract of the form:

$$(18) \quad w = s + 2b\pi^c\pi - b(\pi^c)^2,$$

where π^c is an arbitrary constant to be determined by society. Substituting 18 into 3 and rearranging yields

$$(19) \quad U^M = s - (y - y^n - k^M)^2 - b(\pi - \pi^c)^2.$$

If $k^M = k^S$, this contract looks very much like society's utility function except that the central banker's target inflation rate is now different from zero. Thus, the contract in 18 is observationally equivalent to appointing a central banker with a different inflation target than the rest of society's. A central banker with this contract will set policy such that, in equilibrium, inflation and output are given by

$$(20) \quad \pi = \frac{k^M}{b} + \pi^c - \frac{1}{1+b}u$$

$$(21) \quad y = y^n + \frac{b}{1+b}u .$$

Notice that in setting $\pi^c = -k^M/b$, we obtain the socially optimal solution. Thus, by having the central banker target a desired inflation rate of *minus* the inflation bias, society obtains its most preferred outcome. Because the central banker's targeted inflation rate is less than society's preferred rate, the central banker appears more conservative than the rest of society; in contrast to Rogoff's model, however, this type of conservative central banker does not cause stabilization to be sub-optimal.

The key point of this discussion is that offering the central banker a performance contract may be equivalent to appointing an appropriately defined conservative central banker. Once we realize this, there is no reason to believe that these central bankers will understabilize the economy.

IS TIME INCONSISTENCY THE SAME AS A PRINCIPAL-AGENT PROBLEM?

In the performance contract approach above, it was shown that appropriately chosen contracts can induce the central banker to produce the socially optimal outcome. This result was demonstrated without any reliance on the assumption that the central banker's output target was equal to society's. Walsh conducts his analysis under the assumption that society and the central banker have the same objective functions, that is, $k^M = k^S$. This assumption is common in the time-inconsistency literature, but is not consistent with the principal-agent model. Usually in a principal-agent problem, the agent has a different objective than the principal. A more classical depiction of the principal-agent problem would look like the following utility functions:

$$(22) \quad U^S = -(y - y^n)^2 - b\pi^2$$

$$(23) \quad U^M = w - (y - y^n - k^M)^2 - b\pi^2 .$$

With this formulation, society has preferences that are consistent with the socially optimal solution given in 4 and 5. The central bank, on the other hand, wants output to be higher than its trend value (for some unspecified reason). Thus, the central banker uses his discretionary powers to create an inflation surprise, thereby expanding output. Rational agents foresee this and adjust wages so that they are not fooled. The outcome is an inflation bias with no additional output gains.

Although the story is the same as the time-inconsistency model described above, there is one fundamental difference: Society does not want the central bank to try to expand output above trend. The central bank does so in pursuit of its own self-interest. This situation is what performance contracts were designed for: enticing a "misbehaving" agent to produce the principal's desired policy.

But if the performance contract generates the socially optimal outcome regardless of whether society and the central banker have the same output targets, why is it important to classify the problem as a time-inconsistency problem rather than a principal-agent problem? The reason is that if the policy game is described as the principal-agent problem as in equations 22 and 23 above, the credibility of contract enforcement is not an issue. The principal very clearly wants the socially optimal policy to be implemented and has every incentive to hold the central banker to the contract and not renegotiate it. But in the case in which the central banker is trying to give society what it wants, society is inconsistent—it wants higher output, which can only be achieved by being "fooled;" yet, society does not want to be fooled. If the central banker is maximizing social welfare, then society should renege on the performance contract once private agents set their wages—it should let itself be fooled. Since it is optimal ex post to renege on the performance contract, then private agents will never believe it changes the central banker's incentives, and we are right back where we started.

The credibility of contract enforcement raises an important point: Time-inconsistency and principal-agent relationships are not the same thing, even though performance contracts appear to solve both types of problems. Thus, one needs to be careful in using solution concepts interchangeably.

Enforceability of the performance contract corresponds to McCallum's (1995) second fallacy of central bank independence. McCallum argues that a performance contract "does not actually overcome the motivation for dynamic inconsistency; it merely relocates it" (p. 210). As long as the central banker is presumed to be maximizing social welfare, this argument is correct. But if the inflation bias is actually the result of a "true" principal-agent problem rather than a time-inconsistency problem, society can pre-commit itself to enforcing the contract.

Actually, McCallum's criticism of performance contracts is too strong. While it is correct to say that a perfect commitment technology or institutional design does not exist (for example, even the U.S. Constitution is not a perfect commitment to liberty because we can change it anytime we want), it is possible to make the costs of reneging on promises more costly and thus make monetary policy more credible. The basic idea of performance contracts, and the premise behind the entire institutional-design literature, is to increase the cost of reneging on a cooperative arrangement. Some institutions have low reneging costs (a policy target), while others have very high reneging costs (abolishing the Fed). By relocating the source of dynamic consistency, performance contracts attempt to increase the costs of reneging on low inflation promises.

A TALE OF TWO PRINCIPAL-AGENT PROBLEMS

In equations 22 and 23, the central banker has different objectives than society as a whole in that he wants to increase output above the current trend value. This mathematical form corresponds to the traditional principal-agent problem. But why would the central bank have an objective that differs from what society wants?

The answer to this question lies in the policy structure of most democracies. The general public elects a leader who either conducts policy himself or delegates the control of policy to someone else. Monetary policy typically falls in the delegation category. In the United States, for example, voters elect the President and members of Congress who, in turn, delegate the control of monetary policy to the Federal Reserve. Although they delegate control of monetary policy, the President and the Senate jointly determine who shall serve as the head of the Federal Reserve. Thus, there are typically three actors in any monetary policy model: the voters, the elected leaders and the central banker. In the time-inconsistency model, all of these actors are assumed to have the same objective. From a principal-agent perspective, however, the presumption is that they have differing objectives.

The "Rogue" Central Banker

Consider the following principal-agent problem. The voters and elected leaders have the same policy objective, given by equation 22, while the central banker has the objective function given in 23. In this case, the central banker is a "rogue" policymaker who sets policy to maximize his self-interest rather than society's or the elected leaders' and who, by doing so, creates an inflation bias.

Why would the central bank behave this way? Central bankers may want to maximize their amenities such as the number of staff members, the luxuriance of buildings and the size of travel budgets, all of which are funded by excessive seigniorage creation.[5] Or if the central bank is unduly influenced by a special interest group, say the banking/financial sector, it may pursue policies that benefit these sectors rather than society. Regardless of the source of the problem, performance contracts are a desirable way of dealing with it. Society and the elected leaders use a performance contract to rein in the central banker and make him accountable to the electorate (why elected leaders do not simply take control of monetary policy then is somewhat puzzling).

According to this scenario, central bank independence is an undesirable institutional structure. The performance contract approach can work only if the elected leaders have control over the central bank through the setting of budgets and salaries, and the ability to dismiss the central banker over policy actions. For example, Walsh (forthcoming) shows that if adjusting the bank's budget and salaries is infeasible, then threatening to dismiss the central banker if certain poor policy outcomes arise can replicate the equilibria supported by performance contracts. Walsh refers to these optimally designed threats as "dismissal contracts," since the central banker knows exactly which conditions will lead to his dismissal and agrees to such an arrangement.

The implications for central bank independence in this setting are very different from what is generally thought to be. Central bank independence is generally believed to be a crucial element of good inflation performance, and the empirical evidence to date is consistent with that view (see Alesina and Summers, 1993). Because of this theoretical and empirical evidence, legislation has been introduced around the world that aims at increasing the independence of central banks.

Why do the implications for central bank independence forthcoming from the principal-agent story described above differ so much from what is actually happening in the world? A likely explanation is that this principal-agent story is not the correct view.

Elected Leaders As Monetary Authority

Consider an alternative principal-agent problem proposed by Fratianni, von Hagen and Waller (1995). Suppose that voters face an agency problem with elected leaders. Voters want leaders to carry out policies consistent with their objective function in equation 22, but leaders may

[5] Actually, this would imply that the central banker has a different inflation rate target than society's rather than a different output target.

have incentives to misuse monetary policy for political reasons. For example, elected leaders may follow policies that benefit special interest groups or that further their short-run re-election chances. If unusually high levels of output increase an incumbent's chances of being re-elected, he may try to create surprise inflation to expand output above trend. Furthermore, significant partisanship in the policy process may lead to a redistribution of resources that does not promote the public good. These are all reasons the elected leaders may have an objective function similar to equation 23, if they controlled monetary policy directly.

If elected leaders have an incentive to misuse monetary policy, it is in society's interest to delegate policy to a non-political agent who will enact the policies desired by the general public. This agent would have society's objective function as his own. The problem is: How is this non-political agent chosen? Elections will not work since getting re-elected may be why policy is misused in the first place. The central banker needs to be appointed, but this is typically done by the elected leaders.[6] Thus, elected leaders can use appointment or the threat of non-reappointment to pressure the central bank into implementing policies aimed at helping the incumbent leaders. If the central bank's budget or the central bankers' salaries are under legislative control, then the central bankers can be pressured through budgetary cuts to pursue sub-optimal policies.

In this framework, the central bank would like to do the right thing but its immediate principal—the elected leaders—have objectives that differ from the general public. The elected leaders, not the central bank, need to be made accountable. Accordingly, society benefits by making the central bank as free of political interference as possible, since inflation will be reduced and output will be stabilized optimally. Thus, central bank independence is crucial for good monetary policy; without it, the central bank is merely a veil for political leaders. Anything that makes the central banker's appointment and budget less susceptible to political pressure will lead to better monetary policy.[7] This view of the principal-agent nature of monetary policy has led academic economists to support the movement toward greater central bank independence.

What would be the purpose of central bank performance contracts in this latter version of the principal-agent problem? If the elected leaders are the ones who write and enforce the central bank's performance contract, then they probably will not solve the problem. Clearly, enforcement of the contracts would lack credibility since elected leaders have an incentive to forgive any transgressions the central bank makes (as long as the transgressions benefit the elected leaders).

There is one potential benefit of using performance contracts in this environment. Performance contracts make policy more visible and the goals of the monetary authority more transparent. Presumably, this visibility would lead to better policy actions, since deviations from the socially optimal path would have to be explained publicly at specified intervals of time. Individuals who employ political pressure on the central bank would be brought into the public limelight and the personal costs to elected leaders from this attention, we hope, would deter them from putting pressure on the central bank. Furthermore, although it is a blunt instrument, the ballot box may provide enough credibility in the enforcement of the contract such that better macroeconomic performance would be achieved.

CONCLUSIONS

Although theoretically appealing, performance contracts may not be feasible in practice. In fact, political infeasibility may well be the reason we do not observe this type of institutional arrangement in the real world. Nevertheless, the performance contract research we see today could well turn out to be the foundation for the design of central banks in the 21st century. But we'll need to try a few experiments first to see how well they work in practice. New Zealand's recent reforms of its central

6 The interested reader should see Waller (1992, 1995) for an example of such an appointment process.

7 Waller (1992, 1995), Waller and Walsh (1995) and Alesina and Gatti (1995) show how reducing the degree of political influence in the appointment process can lead to superior macroeconomic outcomes.

bank structure seem to be very similar to a performance contract and may well be the test case we need. Evidence to date is sparse, but the reforms appear to have played a role in reducing inflation and inflation expectations.[8]

Future designs of central bank institutions will probably reflect a combination of independence and performance contracts. The result would be highly autonomous central banks that are clearly held accountable to the electorate. What more could we ask for?

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[8] See Hutchison (1995) and Spiegel (1995).

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Capacity Utilization and Prices Within Industries

Peter S. Yoo

The strength of the economic expansion during the past two years has renewed fears of accelerating inflation. As these fears have grown, people have turned to various statistics to substantiate any signs of rising inflation. Commodity prices, wages, sales-to-inventory ratios, civilian unemployment rates and capacity utilization rates are some of the statistics commonly used to predict the future path of inflation. These measures embody the basic idea of supply and demand: As the demand for scarce goods increases, their prices must also increase.

The staff of the Board of Governors of the Federal Reserve System measures capacity utilization as the ratio of industrial production to industrial capacity.[1] Since the denominator in this ratio normalizes industrial production by a measure of the potential industrial output of the economy, the ratio provides a cyclical measure of industrial output. The Board's measure of capacity assumes that a firm's or an industry's production capacity is fixed over some moderate time horizon, usually due to the quantity of the available plant and equipment stock. When firms attempt to produce beyond their "normal" levels, the cost of producing the additional output becomes increasingly expensive if the firm's production process exhibits diminishing returns-to-scale. The higher cost then translates into higher prices.

Most of the empirical researchers on this subject use total industrial capacity utilization and the consumer price index (CPI) or producer price index (PPI) finished goods-based measures of inflation. Since inflation is an aggregate phenomenon, their focus is undoubtedly justified. Yet, the economic analysis that links inflation to capacity utilization should apply to any product market, regardless of its size. Therefore, the relationship between price and capacity use should also be evident in industry level data—perhaps more so.

In this paper, I use two-digit standard industrial classification (SIC) industry measures of capacity utilization to explore the robustness of the relationship between capacity utilization and prices. The results suggest that such measures do not have a consistently strong and simple relationship with each industry's price data.

THE RELATIONSHIP BETWEEN PRICE AND CAPACITY UTILIZATION

Economists typically have used two frameworks to estimate the relationship between prices and the strength of economic activity. First is the supply curve, a relationship between prices and quantities. Shea (1993) finds that the supply curve of several four-digit SIC industries is upward sloping: Any increase in demand is met by a combination of additional output and higher prices. Over some moderate time frame in which firms have finite and fixed capacity, any increased production then implies higher rates of capacity utilization, which creates a positive relationship between price changes and capacity utilization.

The second and more common framework is a forecasting relationship between capacity and inflation. Such studies include Garner (1994), McElhattan (1978, 1985) and Finn (1995). Garner and Finn estimate simple linear equations in which the current rate of inflation is a function of previous periods' inflation and total industrial capacity utilization rates. McElhattan assumes there is a boundary point of total industrial capacity

[1] See *Federal Reserve Measures of Capacity and Utilization* (1978) and Shapiro (1992) for discussions about the construction of the series.

utilization, beyond which inflation increases or decreases, a concept analogous to the nonaccelerating inflation rate of unemployment. Therefore, she regresses changes in inflation on previous changes in inflation and on lagged capacity utilization rates. All three of these studies find a statistically significant relationship between total industrial capacity utilization rates and inflation.

The accompanying figures show the relationship between price changes and capacity utilization for 23 two-digit industries and three aggregate groups: total, mining and manufacturing industries.[2] The price changes in the figures are monthly percentage changes in each industry's net output price level without their seasonal components. (I used regressions with 12 monthly dummy variables to remove the seasonal component from each industry's monthly percentage price changes.) The finished goods producer price index is the price index associated with total industrial capacity utilization rates. The sample covers the period of 1987-94.

The figures yield mixed signals about the relationship between capacity utilization and prices. Total industrial and manufacturing capacity utilization rates seem to track price changes from late 1990 to early 1993, but otherwise show no obvious relationship. The mining aggregate shows volatile price changes, but with little connection to changes in capacity utilization. The 23 two-digit industries show similar ambiguity. Some industries, such as paper and fabricated metals, show an extremely close relationship between capacity use and percentage price changes. The figures for these two industries indicate that capacity utilization rates and price changes moved in tandem from 1987 to 1994. Other industries, such as the leather industry, show no discernible relationships between capacity constraints and price changes. Still others, like stone, clay and glass products, show signs of positive comovements for a portion of the sample period but not for the entire sample period.

[2] I do not use the term inflation when referring to industry data because inflation is an increase in the overall price level, while an increase in an industry's price level is not.

REGRESSIONS

I now turn to linear regressions to examine the ability of capacity utilization rates to forecast price changes within the context of a simple linear relationship. Current price changes are functions of past price changes and capacity utilization rates in forecasting equations:

$$\pi_t = f(\pi_{t-i}, cu_{t-i}),$$

where π_t is the monthly percentage change in an industry's net output price level, the π_{t-i}'s are lagged price changes, and the cu_{t-i}'s are that industry's current and lagged capacity utilization rate. Unlike in Shea's study, estimates of the above relationship cannot be interpreted as supply curves, because capacity utilization and price changes are equilibrium values determined by the intersection of the demand and supply schedules. This causes an identification problem because it is impossible to determine whether prices increased because the demand schedule shifted out or because the supply schedule shifted in. Still, many people estimate such relationships and use capacity utilization rates as sufficient indicators of future price changes. Indeed, the media and other popular sources of business news usually promote the idea that high current rates of capacity utilization indicate imminent price pressures.

Most macroeconomic data series have persistence, that is, current and past values are significantly related. Therefore, a regression that attempts to estimate the relationship between capacity utilization and price changes should include lagged values of price changes to account for their persistence rather than attributing it all to movements in capacity utilization. Including past price changes then allows one to estimate the marginal information contained in capacity utilization about current and future price changes.

Unfortunately, determining the number of lags to include in a regression is a problem. Including too many lags can reduce the precision of the estimated coefficients or yield spurious significant correlations, whereas using too few lags will not capture all of the persistence in the data. The Schwarz information criterion provides a way to capture the amount of persistence in price changes. It weighs the gains in explanatory power against the number of additional variables included in the regression, analogous to an adjusted R^2 measure. I use this criterion because Geweke and Meese (1981) found that it outperformed most others in the consistency of lag-length selection.

I therefore estimate a linear equation in which current price changes are functions of: previous price changes; capacity utilization rates using monthly percentage price changes; and capacity utilization rates that have had their seasonal components removed.[3] The sample starts in 1986 and extends through 1994. To determine the number of lags of price changes and capacity utilization for each regression, I use the Schwarz information criterion, allowing up to 24 lags of both price changes and capacity utilization rates. Table 1 shows the results of the search, in which an entry of zero indicates that only contemporaneous capacity utilization rates are included.

Table 1 shows that most two-digit industry price changes have a simple relationship with lagged price changes and capacity utilization rates. Eleven of the 23 industries appear to be well-described by their previous month's price change and contemporaneous capacity utilization. Among those industries with more complex relationships, only two industries—lumber and electrical machinery—show any link between additional lags of capacity utilization and current price changes. Moreover, none of the industries shows a noticeable relationship between current price changes and either lagged price changes or capacity utilization beyond three months.

Given the results in Table 1, I estimate the simple forecasting equations for the 23 two-digit industries and three aggregated groups (mining, manufacturing and total industrial). Each industry's equation includes the number of lags indicated by Table 1. In addition, I calculate the sum of the coefficients of the capacity utilization variables to measure the cumulative relationship between capacity utilization and price changes.[4]

Table 2 shows the regression results from estimating the above equation over the sample period of January 1986 through December 1994, with t-ratios in parentheses.[5] Two of the three aggregate groups, total industrial and manufacturing, indicate that current price changes are positively and significantly related (at the 5 percent level) to previous price changes, with a percentage-point increase in the previous month's price change associated with 0.38 and 0.47 percentage-point increases in current prices, respectively. The same two groups also show positive and statistically significant relationships with contemporaneous capacity utilization. The estimates indicate that a percentage-point increase in capacity utilization is associated with a 0.04 percentage-point increase in prices in the current period and just over a 0.06 percentage-point increase in the long run. While the effect is significant and has the correct sign, the size is an order of magnitude smaller than that of lagged price changes.

The regression results for the two-digit industries also reveal a strong relationship between current and previous price changes. Seventeen of 23 regressions show statistically significant relationships between current and lagged price changes, with 16 of the 17 industries statistically significant at the 5 percent level and coal mining significant at 10 percent. Most of the statistically significant relationships between current and lagged price changes indicate a positive and sizable correlation. On average, a 1.0 percentage-point increase in the previous month's price change is associated with a 0.30 percentage-point increase in current prices. The coefficients of the previous period's price change vary from -0.40 to 0.52, and the cumulative sums for multiple lags of price changes range from 0.10 to 0.79.

The relationship between current price changes and capacity utilization, however, is not as clear. Among the forecast equations for two-digit industries that include only contemporaneous capacity utilization, seven—furniture and fixtures, paper products, printing and publishing, rubber and plastic products, primary metals, fabricated metals and miscellaneous manufacturing—indicate statistically significant and positive coefficients at the 5 percent level, with one—textile mill products—at the 10 percent level. Together, these eight industries produce 26.5 percent of industrial output. The magnitudes of the coefficients are not very large, ranging from 0.01 to 0.02, noticeably smaller than the

[3] The Board of Governors does not release capacity utilization in a seasonally unadjusted form. It does, however, release industrial production seasonally unadjusted. Because the published capacity measure does not have a seasonal component, I define seasonally unadjusted capacity utilization as seasonally unadjusted industrial production divided by capacity. This measure allows me to filter the seasonality of price changes and capacity utilization rates in a similar manner, so any distortions introduced by the filter will be minimized.

[4] I did not consider first-differencing the data because none of the price change series indicate a unit root and, moreover, it seems unlikely that prices are I(2) processes.

[5] I use Newey-West robust standard errors when calculating the t-ratios to correct any remaining serial correlation of the residuals and heteroskedasticity.

typical coefficient on previous price changes. These estimates indicate that a 1.0 percentage-point increase in capacity utilization is associated with a 0.01-to-0.16 percentage-point increase in prices in the long run. The forecast equations for the two industries with lagged capacity utilization rates included in the regressions (lumber products and electrical machinery) show very small, statistically insignificant, cumulative relationships with current price changes.

Of course, it is possible that the number of lags included in these equations is not sufficient to capture the dynamic relationship between prices and capacity utilization, especially if the Schwarz criterion underestimates the number of lags.[6] To check the robustness of the specification, I also select a common forecasting equation for each of the industries, using three lags of price changes and contemporaneous-plus-three lags of capacity utilization. The additional lags allow some latitude for possible misspecification, but do not impose a large penalty for the number of additional regressors.

Table 3 shows the regression results from estimating the forecasting equation with the additional lags over the same sample period. Forecast equations for six of the two-digit industries—coal mining, printing and publishing, chemical products, leather products, primary metals and miscellaneous manufacturing—as well as total industrial and manufacturing aggregates, show statistically significant coefficients (at the 10 percent level) for the added capacity utilization lags. The sums of the capacity utilization coefficients suggest that the conclusions about the relationship remain essentially unchanged. Nearly all of the sums equal the single coefficient shown in Table 2, and with the exception of stone and earth minerals, stone, clay and glass products, and primary metals, the significance of the total estimated relationship between capacity utilization and price changes remains unaffected by the change in the forecasting equation's lag structure.

CONCLUSIONS

Two conclusions emerge from the analysis in this article. First, although the possibility of forecasting inflation based on the relationship between capacity constraints and prices is appealing, the evidence from two-digit industry data is weak. The simple forecasting results reported in this article have not identified strong, consistent relationships between prices and capacity constraints. Second, even among the industries with a statistically significant relationship, the size of the relationship is small. These results suggest that current price changes are the best indicators of future price changes, and that the forecasting information contained in the current period's capacity utilization rate is smaller in magnitude than the informational content of past price changes.

[6] Geweke and Meese (1981) found that although the Schwarz criterion was consistent in its estimation of lag-length selection, it can underestimate the lag length. They found the degree of underestimation to be very small, however.

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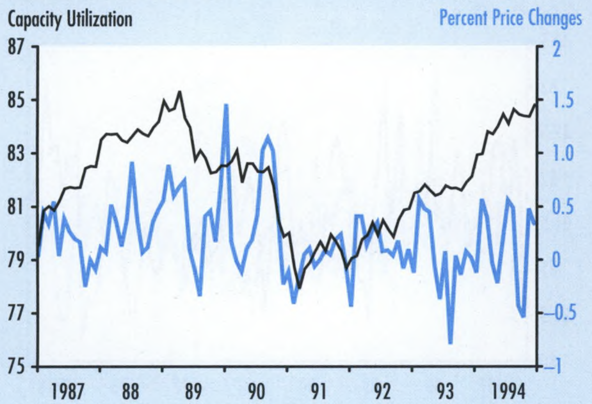
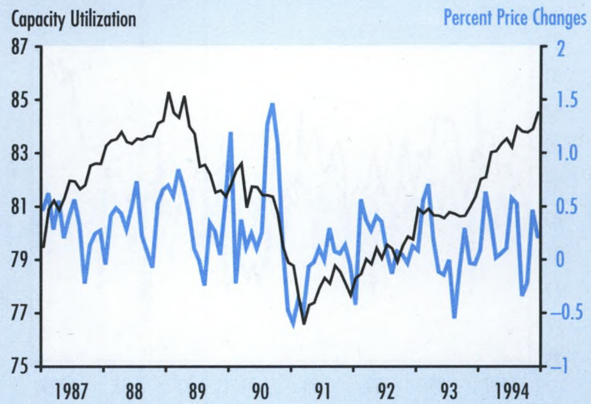
Capacity Utilization and Net Output Price Curves for Selected Industries

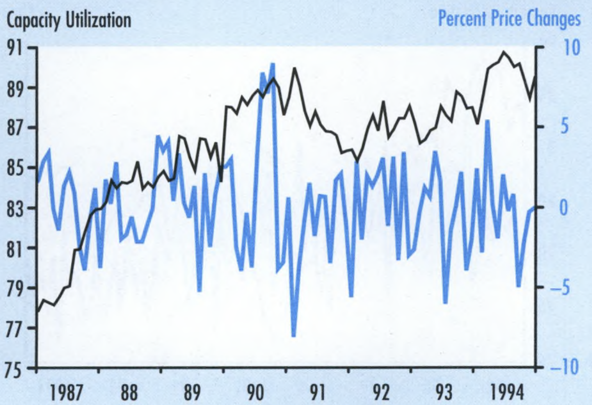
Total Industrial Capacity Utilization and Finished Goods PPI



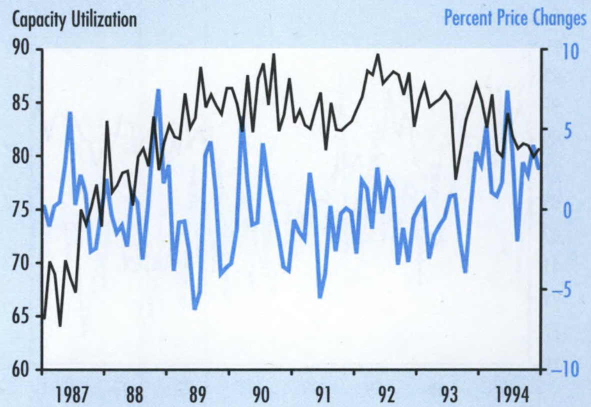
Manufacturing



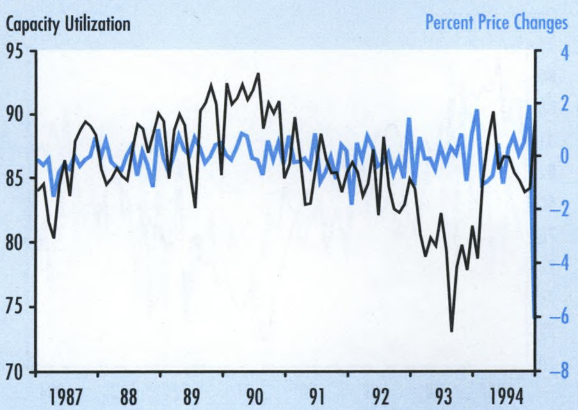
Total Mining



Metal Mining



Coal Mining



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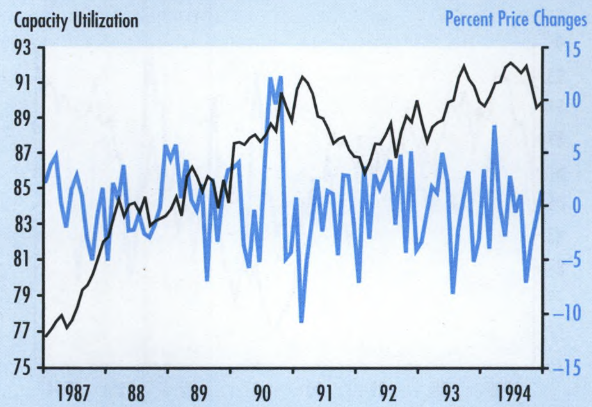
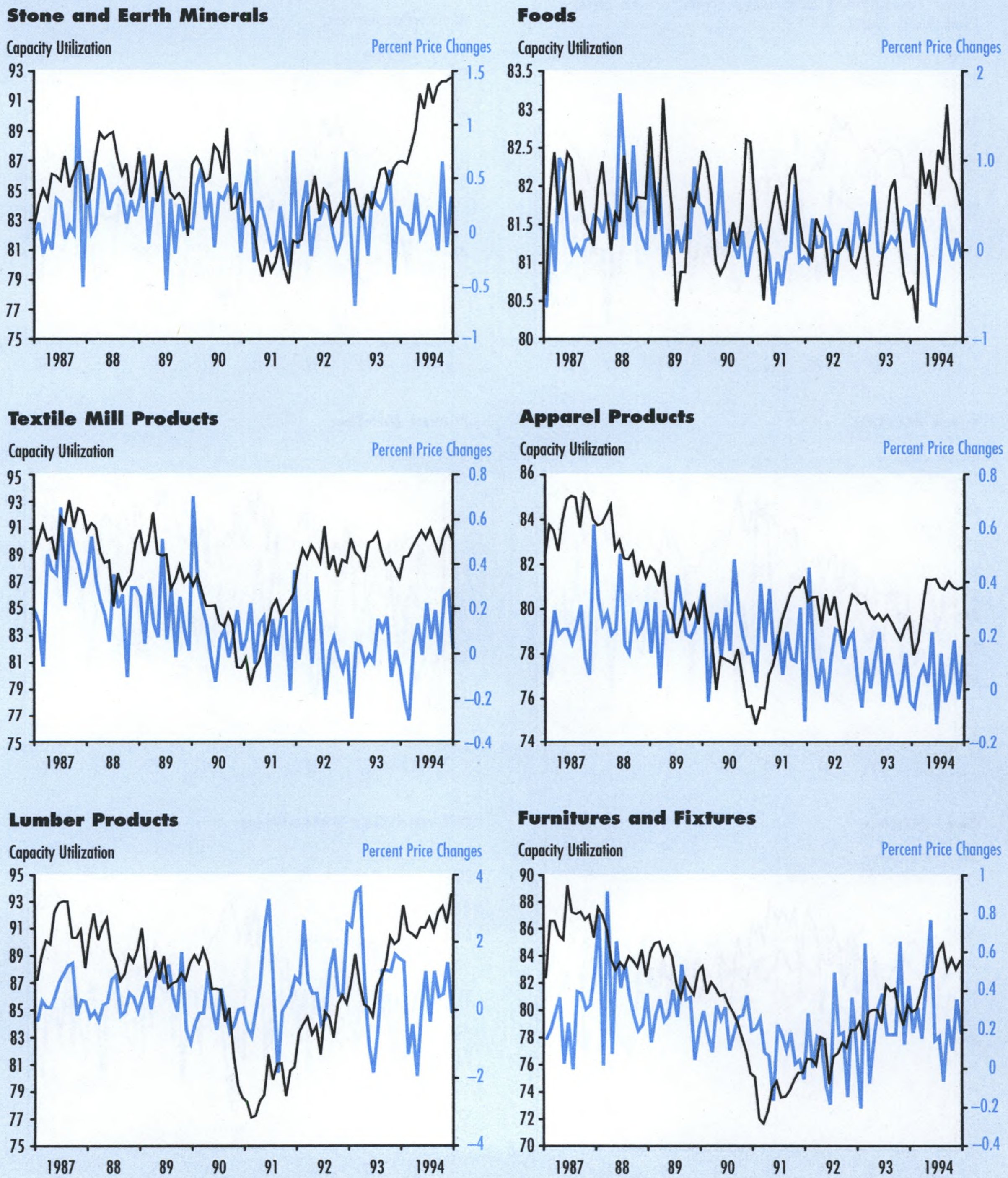
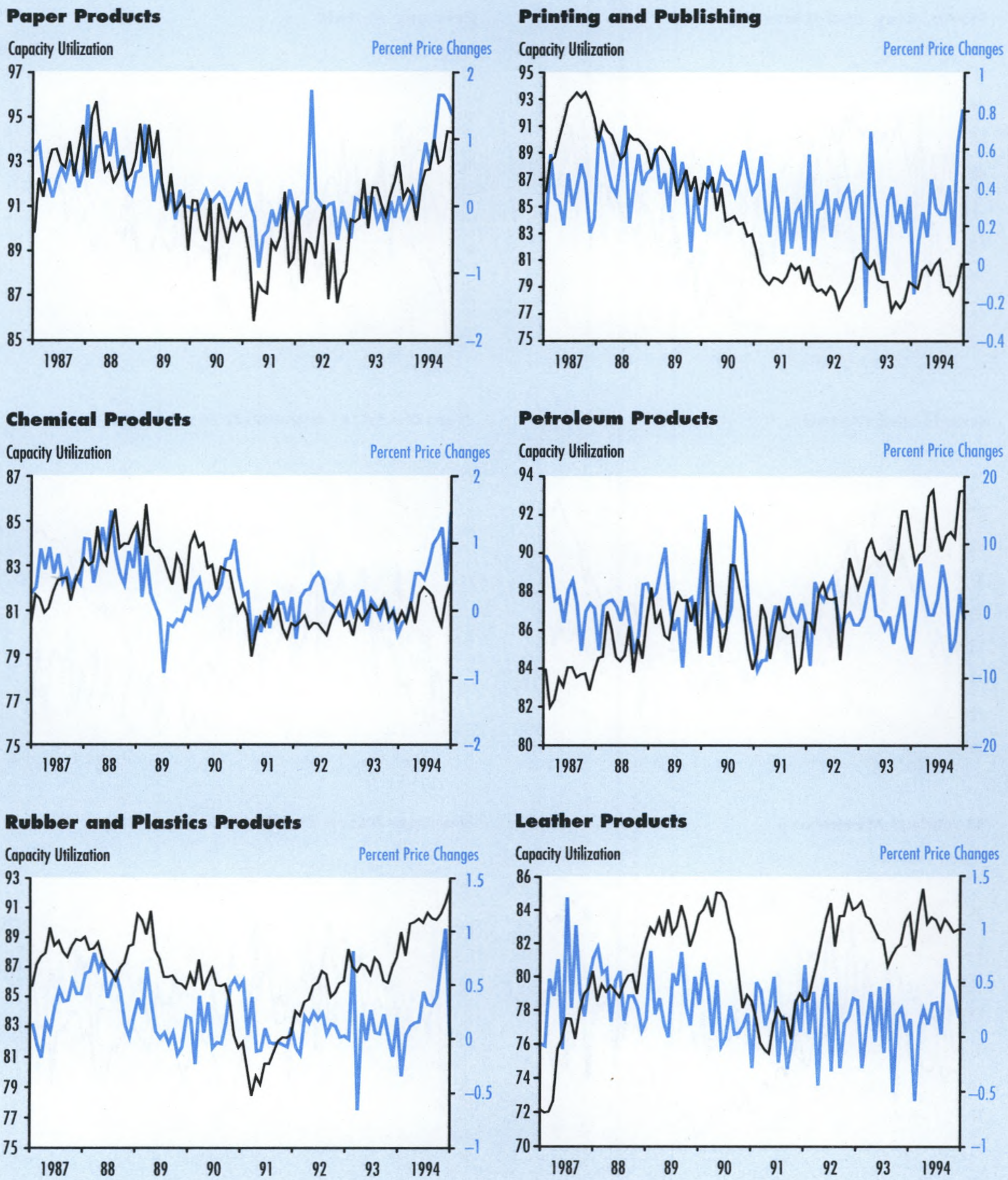


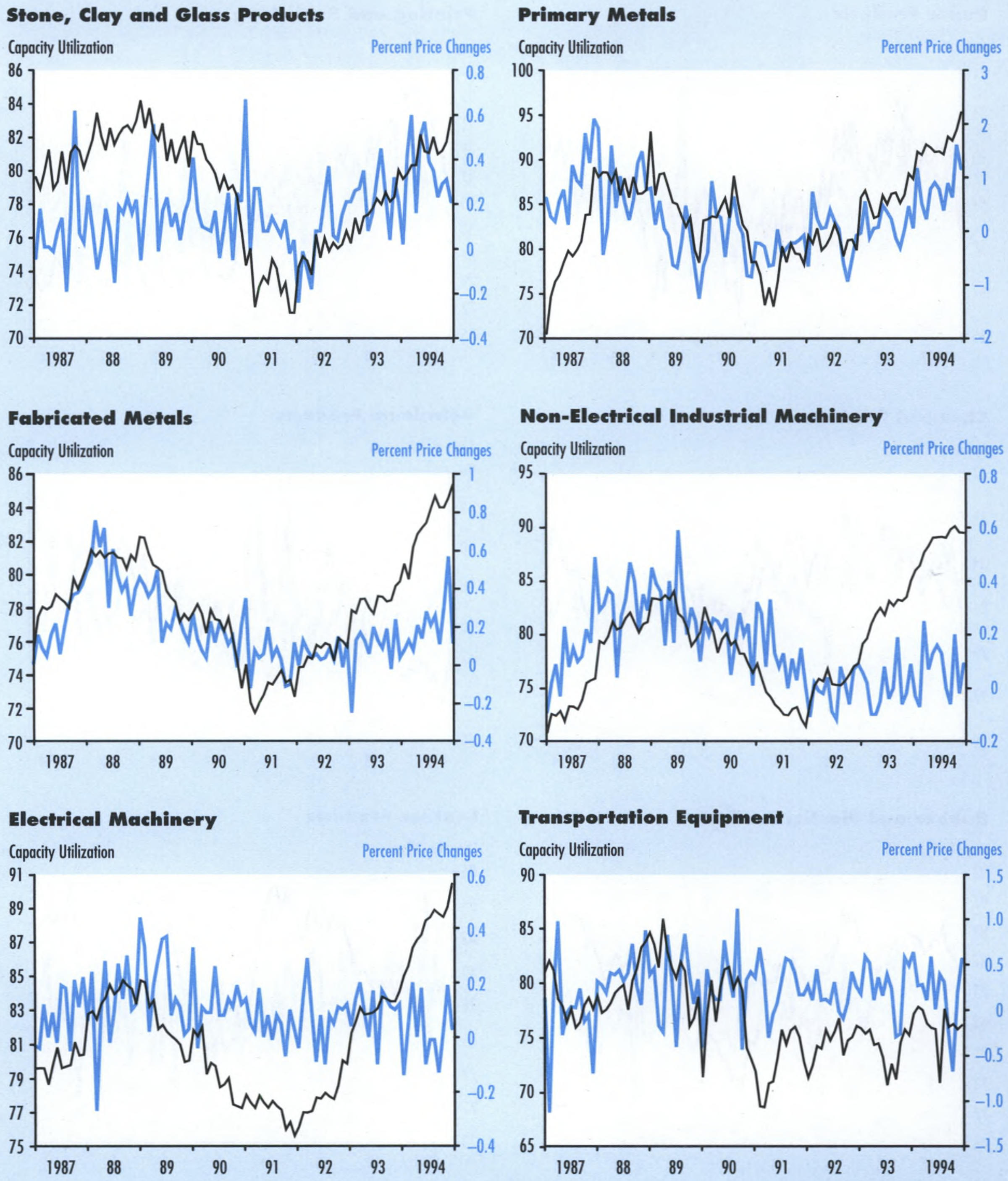
Capacity Utilization and Net Output Price Curves for Selected Industries



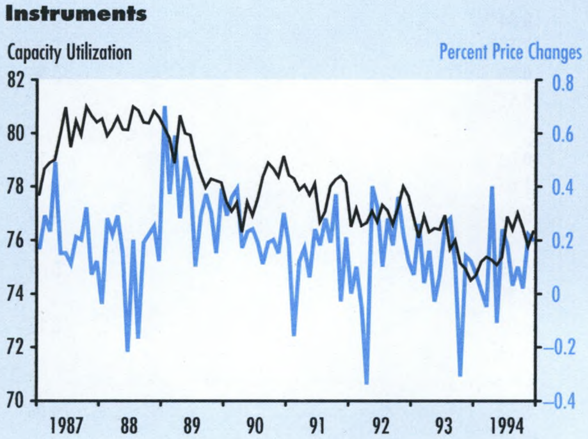
Capacity Utilization and Net Output Price Curves for Selected Industries



Capacity Utilization and Net Output Price Curves for Selected Industries



Capacity Utilization and Net Output Price Curves for Selected Industries



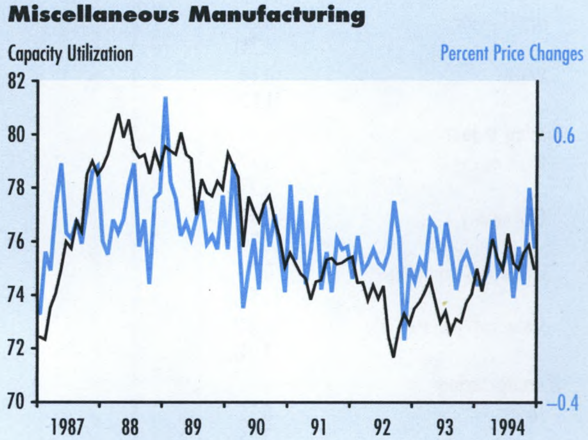


Table 1

Schwarz Information Criteria for Selecting the Number of Lags

Industry	Price Changes	Capacity Utilization Rates	Industry	Price Changes	Capacity Utilization Rates
Total industrial	1	0	Printing and publishing	1	0
Manufacturing	1	0	Chemical products	2	0
Mining	1	0	Petroleum products	1	0
Metal mining	1	0	Rubber and plastics products	2	0
Coal mining	1	0	Leather products	2	0
Oil and gas extraction	1	0	Stone, clay and glass products	1	0
Stone and earth minerals	1	0	Primary metals	1	0
Foods	1	0	Fabricated metals	3	0
Textile mill products	3	0	Non-electrical industrial machinery	3	0
Apparel products	3	0	Electrical machinery	1	3
Lumber products	1	2	Transportation equipment	1	0
Furniture and fixtures	2	0	Instruments	2	0
Paper products	2	0	Miscellaneous manufacturing	1	0

Table 2

Regression Summary, Variable No. of Lags – Price Changes by 2-Digit Industries: 1/86-12/94

	π_{t-1}	π_{t-2}	π_{t-3}	Sum π's	cu_t	cu_{t-1}	cu_{t-2}	cu_{t-3}	Sum cu's	R^2
Aggregate Groups										
Total industrial	0.38**				0.04**					0.23
	(3.74)				(2.17)					
Manufacturing	0.47**				0.04**					0.35
	(4.24)				(2.58)					
Mining	0.19				0.03					0.04
	(1.62)				(0.51)					
Mining Industries										
Metal mining	0.39**				–0.03					0.17
	(5.33)				(1.03)					
Coal mining	–0.40*				–0.01					0.09
	(1.70)				(0.40)					
Oil and gas extraction	0.19				0.02					0.04
	(1.56)				(0.32)					
Stone and earth minerals	–0.34**				0.01					0.12
	(4.04)				(1.16)					
Manufacturing										
Foods	0.25**				–0.02					0.06
	(3.05)				(0.41)					
Textile mill products	0.07	0.27**	0.28**	0.62**	0.01*					0.27
	(0.76)	(3.70)	(3.09)	(5.70)	(1.67)					
Apparel products	0.05	0.24**	0.25**	0.54**	0.00					0.16
	(0.60)	(2.95)	(3.46)	(5.53)	(0.66)					
Lumber products	0.46**				0.10**	0.10	–0.21**		–0.02	0.34
	(4.83)				(2.10)	(1.48)	(3.99)		(0.72)	
Furniture and fixtures	–0.12	0.22**		0.10	0.02**					0.17
	(1.25)	(2.00)		(0.67)	(3.13)					
Paper products	0.40**	0.22**		0.61**	0.06**					0.50
	(3.98)	(2.80)		(5.04)	(3.32)					
Printing and publishing	–0.08				0.01**					0.11
	(0.69)				(3.42)					
Chemical products	0.39**	0.36**		0.74**	0.04					0.53
	(4.10)	(3.68)		(8.81)	(1.55)					
Petroleum products	0.40**				0.15					0.18
	(3.52)				(0.94)					
Rubber and plastics products	0.18	0.37**		0.54**	0.02**					0.30
	(1.34)	(4.24)		(4.54)	(2.61)					
Leather products	–0.05	0.28**		0.23*	–0.00					0.09
	(0.63)	(2.98)		(1.81)	(0.42)					
Stone, clay and glass products	0.26**				0.01					0.10
	(2.75)				(1.51)					
Primary metals	0.52**				0.02**					0.39
	(5.07)				(3.07)					
Fabricated metals	0.11	0.35**	0.23**	0.69**	0.01**					0.58
	(1.04)	(3.73)	(2.92)	(6.10)	(3.26)					
Non–electrical machinery	0.21**	0.32**	0.26**	0.79**	0.00					0.44
	(2.72)	(4.08)	(3.26)	(12.81)	(0.93)					
Electrical machinery	–0.00				0.01	–0.04**	0.01	0.02	0.00	0.06
	(0.04)				(0.66)	(2.00)	(0.21)	(1.18)	(0.45)	
Transportation equipment	–0.08				0.01					0.01
	(0.70)				(0.63)					
Instruments	0.07	0.18		0.25*	0.02					0.08
	(0.97)	(1.62)		(1.70)	(1.49)					
Miscellaneous manufacturing	0.14				0.02**					0.16
	(1.62)				(3.07)					

t-ratios in parentheses. * denotes significance at 10 percent. ** denotes significance at 5 percent.

Table 3

Regression Summary, Fixed No. of Lags – Price Changes by 2-Digit Industries: 1/86–12/94

	π_{t-1}	π_{t-2}	π_{t-3}	Sum π's	cu_t	cu_{t-1}	cu_{t-2}	cu_{t-3}	Sum cu's	R^2
Aggregate Groups										
Total industrial	0.34**	–0.05	–0.10	0.19	–0.01	0.18**	–0.15**	0.02	0.04**	0.21
	(2.93)	(0.46)	(1.19)	(1.48)	(0.17)	(1.97)	(2.06)	(0.45)	(2.90)	
Manufacturing	0.46**	–0.20*	0.03	0.28**	0.05	0.08	0.02	–0.12**	0.04**	0.35
	(2.69)	(1.88)	(0.30)	(2.32)	(1.21)	(1.14)	(0.28)	(2.64)	(3.07)	
Mining	0.13	0.07	–0.05	0.15	0.28	0.13	–0.41	0.00	0.00	0.06
	(0.97)	(0.90)	(0.52)	(1.06)	(1.07)	(0.38)	(0.83)	(0.01)	(0.02)	
Mining Industries										
Metal mining	0.47**	–0.22*	–0.02	0.24**	–0.04	0.01	–0.06	0.05	–0.04	0.21
	(5.93)	(1.93)	(0.20)	(2.12)	(0.48)	(0.06)	(0.66)	(0.43)	(1.52)	
Coal mining	–0.42*	–0.12	0.05	–0.49	–0.06	0.02	0.01	0.05**	0.02	0.15
	(1.88)	(1.18)	(0.54)	(1.55)	(1.36)	(0.77)	(0.20)	(2.58)	(0.71)	
Oil and gas extraction	0.12	0.07	–0.09	0.09	0.86**	–0.56	–0.16	–0.15	–0.01	0.08
	(0.90)	(0.91)	(1.00)	(0.61)	(2.46)	(0.95)	(0.27)	(0.42)	(0.13)	
Stone and earth minerals	–0.32**	–0.03	0.06	–0.28	–0.02	0.03	–0.00	0.01	0.02*	0.14
	(3.24)	(0.29)	(0.70)	(1.37)	(1.35)	(1.62)	(0.01)	(0.38)	(1.78)	
Manufacturing										
Foods	0.21**	0.09	–0.06	0.24*	–0.02	–0.04	0.10	–0.02	0.02	0.07
	(2.44)	(1.04)	(0.40)	(1.89)	(0.27)	(0.49)	(1.09)	(0.30)	(0.34)	
Textile mill products	0.07	0.27**	0.26**	0.61**	–0.00	0.01	0.01	–0.01	0.01*	0.29
	(0.80)	(3.58)	(3.00)	(5.33)	(0.21)	(0.81)	(1.12)	(1.05)	(1.90)	
Apparel products	0.04	0.24**	0.25**	0.53**	0.00	–0.01	0.01	0.01	0.00	0.17
	(0.49)	(2.92)	(3.60)	(5.19)	(0.12)	(0.67)	(0.31)	(0.59)	(0.82)	
Lumber products	0.48**	–0.13	–0.04	0.31**	0.10**	0.11*	–0.14**	–0.09	–0.02	0.37
	(4.00)	(1.09)	(0.41)	(2.16)	(2.27)	(1.68)	(2.06)	(1.62)	(1.08)	
Furniture and fixtures	–0.22*	0.15	0.04	–0.02	–0.01	–0.01	0.02	0.02	0.02**	0.24
	(1.74)	(1.52)	(0.35)	(0.15)	(0.54)	(0.58)	(1.14)	(1.46)	(4.33)	
Paper products	0.35**	0.17**	0.05	0.56**	0.03	0.05	0.01	–0.00	0.08**	0.52
	(3.36)	(2.24)	(0.60)	(3.53)	(1.25)	(1.59)	(0.23)	(0.07)	(3.32)	
Printing and publishing	–0.12	–0.03	0.10	–0.05	0.03*	–0.06**	0.00	0.05**	0.01**	0.25
	(1.00)	(0.35)	(1.00)	(0.26)	(1.97)	(3.51)	(0.05)	(3.17)	(3.29)	
Chemical products	0.42**	0.47**	–0.15	0.74**	0.07*	0.07	–0.09**	–0.02	0.02	0.57
	(4.97)	(4.53)	(1.61)	(9.42)	(1.80)	(1.26)	(2.58)	(0.64)	(1.08)	
Petroleum products	0.43**	–0.21**	0.10	0.32**	0.27	–0.30	0.34	–0.29	0.03	0.17
	(3.31)	(2.19)	(0.83)	(2.74)	(1.27)	(0.76)	(0.56)	(0.73)	(0.19)	
Rubber and plastics products	0.11	0.32**	0.07	0.49**	0.00	–0.02	0.03	0.02	0.03**	0.34
	(0.67)	(4.47)	(0.58)	(4.21)	(0.15)	(0.64)	(0.60)	(0.76)	(3.34)	
Leather products	–0.09	0.27**	0.11	0.29**	0.01	0.01	0.03	–0.05**	–0.01	0.17
	(1.06)	(3.19)	(1.57)	(2.66)	(0.46)	(0.49)	(1.31)	(2.95)	(1.15)	
Stone, clay and glass products	0.20**	–0.00	0.25**	0.45**	–0.01	–0.00	0.00	0.01	0.01*	0.17
	(2.37)	(0.03)	(2.44)	(2.86)	(0.25)	(0.08)	(0.10)	(0.88)	(1.71)	
Primary metals	0.41**	0.01	0.15	0.58**	0.07**	–0.00	–0.01	–0.04**	0.01	0.45
	(4.60)	(0.08)	(1.36)	(4.61)	(3.10)	(0.18)	(0.32)	(2.08)	(1.24)	
Fabricated metals	0.09	0.39**	0.24**	0.72**	0.04**	–0.03	–0.00	0.01	0.01**	0.60
	(0.91)	(4.67)	(3.10)	(5.56)	(2.10)	(1.36)	(0.22)	(0.80)	(2.61)	
Non–electrical machinery	0.21**	0.31**	0.27**	0.79**	–0.01	0.02	–0.01	0.00	0.00	0.45
	(2.61)	(4.34)	(3.51)	(10.91)	(0.58)	(1.10)	(0.77)	(0.01)	(0.81)	
Electrical machinery	–0.03	0.13	0.20**	0.30**	0.01	–0.03**	0.00	0.02	0.00	0.11
	(0.25)	(1.33)	(2.76)	(2.09)	(1.07)	(2.02)	(0.01)	(1.09)	(0.52)	
Transportation equipment	–0.08	–0.20**	0.03	–0.25	–0.01	0.01	–0.02	0.03	0.01	0.07
	(0.75)	(2.28)	(0.45)	(1.31)	(0.34)	(0.35)	(0.77)	(1.18)	(0.99)	
Instruments	0.05	0.17	0.09	0.31**	0.02	–0.03	0.01	0.02	0.02	0.10
	(0.68)	(1.51)	(1.38)	(2.20)	(0.86)	(1.22)	(0.39)	(0.86)	(1.61)	
Miscellaneous manufacturing	0.14	0.11	–0.16	0.10	0.03*	–0.01	0.02	–0.02*	0.02**	0.25
	(1.50)	(1.31)	(1.58)	(0.78)	(1.92)	(0.47)	(0.89)	(1.74)	(3.17)	

t-ratios in parentheses. * denotes significance at 10 percent. ** denotes significance at 5 percent.

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Deflation and Real Economic Activity Under the Gold Standard

Christopher J. Neely and Geoffrey E. Wood

In the past few years, several countries have announced explicit target ranges for inflation. New Zealand did this in 1990, Canada in 1991, the United Kingdom in 1992, and Sweden and Finland in 1994. Even when an inflation target is achieved, the future price level is not easy to predict because none of these countries has committed itself to reversing the consequences of shocks to the price level. Indeed, in New Zealand there is an explicit commitment *not* to reverse certain such shocks.

One alternative to inflation targeting is price level targeting.[1] The adoption of a constant price level target would have several advantages over an inflation target. Chief among these is that consumers and firms could write simpler contracts and make long-run plans without worrying about inflation. Price level targeting also may avoid the "time-inconsistency" problem of an inflation targeting regime in that the monetary authority would have less incentive to inflate the economy in a one-time bid to increase output temporarily. Under a price level target, any "surprise" inflation must be reversed.

Critics of price level targeting argue that making a commitment to reverse surprise increases in the price level is undesirable because a fall in the general price level, or deflation, can have harmful effects. One such critic, Stanley Fischer, put it this way:

> "I argue for the inflation target because I fear the consequences of having to aim to deflate the economy half the time, which is what the price level approach requires."[2]

Since the end of World War II, year-over-year declines in the price level have been rare in the industrialized world; during the period of the gold standard, however, both long downward trends in the price level and much shorter periods of falling price levels were common.[3] Ironically, although Irving Fisher advocated a price level target precisely to avoid the protracted downward (and upward) swings in the price level observed under a gold standard, the experience of this period provokes, in part, the criticism of price level targeting today. Perhaps more important for these beliefs about deflation is the deflationary period (not examined here) from 1929 through 1933, in which the price level fell by 20 to 30 percent. Bernanke (1995) argues persuasively that this price decline, caused by the U.S. determination to stay on the gold standard, was a major contributor to the severity of the Great Depression. This article reexamines the facts surrounding temporary periods of deflation that occurred under the gold standard from 1870 to 1913. We first describe the behavior of price, money and output data, then perform some simple tests to determine whether output growth grew more slowly during periods of falling prices and whether knowledge of a falling price level would, in fact, have helped predict lower output growth. Although we must be cautious about drawing conclusions from 100-year-old data generated under a much different monetary regime, another look at this experience is warranted because several countries have adopted policies that are likely to be associated with temporary periods of deflation.

The next section briefly reviews why deflation may affect real output. A description of our data set and an explanation of our statistical tests follow. We then report the results of our tests, before concluding with some ideas for future work.

[1] A price level is a weighted average of prices in a country. Price level targets may be either constant over time (static) or have a trend. In this paper, we will use price level targeting to refer to a static price level target. The shaded insert on pp. 34 and 35 distinguishes price level and inflation targets.

[2] *The Financial Times*, June 24, 1994. Note that Fischer refers to a static price level target. A price level target with a positive trend would only require the monetary authority to "disinflate" half the time, that is, to run a rate of inflation below the long-run trend.

Disinflation is not the only potential drawback of price level targets. Some oppose them because they might lead to greater short-run volatility in the inflation rate.

[3] Periods in which prices fall on a year-over-year basis are considered periods of deflation.

PRICE STICKINESS, DEFLATION AND OUTPUT

It is now widely accepted that there is no long-term trade-off between inflation and output or employment; the existence of a short-run trade-off, on the other hand, is not generally denied. There are several explanations for this trade-off: lags between actual and expected inflation (see Hume, 1752; Fisher, 1926; and Friedman, 1968); misperceptions about relative and general price shifts (Lucas, 1972); and staggered wage or price setting (Fischer, 1977; Taylor, 1980).[4] None of these theories, however, predicts that lowering the price level is more costly than lowering inflation. Nevertheless, prices have not fallen (by anything more than a trivial amount) in any major economy since 1945.

The means by which deflation might reduce output, however, are often not explicitly stated.[5] One view is that deflation interferes with the adjustment of relative prices because nominal wages or some prices do not adjust downward easily. If wages and/or prices are sticky downwards, a negative demand shock will tend to cause persistent unemployment as prices and wages are slow to fall as required to clear markets. With a sufficiently high inflation trend, relative prices can adjust to a negative demand shock without any actual prices having to fall. Because markets work better with a little inflation, according to this view, output will be less variable over business cycle horizons and, perhaps, even higher in the long run.

Critics of the theory of downward price rigidity point out that many wages and prices do, in fact, decrease, and that the extent to which prices are sticky depends on whether people expect inflation. An atmosphere of overall price stability will make people more willing to accept reductions in their wages or prices.

There is mixed evidence from microeconomic data on the idea that prices are sticky; certainly, some prices change more frequently than others. There is, however, little evidence of asymmetry in price stickiness.[6] Blinder (1991) presents the results of a survey in which firms report asymmetric price rigidity. He finds greater upward rigidity. Nevertheless, despite evidence to the contrary, many economists continue to believe that some prices are inflexible downward and that even temporary periods of deflation might reduce output through this channel.[7]

Bernanke and James (1991) argue that deflation might alternatively affect the economy by increasing the real value of nominally denominated debt. For example, a 2 percent annual deflation would translate a nominal interest rate of 4 percent into a real interest rate of 6 percent. Increasing the real rate of interest might promote debtor insolvency and financial distress.

The opposition to price level targeting from those who fear the results of deflation, either because of downward price rigidity or the consequences of debt-deflation, makes the study of the historical association between output and deflation worthwhile. A review of the evidence would be a first step in considering whether a central bank should now adopt a price level target.

THE RELATION BETWEEN PRICE AND OUTPUT GROWTH DURING THE GOLD STANDARD ERA

We use two sets of data. The first consists of 44 annual observations on money, prices, interest rates and output in the United Kingdom from 1870 to 1913. The period 1880-1913 is generally considered the heyday of the classical international gold standard. We end the sample before the beginning of World War I in 1914. The source for the monetary series is Capie and Webber (1985).[8] The interest rate is a short-term one from the last quarter of each year. The output series is Feinstein's (1972) compromise estimate of GDP and, therefore, his implicit price deflator is used as the price series.[9] All data are annual to conform to the necessity of using annual GDP data.

The second data set consists of 44 annual output and inflation observations (1870 to 1913) from nine of 10 industrialized countries compiled for comparison of international business cycles by Backus and Kehoe (1992), from which more complete description of the data is available.[10]

[4] An excellent review of these issues can be found in McCallum (1989), Chapter 9. Ohanian and Stockman (forthcoming) consider the consequences of monetary shocks for the economy when some, but not all, prices are sticky. That paper also sets out several explanations for price stickiness in addition to those reviewed in McCallum.

[5] Barro (1995) finds benefits of lower inflation in the form of higher long-run growth in a cross-country study. Here, we are concerned with short-run effects.

[6] See Wynne (1995) for a survey of price stickiness and Craig (1995) for evidence on wage rigidity.

[7] Advocates of this view might point out that real wages rose substantially during the severe deflation of the Great Depression.

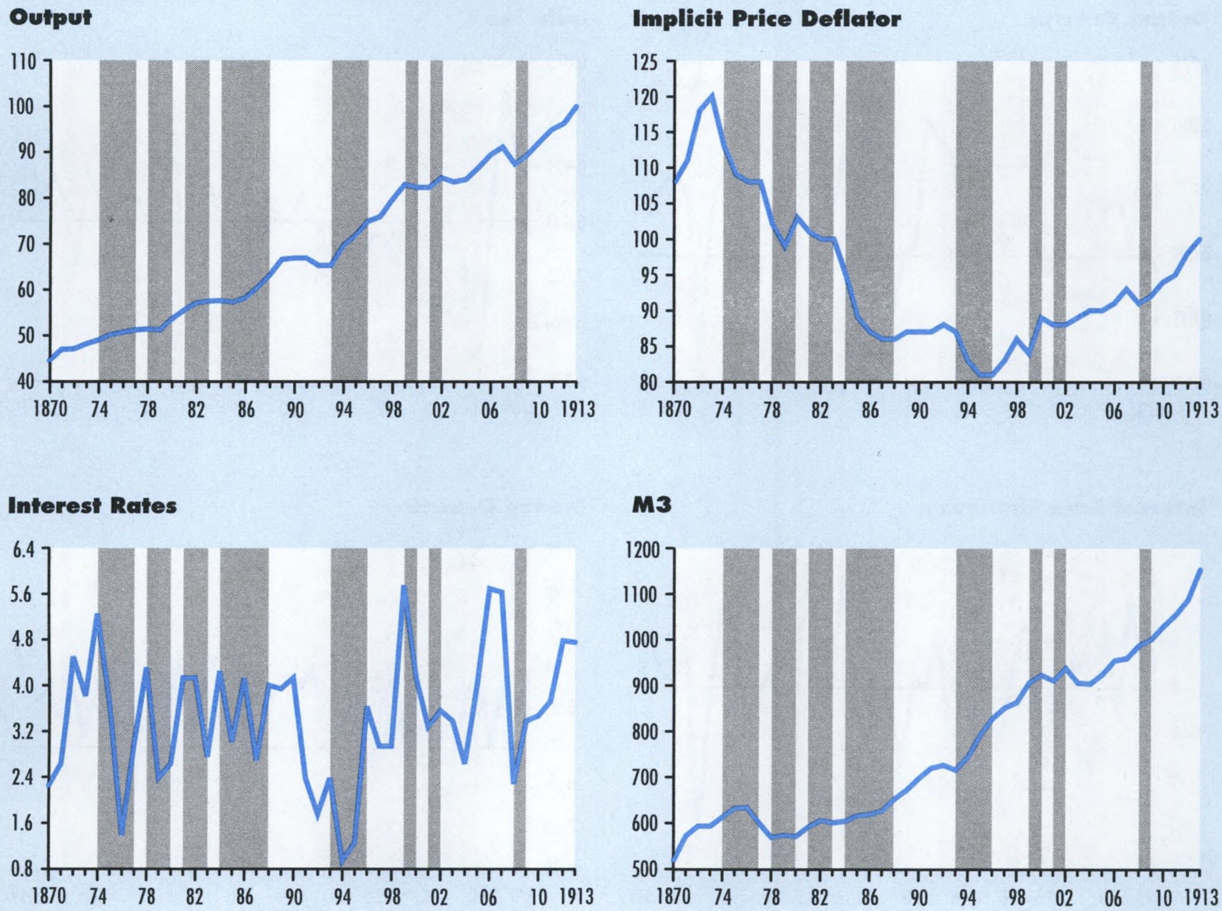
[8] Various series existed before publication of that volume, but they had deficiencies that were remedied (as well as some new data permitted) by Capie and Webber. See Capie and Webber for discussion of previous series deficiencies and how they are remedied. The crucial point is that these previous series contained a spurious trend.

[9] There has recently been some discussion of the reliability of that output series—see the interchange between Greasley (1986, 1989) and Feinstein (1989), and the discussion in Crafts, Leybourne and Mills (1989)—but there seems to be general agreement that whatever its deficiencies, it is the best available.

[10] We dropped Japan from the sample because it did not have a metallic standard during the 19th century and because its national banking and financial system was just forming (see Backus and Kehoe, 1992). Uniquely, Japan's growth under falling prices (5.4 percent) was substantially higher than its growth under rising prices (1.5 percent).

Figure 1

Time Series of the Levels of the United Kingdom Data



The Time Series

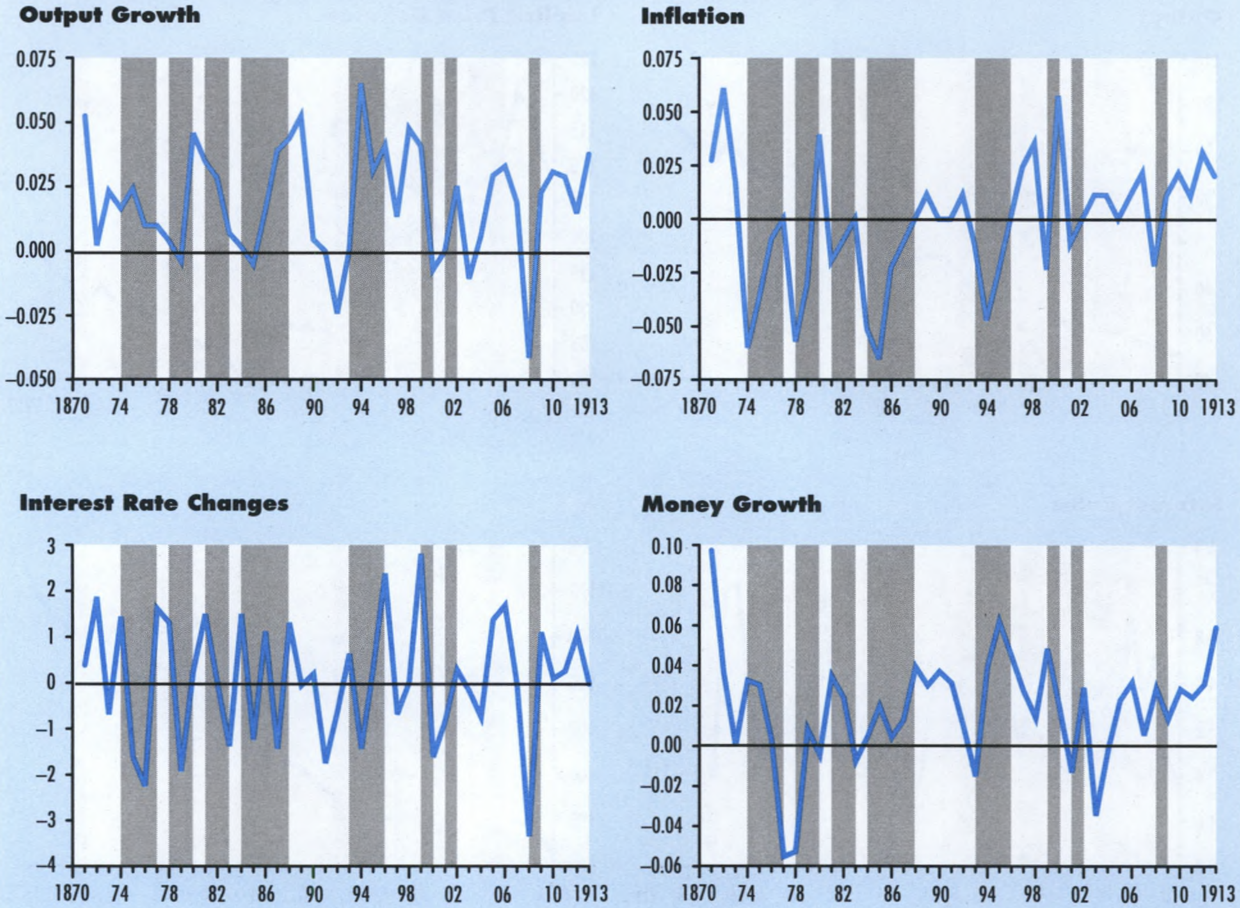
Figures 1 and 2 display the time series of the log levels and log differences of the four United Kingdom series from 1870 to 1913. The shading in the figures represents periods in which the price level fell (not periods of recession). The monetary series, M3, and the output series generally grew over time. The price deflator series does not display the consistent rise typical of modern price indices; rather, periods of rising and declining prices seem to be nearly equally common. The long downward trend in the price level until 1896, followed by an upward swing through the end of the sample in 1913, was caused by fluctuations in the world supply of and demand for gold. For example, the downward drift in prices until 1896 was partly due to the United States and France returning to the gold standard, raising the demand for and price of gold. The nominal interest rate seems to display typical cyclical fluctuations around a stationary mean.

Inflation and Output During the Two Subperiods

Figure 3 shows the higher average rates of inflation, displaying a scatterplot of the mean rates of output growth vs. mean inflation rates for each of nine countries from the Backus and Kehoe data set for each of the two subperiods (1870-96 and 1897-1913). The figure shows that average inflation rates were uniformly lower in the first period (1870-96) than they were in the second period (1897-1913).

Figure 2

Time Series of the Differences of the United Kingdom Data



Consistent with the idea that deflation reduces output growth, the mean levels of output growth also appear to be lower during the first period. Curiously, across countries there seems to be a negative relationship between output and price changes in the first period and a positive relationship in the second.

Output Growth and Deflation Over Short Horizons

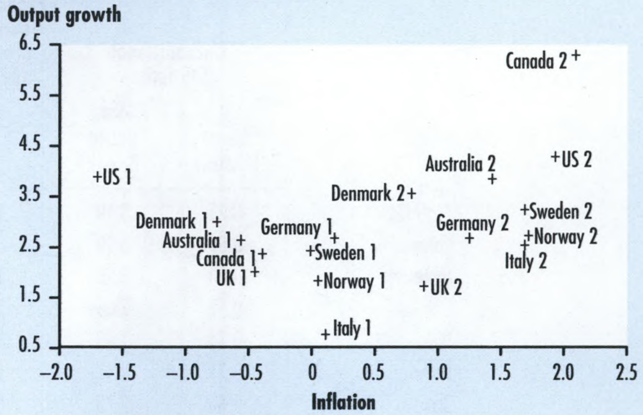
Examining inflation and output growth over the two long subperiods is a convenient way to examine the relationship between average inflation and average output growth over longer periods. It does not, however, get directly at the question of whether price declines were associated with lower output growth over short periods. To see this, we sort the data on output growth by the rise or fall of prices. For the purpose of categorization, we define a deflationary period as any year in which prices fell; we make no distinction between the episodes on the basis of length, severity or cause. For the United Kingdom data, five of nine deflationary episodes lasted more than one year, and three lasted more than two years.

Table 1 (page 32) provides some summary statistics for data from the nine countries used by Backus and Kehoe for the period 1870-1913. The first two columns provide the unconditional means of output growth and inflation. The third column shows the percentage of the time that prices were rising during the sample period. Mean price declines were of comparable magnitude to mean price rises, and periods of mild price rises were only slightly more common than periods of declining prices; the data show that prices rose about 46-67 percent of the time during the sample.

Figure 4 is analogous to Figure 3 in that it depicts mean output growth for the nine countries from the Backus and Kehoe sample, conditioned on whether prices rose or fell. Again, the means of output growth during periods of rising prices appear generally higher than the means during periods of falling prices. This positive relationship between price changes and output growth is again consistent with the idea that deflationary periods were associated with relatively hard times.

Figure 3

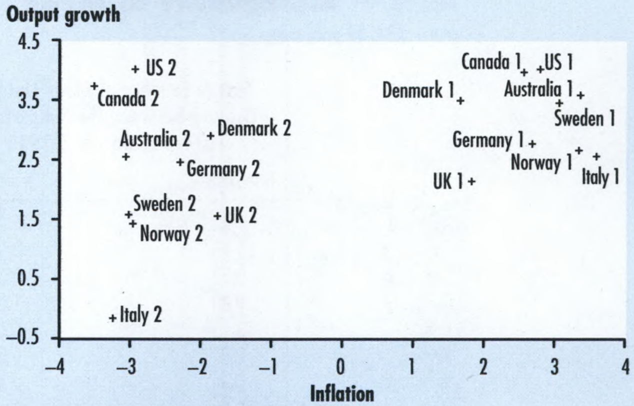
Mean Output Growth in the First Period (1870-96) and the Second Period (1897-1913)



Note: Sample 1= 1870-96, sample 2 = 1897-1913.

Figure 4

Mean Output Growth Conditional on Inflation or Deflation



Note: Sample 1= inflation, sample 2 = deflation.

TESTING THE RELATIONSHIP BETWEEN DEFLATION AND OUTPUT GROWTH

The positive relationship between price changes and output growth must be interpreted with a great deal of caution. First, the positive correlation between price changes and output growth could be due to chance. In other words, how likely is it that the observed data would have been generated if the means of output growth were equal under deflation and inflation? Second, the previous section only examined the relationship between price changes and output growth period by period; we would like to know about their relationship over time as well. Third, even if deflation is statistically associated with lower output growth, that does not mean it causes lower output growth—a third factor could be causing both.

Is It a Coincidence That Output Growth Is Lower During Periods of Deflation?

To test whether the apparent relationships between output growth and price level changes pictured in Figures 3 and 4 could be coincidence, we can determine if it is likely that such a relationship would have been generated if mean output growth were really equal under inflation or deflation. That is, we test the statistical significance of the correlation.

The second and third columns of Table 2 present results of the F-tests of the hypothesis that the mean output growth for each of the nine countries in Figure 3 was the same during the second period (1897-1913) as in the first period (1870-1913). The third column gives the probability that we would obtain at least as extreme a result if the means were truly the same. This number, called the "p-value," is often loosely interpreted as the strength of the evidence against the hypothesis that the means are the same. Values less

Table 1

International Output Growth and Inflation Statistics Under Rising and Falling Prices

	Unconditional Statistics		Proportion of Years Prices are Rising (percent)	Rising Prices		Falling Prices	
	Mean Inflation	Mean Output Growth		Mean Inflation	Mean Output Growth	Mean Inflation	Mean Output Growth
Australia	0.23	3.10	51.16	3.37	3.60	–3.06	2.57
Canada	0.59	3.90	67.44	2.57	3.98	–3.51	3.75
Denmark	0.14	3.20	48.84	1.67	3.51	–1.86	2.91
Germany	0.61	2.66	58.14	2.69	2.79	–2.29	2.48
Italy	0.74	1.45	58.14	3.60	2.58	–3.24	–0.13
Norway	0.71	2.17	58.14	3.35	2.68	–2.96	1.45
Sweden	0.66	2.73	60.47	3.07	3.47	–3.02	1.60
United Kingdom	0.08	1.88	51.16	1.83	2.16	–1.76	1.58
United States	0.26	4.03	46.51	2.80	4.03	–2.93	4.03

Table 2

Tests of the Equality of Mean Output Growth Under Inflation vs. Deflation

	Test of Equality of Mean Output Growth Between the Subperiods 1870-96 and 1897-1913		Test of Equality of Mean Output Growth Conditioned on Inflation or Deflation	
	Test Statistic	p-value	Test Statistic	p-value
Australia	1.44	0.23	1.06	0.30
Canada	15.45	0.00	0.05	0.82
Denmark	0.32	0.57	0.36	0.55
Germany	0.00	1.00	0.10	0.76
Italy	3.19	0.07	7.36	0.01
Norway	0.82	0.37	1.52	0.22
Sweden	0.66	0.42	3.50	0.06
U. K.	0.09	0.77	0.33	0.56
U. S.	0.16	0.69	0.00	1.00
Aggregate	11.01	0.28	15.32	0.08

than 0.1 or 0.05 are usually interpreted as meaning that we can reject the idea that the means are the same. A lower p-value means that it is less likely that the means are the same. These tests of equality of means reject the idea that the conditional means are equal for Canada and Italy, but not for the other countries if our criterion for rejection is a p-value less than 0.1.

If we pool the observations from all the countries, we can test the hypothesis that the overall mean output growth for all nine countries for the second period is the same as the overall mean output growth for the first period. The p-value from such a test is 0.28 (see the third column, last row of Table 2), which strongly suggests that it is very possible that the data were generated by processes with equal means. That is, for only two countries could we conclude that aggregate mean output growth in the second period was statistically significantly higher

Table 3

Fit of Asymmetric Vs. Symmetric Models of Prices and Output

	Preferred Model Under the Akaike Criterion	Schwarz Criterion
Australia	symmetric	symmetric
Canada	symmetric	symmetric
Denmark	asymmetric	asymmetric
Germany	asymmetric	symmetric
Italy	symmetric	symmetric
Norway	symmetric	symmetric
Sweden	symmetric	symmetric
UK	asymmetric	symmetric
US	symmetric	symmetric

Table 4

Tests of Linear Forecasting Ability of Price Changes and Output Growth

	Granger Causality Statistics (p-value) Test that Price Changes Do Not Help Forecast Output Growth	Test That Output Growth Does Not Help Forecast Price Changes
Australia	20.537 (0.000)	7.367 (0.010)
Canada	3.875 (0.018)	8.848 (0.000)
Denmark	1.848 (0.172)	5.768 (0.007)
Germany	5.493 (0.024)	0.343 (0.562)
Italy	2.262 (0.119)	0.061 (0.941)
Norway	1.347 (0.253)	7.245 (0.010)
Sweden	0.210 (0.649)	5.071 (0.030)
US	2.020 (0.130)	1.443 (0.248)
UK	1.346 (0.253)	2.089 (0.156)

than the mean of output growth in the first period.

Columns four and five of Table 2 present results of similar tests for equality of means for the data in Figure 4. For Italy and Sweden, we reject the idea that the mean of output under inflation was the same as that during deflation. For this test, however, aggregating the observations across countries leads to the conclusion that output growth was significantly lower in a statistical sense during periods of deflation. The p-value for the test of that hypothesis is 0.08 (see the fifth column, last row of Table 3).

Do Price Changes Have an Asymmetric Effect on Output?

The previous analysis described the period-by-period relationship between average output growth and average price changes conditioned on the sign of the price changes. Macroeconomic variables, however, influence each other not just contemporaneously, but also over time. The symmetry of the dynamic relationship between output growth and price changes is important, because an essential implication of the idea that deflation is harmful to output is that output reacts asymmetrically to price changes over time.

To explore this issue, we again break the price changes into positive and negative changes so that we can fit two systems of regression equations (called vector autoregressions, or VARs) in which we regress output growth and price changes on their own lagged values. VARs are a commonly used, general method of modeling the dynamic relationship between macroeconomic variables.

In the first system of equations, we treat positive and negative price changes as two different variables and allow them to influence output growth (and each other) differently.[11] In the second system, we treat price changes as one variable, forcing positive and negative changes to have mirror-image effects on output growth. Then we examine which model fits the data better.

We judge the fit of the systems according to two commonly used criteria: the Akaike information and the Schwarz information criteria. These measures of the fit of the two models on the Backus and Kehoe data are shown in Table 3. The results indicate that the Akaike criterion favors the asymmetric model for Denmark, Germany and the United Kingdom, but the Schwarz criterion favors it only for Denmark. For the other countries, the simpler symmetric model

[11] The three variables in the system are output growth, positive price changes (INFLDP) and negative price changes (DEFDP), where

$$INFLDP = DP, \text{ if } DP \geq 0$$
$$= 0, \text{ otherwise}$$
$$DEFDP = DP, \text{ if } DP < 0$$
$$= 0, \text{ otherwise}$$

and DP is the rate of change of prices.

PRICE LEVEL VS. INFLATION TARGETING

Price stability has attracted a lot of attention lately. Unfortunately, the important choice between inflation and price level targeting has been neglected. Either would lead to a lower and more stable inflation rate than we have observed over the past 25 years, but there is a fundamental distinction between the two. Price level targeting "corrects" past errors in monetary policy, while inflation targeting ignores them.

To make this distinction more concrete, consider the problem of a monetary authority with an inflation target of zero to 2 percent in which the 1995 inflation rate is 3 percent, 1 percentage point above the target range. In choosing monetary policy for 1996, the authority will aim, as usual, for an inflation rate of zero to 2 percent. It will not try to make up for past errors. In contrast, if the same monetary authority has targeted a static price level (zero percent inflation on average) and observes 1 percent inflation, it will have to try to reduce the price level by 1 percent in the years ahead.

This difference makes price level targeting a long-run commitment in ways in which inflation targeting is not. There are three major consequences of this divergence between the two.

First, the average rate of inflation over a long horizon can be predicted very well under a price level targeting regime; it is less certain under an inflation targeting regime.[1] Advocates of price level targeting often point to the greater certainty of the price level (average inflation rate) in the long run as an advantage. As the accompanying chart shows, uncertainty about the future price level associated with an inflation targeting range of zero to 2 percent increases as the time horizon grows. In contrast, the level of uncertainty associated with a price level target is constant (and small), even over long time horizons. For example, an investor evaluating the real return on, or the present value of, a project can do so much more easily because the price level can be predicted over long periods.

Second, an important theoretical advantage of the long-run nature of price level targeting is that by being a multi-period commitment, it does not suffer from the time-inconsistency problem described by Barro and Gordon (1983). In their model, a monetary authority has an incentive to produce a one-time monetary stimulus that results in a burst of output

[1] The expected prediction error for future average inflation would go to zero under a price level targeting regime as the time horizon increases, while it would remain constant under an inflation targeting regime.

is favored.[12] These tests provide mixed evidence on the hypothesis that price changes have an asymmetric effect on output for the countries considered here.

Does Deflation Forecast Lower Output Growth?

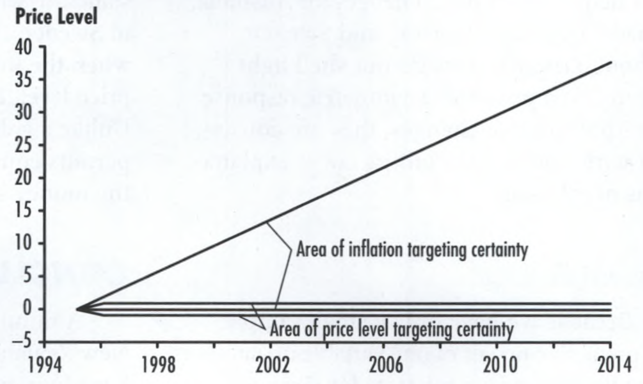
Previously, we showed that, under the gold standard, output growth tended to be lower than average during periods of deflation. Then we showed at least some evidence in favor of the hypothesis of an asymmetric dynamic relationship between price changes and output growth. Although we cannot test directly whether the deflation itself was the cause of lower growth, we can test whether the falling price level helped to forecast it. Such a test of linear forecasting ability is called a test of Granger causality. If price changes improve the forecasts of output growth, they are said to "Granger-cause" output growth. The idea is that if a falling price level causes lower growth, then it should precede output growth and be useful in forecasting it. Note, however, that if a third factor is causing both deflation and lower growth, this statistical procedure can find that deflation helps forecast lower growth, even when it is not the cause of lower growth.

[12] Because the Akaike and Schwarz criteria are non-nested model selection criteria, they are not formal statistical tests and do not have "significance levels." Instead, they informally test for statistical significance by penalizing more complex models.

growth and inflation. Because the public understands this incentive, it reacts in such a way that the authority inflates each period but fails to increase output.

A price level target solves the time-inconsistency problem by requiring the monetary authority to correct past errors. The authority has no incentive to stimulate the economy with a little inflation, because it would then have to reduce the price level back to the target level. Therefore, a price level target should be more credible than an inflation target.[2]

Price Level Vs. Inflation Targeting



A third major difference motivates the subject of this article. A static price level target requires the monetary authority to *reduce* the price level in response to surprise increases. While an inflation rate target may produce occasional reductions in the price level accidentally, they will be rare if the average inflation rate is high relative to the volatility in inflation. In contrast, under a static price level target, price changes will be negative roughly half the time.

A hybrid of targeting inflation and targeting a static price level is targeting a small upward trend in the price level. Such a system has the long-term predictability of a static price level target but does not require the monetary authority to correct past upward deviations in the price level with deflation.

[2] This argument assumes that even anticipated deflations will be as costly as the benefit gained from the initial inflation.

To test whether price changes improve the forecasts of output growth, we first forecast output growth using only its own lags. Then we add lagged price changes as another explanatory variable to see if their inclusion improves the forecasts. The second column of Table 4 displays the test statistic and p-value (significance level) from the tests that price changes do not Granger-cause (help forecast) output growth. For Australia, Canada and Germany, we reject the null hypothesis that lagged values of price changes do not improve the forecasts of output growth. In other words, the data suggest that price changes *do* help forecast output growth for three countries in this period. We should emphasize that rejections of Granger causality tests are a necessary but not sufficient condition to determine that output growth is not "caused" by price changes. Once again, the data provide us with mixed results on the idea that price changes have an asymmetric effect on output.

We can also investigate whether output growth helps forecast price changes in this system. Economic commentators commonly suggest that price pressures (or the lack thereof) are due to the level of output growth, employment, capacity utilization or some other real variable. The test statistics and p-values from the tests that output growth does not help forecast future price changes are in the third column of Table 4. These statistics indicate that output growth does help forecast price changes for Australia, Canada, Denmark, Norway and Sweden. Although these results do not shed light directly on a possible asymmetric response of output to price changes, they are consistent with traditional Phillip's curve explanations of inflation.

Caveat Emptor

Because we have only a small sample, the predictive power of one variable on another must be very strong for tests for Granger causality to find a relation. Weaker but important relations may not be found at all. Statisticians would say that tests of Granger causality may have "low power." Another complication is that both price and output changes may result from some third factor, which has been left out of the analysis.

No matter how confident we are that we understand how these economies functioned 100 years ago, we must be cautious about using historical data to answer policy questions today. For example, economic structures such as the wage-setting mechanism, the degree of flexibility of the labor market and credit allocation mechanisms—all of which may influence how changes in the money supply translate to changes in the price level—have changed a great deal in the last century. Even methods of data collection are much different now.

Finally, we remind the reader that the economists who observed this episode first-hand believed that deflation was a disruptive factor causing lower output growth. Many recommended a price level target as a remedy for that problem.[13] Presumably, the finite sample variance of the price level would be much different under a price level targeting regime than it was under the gold standard. Some evidence in favor of this view can be found by comparing Sweden's experience with prices during the Great Depression with that of countries that stayed on the gold standard. Sweden left the gold standard in 1931 and began to target the consumer price index. From 1931 to the trough of the Depression, the price level fell by 20 percent to 30 percent in countries that stayed on the gold standard, while falling less than 2 percent in Sweden (from 100 in September 1931, when the Riksbank started targeting the price level, to 98.4 in October 1933). Unlike a gold standard, price level targeting permits control of the price level through the money supply.

CONCLUSION

A number of countries, including New Zealand, Canada and the United Kingdom, have recently announced explicit target ranges for inflation. Such a policy has also been suggested for the United States. Others have suggested that we target the price level instead of the rate of inflation. One potential reason to oppose this suggestion is that such a policy would necessitate that the monetary authority reduce the level of prices, that is, deflate the economy, to offset any transient, positive shocks to the price level. The historical association between deflation and bad economic performance has led some economists to reject price level targeting as bad policy.

We find that lower output growth was associated with periods of deflation in nearly all the countries examined. For a majority of the countries, the dynamic relationship between price changes and output growth appeared to be symmetric, and price changes did not help forecast output growth. There is more evidence, however, that output growth forecasts price changes.

Ultimately, a final conclusion about the desirability of a price level target requires more complete economic modeling than we have attempted. What we have presented are some simple facts about deflation and output that are touted as reasons to reject a particular type of price stability. Economists who support price level targeting must make the case that the temporary periods of deflation necessary to maintain long-term price stability would be fundamentally different than those observed under the gold standard.

[13] See *Stable Money: A History of the Movement* by Irving Fisher, 1934.

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