Current Challenges for U.S. Monetary Policy

J. Alfred Broaddus, Jr.

It is a pleasure and an honor to be invited to participate in this conference. I last visited Vienna in 1962, when I was a Fulbright scholar at the University of Strasbourg in France. Needless to say, Vienna has maintained its appearance much more successfully in the intervening years than I have, but I am very happy to have this opportunity to return nonetheless.

Let me offer a few of my views regarding the challenges facing U.S. monetary policymakers currently. Notice that I said challenges we're confronting "currently" rather than "in the new economy" or "in the new economic paradigm." In this regard, some of you may have seen the comments about paradigms by my friend and colleague Bob McTeer, president of the Dallas Fed, in his Bank's current *Annual Report.* Bob points out that if you want to cook a frog, which I gather some people do, you don't just throw it into a pot of boiling water because it will jump out. Instead, you put it into a pot of cold water and slowly increase the heat, since it won't realize its paradigm is shifting.

I don't know whether Bob had me specifically in mind when he told that story, but I suspect he had in mind people who think about this issue the way I do. I confess to being very skeptical about the view that the macroeconomy functions—if that's the right word—in a systematically different way now from the past, requiring a markedly different approach to conducting policy.

I do, however, recognize that some of the U.S. economy's key parameters, like the sustainable longer-term GDP growth rate, may have changed, and that the Fed and other central banks facing similar changes need to take this into

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account in their efforts to optimize the contribution of policy to economic performance. Where I might differ from some new paradigm advocates is that I believe we can do this effectively using analytical models that have evolved from the rational expectations revolution of the 1970s. Specifically, my own approach to policy analysis currently draws heavily on new neoclassical synthesis models, which integrate real world phenomena like price stickiness that many would think of as Keynesian with modern real business cycle theory. My colleague Marvin Goodfriend and several other members of our Bank's staff have made important contributions to the development of these models and to our appreciation of how they can be used to help guide monetary policymakers in making policy decisions in a changing environment.

This is not the place for a detailed discussion of these models, and I am certainly not the one to deliver it in any case. But let me briefly describe one of their key features, which will be useful when I turn in a minute to the U.S. economy and the immediate monetary policy challenges we face. In these models, the real interest rate (presented in the models as a single, representative rate) plays a central stabilizing role. Basically, the real rate serves as an intertemporal rate of substitution. In simple language, the real rate establishes how much households and business firms have to give up in terms of future consumption if they choose to consume and invest today. An unsurprising corollary is that the level of the rate directly affects the strength of the aggregate *current* demand for goods and services—the lower the rate, the stronger demand, and vice versa. In what follows I hope to show how this quite straightforward framework can be useful in analyzing current policy options in the U.S. and elsewhere.

Before doing this, let me briefly review a few of the main features of recent U.S. economic developments. As you may know, the U.S. economy recently entered its tenth consecutive year of economic expansion; indeed, we are enjoying the longest continuous expansion in our history. GDP growth during the early years of the expansion was somewhat below average compared to the corresponding phases of earlier post-World War II expansions. Growth equaled or exceeded 4 percent in each of the last four calendar years, however, and was about 5.5 percent at an annual rate in the first quarter of this year. These are exceptionally high growth rates at such an advanced stage of an expansion. Moreover, domestic demand grew at a 5.1 percent annual rate over this same time period. Most economists believe growth at this rate exceeds the sustainable growth in aggregate domestic supply, a supposition supported by the steady recent increase in the U.S. current account deficit. Beyond this, labor markets are exceptionally tight, and the national unemployment rate—at 4.1 percent—is close to its lowest level in a generation. Despite these signs of domestic macroeconomic imbalance, U.S. inflation has remained reasonably well contained up to now. The core consumer price index rose 1.9 percent in 1999, and the core personal consumption expenditures price index rose 2.1 percent. Most recently, however, core inflation has shown signs of accelerating.

The core CPI, for example, rose 2.2 percent in the 12 months ended in April compared to only 1.9 percent in the 12 months ended last December.

There are some signs in the most recent monthly economic data that the growth of demand may be moderating. These signs are hopeful but at this point must still be considered tentative.

In this situation, as you know, the Federal Open Market Committee has increased its federal funds rate operating instrument on six occasions recently, from 4.75 percent last summer to 6.5 percent currently. In a world where central bank transparency is increasingly valued, it is essential that the American public understand clearly the rationale for Fed actions, particularly tightening actions such as these. In this instance, while the increases have been reasonably well received by many Americans, they have not been accepted by all, at least in part because the increases seem counterintuitive to some in the context of the new economy-new paradigm idea. Specifically, many "new economy" adherents apparently believe that rising labor productivity growth has restrained increases in labor costs and hence reduced the risk of a renewal of inflation and reduced the need for preemptive monetary restraint by the Fed.

It is true that accelerated productivity growth temporarily limits labor cost increases in the interval before increased demand for workers forces wages up, and the initial increase in the output of goods and services can temporarily restrain price increases. I don't believe, however, that new economy advocates have thought this matter through fully. The analytical framework I mentioned earlier suggests exactly the opposite policy conclusion. It indicates that higher interest rates are required to restore macroeconomic balance and ensure *sustained* higher growth over the longer term.

Some background information on recent U.S. productivity growth trends is required to appreciate this result. U.S. hourly labor productivity grew at about a 2.25 percent average annual rate over the 80-year period between 1890 and 1970. This persistent and healthy growth had an enormously positive impact on income and living standards. At this rate, output per worker doubled approximately every 30 years and increased nearly eight-fold over the period as a whole.

Around the mid-'70s, however, trend productivity growth decelerated noticeably to about a 1.5 percent annual rate, at which rate per worker output doubled only about every 45 years, and the reduced growth persisted until the mid-'90s. We still don't fully understand the cause of the slowdown, although it is reasonable to suspect that it was related in part to the oil shocks of the mid- and late '70s and the high inflation of that period. It may also have reflected changes in the composition of the workforce, particularly the entry of a large number of young workers with less than average work experience and therefore lower productivity.

Whatever its causes, the key point is that most Americans perceived the slowdown, although they did not think of it analytically in terms of a reduced trend productivity growth rate. Rather, they thought of it in personal terms as reduced economic opportunities both currently and prospectively. It was during this period that, for the first time in recent U.S. history, many workers concluded that their living standards would be no higher than those of their parents.

As you undoubtedly know, there is now considerable evidence that trend productivity growth in the U.S. has revived since the mid-'90s. It is of course much too early to verify this statistically, but the persistently higher-than-expected real growth in the U.S. economy over the last four years or so without a reacceleration of inflation would be consistent with higher trend productivity growth. Many U.S. economists now estimate that this trend growth has increased 1 to 1.5 percentage points from the reduced mid-'70s-to-mid-'90s rate to the vicinity of 2.5 to 3 percent currently. With trend labor force growth at approximately 1 percent, trend productivity growth at this higher rate would imply that the economy's "speed limit"—its maximum sustainable, noninflationary growth rate—is now in the neighborhood of 3.5 to 4 percent, an appreciable increase from the commonly perceived 2 to 2.5 percent limit in the early '90s.

Just as the earlier slowdown in trend productivity growth was perceived, at least intuitively, by the public, so, too, the apparent recent acceleration in trend growth is perceived. Evidence of this perception is widespread. The long bull market in U.S. stocks reflects higher expected future business earnings growth. And I can assure you that my two grown sons and their friends and associates expect lifetime incomes and living standards well above those of their parents. Again, neither my sons, other households, nor business firms typically think explicitly of their expected higher future income as the result of an increase in trend productivity growth. But their expectations and—as I will indicate momentarily—the actions they take based on these expectations make it clear that they perceive the increase implicitly.

What do all these developments in the "real" economy have to do with monetary policy? The answer is that U.S. households are now borrowing quite liberally against their higher expected future incomes to consume today. They are buying new homes, adding on to existing homes, and buying consumer durables such as new cars, furniture, and electronic equipment. Similarly, firms are borrowing against their higher expected future earnings to invest in new plant and equipment.

The problem posed for monetary policy by all this is that the higher expected *future* income driving the increased current demand for goods and services is not yet available in the form of increased *current* output of goods and services. This mismatch between expected future resources and currently available resources, in my view, is the principal factor creating the present aggregate demand-supply imbalance in the U.S. economy I discussed earlier. The excess demand has been satisfied to date by imports and progressively tighter labor markets. But demand is now rising more rapidly here in Europe and elsewhere around the world, which may soon put upward pressure on the dollar prices of imports. And labor shortages are now widely reported in a number of sectors and industries. On their present course, U.S. labor markets will eventually tighten to the point where competition for workers will cause wages to rise more rapidly than productivity, which sooner or later would induce businesses to pass the higher costs on in higher prices. As I suggested earlier, there is evidence in some of the latest U.S. price and labor cost data that an inflationary process of this sort may now be beginning.

The implication of this analysis, as I indicated at the outset, is that the apparently higher trend productivity growth in the U.S. economy—whether one labels it a "new paradigm" or not—requires higher real interest rates to maintain macroeconomic balance. In order to prevent a reemergence of inflationary pressures and, in doing so, to sustain the expansion, U.S. monetary policy must allow short-term real interest rates to rise to induce households and business firms to be patient and defer spending until the higher expected future income is actually available, in the aggregate, in the form of higher domestic output.

This necessity presents the Fed with several challenges. First, while the need for rate increases seems clear, how do we decide on the magnitude and timing of the increases? In principle, of course, we want to allow rates to rise to the level where the growth in aggregate current demand equals the sustainable growth in productive capacity. In the technical language I noted earlier, ideally we would like to establish an equilibrium intertemporal rate of substitution consistent with aggregate demand-supply balance. Identifying this equilibrium level is difficult, because it is continuously responding not only to the apparent trend productivity growth increase but also to any number of other shocks hitting the economy. Taylor-type rules may offer some operational help in setting the appropriate federal funds rate level, but in the absence of a stronger professional consensus regarding how to use these rules, policymakers in practice will have to apply judgment based on their interpretation of current economic data and forecasts.

As you know, we have in fact been allowing real rates to rise. (I am deliberately avoiding the misleading terminology that the Fed is "raising rates.") In the spirit of the increased emphasis on transparency in monetary policy, perhaps the principal challenge for the Fed currently is making it clear to the public that these actions have not been the misguided result of "old economy" thinking, but steps that are essential for maintaining balance and maximizing long-term growth in the economy, whether one regards it as new, old, or simply evolving.

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The Role of a Regional Bank in a System of Central Banks

Marvin Goodfriend

A modern central bank seeks to maintain a financial environment within which competitive markets support the efficient use of productive resources. The overarching principle is that a central bank should provide the necessary monetary and financial stability in a way that leaves the maximum freedom of action to private markets. In keeping with this principle, monetary policy is implemented by indirect means, with an interest rate policy instrument rather than with direct credit controls. In the banking sphere every effort is made to minimize as far as possible the regulatory burden associated with financial oversight.

The principle that markets should be given free reign wherever possible creates three difficulties of understanding that a central bank must overcome in order to carry out its policies effectively. The presumption that monetary and banking policies are best when they are as unobtrusive as possible creates the first difficulty. Inevitably, central banks seem shadowy and distant from the public's point of view. Yet, to work well, central bank policies need to shape the expectations of households and businesses. Monetary policy encourages economic growth and stabilizes employment over the business cycle by anchoring inflation and inflation expectations. Bank supervision and regulation aims to promote confidence in the banking system.

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The need to influence expectations and promote confidence puts a premium on credibility, a commitment to goals, and a central bank's perceived independence and competence to achieve its objectives. Thus, a central bank must create in the public's mind an understanding of the methods by which its objectives can be sustained. This formidable problem has to be overcome in spite of the fact that a central bank operates in the background, with obscure methods and procedures.

The second and third difficulties arise because central bankers must understand markets. Dynamic markets introduce evermore efficient productive technologies and create new goods and services to better satisfy consumer wants. Economic dynamism complicates the measurement of macroeconomic conditions. A central bank seeks to understand the latest market developments in order to implement monetary and banking policies appropriately. Policy actions are inevitably benchmarked against historical correlations in data. Yet a central bank must be prepared to question its interpretation of data in light of anecdotal and other information that suggests behavior different from historical averages.

The third difficulty of understanding is in the area of economic analysis. Because policies influence economic activity indirectly, central bankers must use economic analysis to think about how their policies are transmitted to the economy. Some sort of quantitative theoretical model must be used to think about how markets respond to monetary and banking policies, and how monetary and banking policies ought to react to the economy.

The role of regional banks in a system of central banks is about creating understanding in the three senses described above. For example, decentralization enhances credibility because the diffusion of power makes it more difficult for outside pressures to be brought to bear on a central bank. The regional presence helps a central bank to get its policy message out and to gather anecdotal and specialized information on regional economies. Information gathering and dissemination are particularly important for central banks such as the Eurosystem and the Federal Reserve System, whose currency areas span large and populous regions. For this reason, the Central Bank of the Russian Federation and the Peoples Bank of China might profitably restructure themselves as a system of regional central banks.[1]

A regional presence also benefits a central bank with responsibilities for bank supervision and regulation, and the power to extend emergency credit assistance to troubled financial institutions. Specialized knowledge of local economies, industries, and businesses is of use to bank examiners and helpful in determining whether a troubled bank deserves emergency credit assistance.

[1] In late 1998, the Peoples Bank of China announced its intention to establish nine provincial branches.

Likewise, central banks that play a role in the provision of payments services run far-flung operations through their regional offices.

Last but not least, the diversification of research within a system of central banks brings a variety of analytical perspectives to policy deliberations that is invaluable in our increasingly complex economy. Moreover, a system of regional banks led by the center institution harnesses competitive forces to encourage innovative thinking within the central bank.

The first half of this article, which includes Sections 1 through 4, highlights the role played by the Reserve Banks in the Federal Reserve System. The remainder of the article, Sections 5 through 8, offers some observations on the new Eurosystem based on the experience of the Federal Reserve System. There is a short concluding section.

Having spent 20 years as an economist at the Federal Reserve Bank of Richmond, I welcome the opportunity to clarify my thinking on these matters. I hope that my discussion of the Federal Reserve System helps the European national banks and the European Central Bank to think about their respective roles in the Eurosystem. Early in the century the Federal Reserve System looked to European central banks for guidance in designing its institutional structure and operating procedures. The Federal Reserve will be pleased if it can now return the favor.

1. THE FEDERAL RESERVE BANK PERSPECTIVE

The improvement over time in communication, information, and transportation technologies has enhanced the role of Reserve Banks in the Federal Reserve System. The United States has seen a deconcentration of metropolitan employment that appears to be the result of urban congestion and technologies that make it increasingly possible to locate businesses away from traditional urban centers.[2] The tendency is toward an equalization of regional economic activity.[3] Think of the growth of California, Florida, and Texas, and the tremendous growth in the South and Southwest. Atlanta, Georgia, has become a major commercial center; Charlotte, North Carolina, is a major banking center; Seattle is the home of aircraft and software production.

The growing dispersion of economic activity increases the value of local information that Reserve Bank presidents bring to the Federal Open Market Committee. The presence of Reserve Banks in the midst of the various regional economies makes possible a deeper understanding of these than can be acquired from Washington. Personal contacts built up over time create trusting relationships that facilitate the timely acquisition of information about local

[2] See, for example, Chatterjee and Carlino (1998).

[3] Barro and Sala-í-Martin (1992) present evidence of convergence within the United States.

businesses and markets. Personal contacts are particularly valuable in periods of financial stress when it is especially difficult to know what is happening in certain sectors. Reserve Banks tend to specialize in knowledge concerning industries concentrated in their respective districts. For instance, the New York Fed follows financial markets generally, the Chicago Fed follows commodity markets and heavy manufacturing, the Dallas Fed follows oil production and developments in Mexico, etc.

Thanks to the progress in information and communication technology, Reserve Banks are no longer at an information disadvantage relative to the Federal Reserve Board or the New York Fed with respect to general market information. All receive news and data instantaneously from everywhere. Reserve Bank presidents, in turn, contribute to policy discussions with speeches and articles transmitted instantaneously around the world by wire services and by the Internet.

Reserve Bank officials are familiar with both their regional private sector world and the world of the Federal Reserve Board. Reserve Banks help bridge the two worlds. Responsibilities and pressures at the Board create a culture very different from the private sector. The Board staff relies on aggregate data and abstract concepts to think about the whole economy. Thinking at the Board reflects consensus beliefs and attitudes, and is cautious in adopting and even considering new ideas. Because the Board has ultimate responsibility for much that is done in the System, it has little trouble attracting hard-working, dedicated, and highly skilled employees. Yet because of the responsibility, the pressure, the need for consensus, and the need to focus on abstractions and aggregates, the Board staff can be distant from the private sector. This is a manifestation of the remoteness described in the introduction that plagues central bankers.

With important exceptions there is less ultimate responsibility for System matters at Reserve Banks. On the other hand, there is opportunity for distinguishing one's Reserve Bank from the others. This is a manifestation of the competitive innovation, described in the introduction, that a system of central banks promotes.

One of the Federal Reserve Board's most important duties is to manage relations with Congress. The Board also handles international relationships and deals directly with large financial institutions and national interest groups. Board members testify and give speeches frequently. While these are critically important responsibilities, such communications are nevertheless rather abstract and remote.

Because of its regional presence and focus, the staff at Reserve Banks is more engaged with the rank and file public. Much of what Reserve Banks do involves direct relations with people in the private sector. For instance, Reserve Bank officials manage relations with their Boards of Directors made up of private citizens. Officials speak to local groups about Federal Reserve policies and current economic conditions. Staff members supervise and examine banks, collect data on banking and regional business conditions, provide financial services, promote economic education, and help facilitate community development. The staff at Reserve Banks understands core policy, regulatory, and operational issues and knows how to explain these to its constituencies. In short, Reserve Banks keep the central bank from becoming disembodied, isolated, and out of touch.

2. FEDERAL OPEN MARKET COMMITTEE MEETINGS[4]

The Federal Open Market Committee (FOMC) meets every six weeks on average at the Federal Reserve Board in Washington. The meetings are attended by the seven governors of the Federal Reserve System, the twelve Reserve Bank presidents, and research directors and other staff members from the Reserve Banks and the Board. The Chairman of the Board of Governors sets the agenda, leads the discussions, shapes the policy decisions, and develops the consensus to support the Committee's policy actions.

The meetings routinely include a report from the open market desk at the Federal Reserve Bank of New York, a briefing by the Board staff on current economic and financial conditions in the United States and abroad, a couple of "go arounds" in which the governors and presidents present their views on the economy and policy, and a discussion and vote on the intended federal funds rate. Normally, an FOMC meeting lasts four to five hours, but twice a year the Committee meets for two days to set annual target ranges for the monetary aggregates and to consider longer-run procedural and strategic issues.

Even though all Reserve Bank presidents but the New York Fed president vote on a rotating basis, all 19 members of the Committee participate on equal terms at every meeting. The time for discussion among the members is, accordingly, limited. More often than not, Committee members influence each other incrementally by revisiting issues as time passes, rather than by exchanging views at any particular meeting. Economic conditions usually do not call for a change in the intended federal funds rate. The Committee uses such occasions to prepare itself for possible future policy actions. Such "down time" affords ample opportunity to consider strategic and procedural questions. All in all, there is time for Committee members to educate and influence each other, and to reach consensus. But, again, much of the back and forth among Committee members takes place over time. In this regard, the verbatim written transcript that is prepared and circulated after each FOMC meeting (but released with a five-year lag) is of great help in enabling members to review each other's statements in detail.

[4] See Meyer (1998).

The deliberative process works reasonably well in practice. The repeated interaction creates a mutual understanding that enables a variety of geographical and professional perspectives (academic economist, banker, business economist, businessperson, financial market professional, government administrator, lawyer, and regulator) to be brought to bear in making policy decisions.

Two related pitfalls have the potential to weaken the FOMC. First, the bonding that takes place as a consequence of repeated meetings can cause Committee members to begin to think alike. As a result, the FOMC could be blindsided by a risk or side effect of a policy stance that it had not taken into account. To some extent, that risk is diminished by the external community of "Fed watchers" offering professional advice on monetary policy.

The sheer size of the FOMC reduces the likelihood that Committee members will think alike. One of the great strengths of policy made by representatives from a system of regional central banks is the diversity and number of points of view brought to the table. But the size of the FOMC actually creates the second potential pitfall: a free rider problem. Recognizing that their influence in the Committee may be small, members may be inclined to free-ride on the preparations of others more interested, expert, or responsible for monetary policy, such as the Chairman and the Board staff.

The free rider problem is dangerous because it has the potential to make the effective size of the FOMC much smaller than the full Committee. Even worse, free riding is hard to detect because free riders can continue to participate with thoughtful-sounding statements. Widespread free riding would weaken the Committee in much the same way as the tendency to think alike.

The Chairman of the Federal Reserve Board

Even though the Chairman has only one vote in the FOMC, he is preeminent for a number of reasons. The Chairman and the other Board members are appointed by the President of the United States, and the Chairman is named by the President to lead the Federal Reserve System. The Chairman has command of the large staff at the Federal Reserve Board. Most importantly, only he is involved in every key central bank operation (monetary policy, bank supervision and regulation, financial services, foreign exchange operations, relations with Congress and the Treasury, and public relations). The Chairman is the only member of the FOMC fully aware of all the potential interconnections in what the Federal Reserve does. Consequently, no major decision can be taken without the Chairman's assent for fear of not having all the facts. For all these reasons it is difficult to challenge the Chairman's leadership.

By the same token, a good Chairman is aware of the risks of excessively centralizing power in his hands. For the reasons discussed above he must encourage diverse points of view in the FOMC. Central bankers worry about a variety of risks to the economy and the Chairman must encourage Committee members to bring their concerns to the table. The Chairman must help prioritize the concerns and suggest a course of action to achieve the central bank's goals. Finally, the Chairman must mobilize the Committee to action. All in all, the Chairman must use his preeminence to make the most of the diversity in the FOMC while preserving the decisiveness needed to make monetary policy.

Reserve Bank Presidents at the FOMC

Broadly speaking, Reserve Bank presidents contribute to FOMC meetings in two important ways. They make regular reports on their respective regional economies, and they provide their own analysis of the national economy and the policy options.

Regional information compiled by Reserve Banks for the FOMC in the Beige Book is of great importance.[5] But information in the Beige Book can be stale by the time of an FOMC meeting. Presidents bring more timely information to the meeting, including confidential information from personal or other sources not included in the Beige Book. Anecdotal information brought to the FOMC can signal changing sentiment before it becomes evident in aggregate data. Mutually supportive signals from various regions may help to identify or confirm a change in trend or a turning point in the aggregate data. It is particularly important that a central bank recognize and react promptly to turning points in inflation and employment trends.

Besides the Chairman, the Board staff presents the most influential economic analysis at FOMC meetings. The staff's analysis is primarily presented in two briefing documents with which Committee members' views are invariably compared. The Greenbook summarizes national and international economic conditions and presents a forecast; the Bluebook lays out the policy alternatives.

Although the briefing books are comprehensive, the analysis of individual members provides essential perspective. Governors and presidents alike contribute substantively to the interpretation of current economic conditions and the analysis of alternative policy options. Many important possibilities such as the risk of an inflation or deflation scare or the chance of a crisis of confidence in financial markets are particularly difficult to assess and take account of in econometric models. The state of consumer and business confidence is also difficult to assess formally. Such issues are addressed in the statements of Committee members themselves.

Economic analysis is a great equalizer among members of the FOMC. An argument based on economic reasoning that can be challenged and debated in the language of economics is ultimately more influential than an intuitive assertion about the economy or policy, no matter who expresses it and how strongly it is held.

[5] See Balke and Petersen (1998).

3. ECONOMIC RESEARCH AT FEDERAL RESERVE BANKS

Reserve Bank research departments are staffed with an average of 15 or so research economists (except for the New York Fed, which has more than twice as many). Economists graduate from top schools where they acquire the latest analytical skills and an appreciation of how to think about macroeconomics, monetary policy, and banking policy. For the most part, there is a belief in the power and practical value of economic theory and empirical work, and a drive to use economics to make good policy.

Reserve Banks are able to attract and retain good economists because they offer a unique combination of opportunities. Above all, there is the opportunity to prepare the bank president for FOMC meetings. In their role as policy advisors, Reserve Bank economists acquire an intimate empirical understanding of the macroeconomy and a broad understanding of policy issues. Economists produce policy essays for the Bank's *Economic Review* and may be encouraged to publish articles in professional economics journals. The best of these essays may influence the way that the Federal Reserve, other central banks, and academic economists think about policy. It is possible for a Reserve Bank economist to become increasingly effective as a policy advisor while acquiring a research reputation in the economics profession at large.

Reserve Bank research departments need not specialize. The expression of alternative points of view is an important strength of a system of central banks. Nevertheless, Reserve Bank research departments often develop a specialization. A Reserve Bank president may encourage research of one type or another; or a particularly skillful economist may happen to make a department strong in a particular sort of research. A Bank may also exploit a feature of its regional economy or its operational responsibilities to develop a research advantage.

Differences of opinion among Federal Reserve economists are discussed at regular System research meetings. From time to time, there are differences of opinion involving essays in a Reserve Bank *Economic Review.* Reserve Banks send review articles to the Board for a prepublication review. Ordinarily essays benefit from comments by the Board staff. On occasion, the Board staff may recommend against publication because an article is thought to be technically flawed or because the article takes a position regarded as inconsistent with System policy. Conflicts arise because the Board staff prepares speeches and testimony for the Chairman and other Board members in which the Federal Reserve explains current policies to Congress and others. Policy essays published by a Reserve Bank that implicitly or explicitly question current policies may be a nuisance or worse from the perspective of the Board.

Obviously, Reserve Bank economists could be prevented from publishing essays critical of current policy. But that would deny the public the work of economists most knowledgeable about central banking. It would leave the field wide open to others less familiar with the subject. Besides, policy essays reveal a healthy open debate within the Federal Reserve System. In keeping with the mission of a central bank to worry about the economy and policy, it is helpful to have policy questioned by enterprising economists at the Reserve Banks. Furthermore, the best essays facilitate policy advances by suggesting alternatives.

Ultimately, a Reserve Bank has both the incentive and the ability to discipline the output of its economists. The Reserve Bank itself has the most to lose by publishing a poor essay in its *Review*. Reserve Bank research is regularly presented at Federal Reserve System committees and at academic conferences and seminars. Research directors have ample opportunity to judge the professional reception of a particular piece of research prior to publishing it in the Bank's *Review*.

4. PUBLIC INFORMATION

The modern era of monetary policy at the Federal Reserve began when Chairman Paul Volcker took responsibility publicly for inflation in the early 1980s, and subsequently brought it down. This was a watershed event because before that Federal Reserve officials and much of the public, too, generally blamed inflation on a variety of causes beyond the central bank's control. Since then, the public has come to understand that Federal Reserve monetary policy determines the trend rate of inflation over any substantial span of time.

The acceptance of the responsibility for low inflation by the Federal Reserve greatly elevated the importance of public information and communication in the policy process. Previously, the Federal Reserve preferred to operate in the background and out of the limelight. The public thought that important economic policy decisions were made elsewhere, and the Fed felt relatively little need to communicate with the public about its policy intentions. All that changed after the disinflation initiated by Chairman Volcker, for two reasons. First, the Fed thrust itself into the limelight with inflation-fighting policy actions that raised interest rates and weakened economic activity in order to bring down inflation. Second, the Fed realized that bringing down inflation and maintaining price stability would be easier if the Fed had credibility for low inflation. Thus, the public became more interested in what the Fed was doing, and Fed officials came to see communication with the public as a tool useful for building credibility.

The Fed has two primary public information objectives with respect to monetary policy.[6] A consensus has emerged among monetary economists and central bankers that some sort of explicit mandate for low inflation is beneficial.

[6] See Goodfriend (1997).

Yet, Congress has not mandated in a clear way that the Fed place a priority on low inflation. Consequently, Fed officials bear the burden of responsibility for educating the public about the benefits of low inflation. Second, the guiding tactical principle of monetary policy is to preempt inflation, or deflation, for that matter. A well-timed preemptive increase in the intended federal funds rate is nothing to be feared. For instance, the 1994 monetary tightening was almost certainly necessary to keep inflation from ending the business expansion. If the Fed is to successfully maintain price stability, it must create an understanding of the need for policy to be preemptive; and the Fed must build a consensus for specific preemptive policy actions when they are needed.

The regional presence of the Reserve Banks is a great advantage in getting the Fed's message out to the public. The participation of Reserve Bank presidents in the FOMC puts them in great demand as speakers in their districts. Economists and other staff members at the Reserve Banks also carry the Fed's message to the public. Reserve Banks produce a variety of literature aimed at educating the public about the Federal Reserve. There are extensive economic education programs through which the staff at Reserve Banks explains monetary policy to schoolteachers and college professors.

Sometimes market participants complain that speeches by members of the FOMC complicate the business of understanding the Fed's current thinking. As mentioned above, the great strength of the Federal Reserve System is that it brings a number of different points of view to the FOMC. There is no reason why the public should not hear these diverse views.

Markets know that the Chairman, and only the Chairman, speaks for the whole FOMC, and the Chairman's rhetoric is understood to represent the current consensus thinking of the FOMC on policy. The Chairman makes use of his numerous appearances before Congress and elsewhere to update or elaborate upon the current thinking of the FOMC. Moreover, the FOMC announces any change in its intended federal funds rate immediately after any meeting in which the rate is changed. Minutes of each FOMC meeting, released shortly after the following meeting, give a fairly comprehensive idea of the concerns and inclinations of Committee members, though without individual attribution. Included with the minutes is the policy directive from the FOMC to the open market desk. The directive contains "symmetry language" that indicates any inclination on the part of the Committee as a whole to be more concerned with the risk of inflation or recession over the next few weeks. The minutes also contain the voting record and any statements of dissent expressed by members of the FOMC.

The public does not seem to mistake the personal views of individual members for information about the FOMC as a whole. Transparency of a Committee member's views, rather than secrecy, seems more likely to build understanding and credibility for the Federal Reserve over time. Not to air differences among Committee members would deprive markets of useful information, and it would put the public at a permanent disadvantage in understanding monetary policy.

It is worth emphasizing that the Federal Reserve's most effective voice is that of its Chairman. The great respect accorded the Fed Chairman is largely due to his own analytical ability and experience, and the informational and analytical support of the capable Board staff. A good measure of credit is no doubt due to recent monetary policy successes. But an important source of the Chairman's personal credibility probably comes from the fact that he represents the views of the diverse members of the FOMC. If the public were to believe that the Chairman was acting alone, the public would be more inclined to worry that the Chairman could be co-opted, i.e., that he might take policy actions for political rather than economic reasons. The Chairman's credibility and influence would suffer accordingly. Even here, the regional nature of the Federal Reserve System plays an important role. The Federal Reserve Chairman needs the FOMC as much as the Committee needs its Chairman.

5. THE EUROSYSTEM[7]

The Eurosystem shares the basic structure of the Federal Reserve System. The Eurosystem consists of the European Central Bank (ECB) headquartered in Frankfurt am Main, more or less the equivalent of the Federal Reserve Board, and 11 national central banks (NCBs), which are like the 12 Federal Reserve Banks. Monetary policy in the Eurosystem is made by the Governing Council (the equivalent of the FOMC). The Governing Council includes six members of an Executive Board housed at the ECB (the rough equivalent of the seven-member Board of Governors of the Federal Reserve System) and the governors of the 11 national central banks. The President of the ECB chairs the Governing Council, playing a role similar to the Chairman of the Board of Governors.

Power in the Eurosystem is more decentralized than in the Federal Reserve System. First of all, the governors of the NCBs all vote on policy matters in the Governing Council on each occasion. The seven members of the Board of Governors and the New York Fed president vote all the time in the FOMC, but the other 11 Reserve Bank presidents have only four votes on a rotating basis. As is the case in the FOMC, policy decisions in the Governing Council require a simple majority vote.

Secondly, the Board of Governors exercises more power in the Federal Reserve System than the ECB does in the Eurosystem. For instance, the Board of Governors exercises general supervision over the Reserve Banks: the Board approves Reserve Bank budgets, approves the appointment of Reserve Bank

[7] *European Union* (1995) contains the Maastricht Treaty, which, in turn, contains the language governing the structure, administration, and objectives of the Eurosystem. Wynne (1999) summarizes the documentation authorizing the establishment of the Eurosystem.

presidents, and appoints three of nine directors at each Reserve Bank, including the chairman. In contrast, the Maastricht Treaty gives the NCB governors control over the terms and conditions of employment of the staff at the ECB. The NCBs are financially independent of both the ECB and their respective national governments. Decentralized control, the so-called principle of subsidiarity, is enshrined in the preamble of the Maastricht Treaty.

Even the ECB itself is more decentralized than the Board of Governors. For instance, the Economic and Research Directorates, which employ the bulk of the ECB's professional economists, do not report to the President of the ECB but to another member of the Executive Board. The fact that there is no Chief Executive of Europe to give his assent to the President of the ECB and other Executive Board members, as in the United States, probably makes for a weaker ECB within the Eurosystem. The NCB governors are appointed by their respective national governments, without approval of the Executive Board.

On the objectives for monetary policy, the Maastricht Treaty states unambiguously that the primary objective of the Eurosystem shall be to maintain price stability. Although the treaty obliges the Eurosystem to support the general economic policies of the European Union, that support is to be without prejudice to the objective of price stability. Accordingly, the Eurosystem mandate is considerably more definite than the objectives given in the Federal Reserve Act.

The Maastricht Treaty safeguards the independence of the Eurosystem. The Eurosystem charter is an international treaty that cannot be revoked without unanimous consent of the signatories. Moreover, the treaty itself actually tells the Eurosystem not to take instructions from other institutions in the European Union. The greatest threat to the Eurosystem's independence and the pursuit of price stability could come from the ambiguity in the treaty on exchange rate policy, which is to be established by the European Council. It is not completely clear how a conflict between exchange rate and price stability objectives would be settled.

On transparency, the Maastricht Treaty mandates that the ECB publish quarterly and annual reports. Executive Board members have signaled their willingness to testify regularly before the European Parliament. The ECB intends to keep the public informed of its policy actions and thinking through press conferences, speeches, and other regular publications. The President of the ECB holds a press conference to discuss monetary policy immediately after one of the two Governing Council meetings held each month. Notably, the treaty specifies that the proceedings of the meetings shall be confidential, but that the Governing Council may decide to make the outcome of its deliberations public.

For now, the Eurosystem does not coordinate and centralize bank supervision and regulation, or emergency credit provision. NCBs carry on in these areas according to their respective national policies. This, of course, differs from

Federal Reserve practice, where the Board exercises control over emergency credit assistance and over the supervision and regulation of banks.

6. DECENTRALIZATION IN THE EARLY FEDERAL RESERVE: IMPLICATIONS FOR THE EUROSYSTEM

The decentralized Governing Council described above is reminiscent of the early Open Market Committee of the Federal Reserve System. Established informally in 1922 with 5 of the 12 Reserve Banks represented, the Committee's membership was broadened to include all 12 banks in 1930. The FOMC took its modern form with the Banking Act of 1935, which gave the seven members of the Federal Reserve Board a vote in open market policy for the first time, and reduced the Reserve Bank votes to five.

As is well known from the account by Milton Friedman and Anna Schwartz, the decentralized structure of the Open Market Committee in the 1920s depended for its decisiveness on the leadership of Benjamin Strong, Governor of the Federal Reserve Bank of New York.[8] Governor Strong's powers of persuasion, personal courage, and good judgment gave coherence and purpose to Federal Reserve policy. After Governor Strong died in October 1928, the Open Market Committee became unworkable. Without Strong's leadership the decentralized Open Market Committee made for drift and indecisiveness in Federal Reserve policy.

The Governing Council of the Eurosystem appears to be susceptible to the same indecisiveness as was the early Open Market Committee. A closer look, however, shows why this is not likely to be the case.

First, the objectives of Federal Reserve monetary policy in the early years were ambiguous. The United States was on a gold standard, and the Fed was committed to defend the dollar price of gold. Yet for much of the 1920s Governor Strong sterilized gold flows and instead tried to stabilize the price level.[9] In large part, Strong's personal discretion substituted for the lack of an agreed objective. The Eurosystem's price stability mandate should go a long way toward preserving the decisiveness of the Governing Council.

Second, it will take some time for the Eurosystem to develop and become familiar with euro-area data. But on the whole, much better macroeconomic data exist today than were available to the early Fed. This, too, should make the Governing Council more decisive than the early Open Market Committee.

Third, today's central banks can draw on the considerable theoretical and practical knowledge that economists have accumulated since the early years of the Fed. Central bankers have accumulated a good deal of practical knowledge

[8] See Friedman and Schwartz (1963).

[9] See Hetzel (1985).

themselves. The early Fed had little experience in managing monetary policy and very little in the way of analytical skills at its disposal to help guide policy.

Fourth, professional central bank watchers today provide external advice and discipline.[10] This, too, should act against policy indecision. Fifth, the Fed did not yet have the tradition of making the Chairman of the Board of Governors the Chairman of the FOMC. In effect, the Fed then lacked an institutional leader designated by the President of the United States. This was a great weakness in a decentralized structure such as the Open Market Committee. The President of the ECB is the designated leader. He is appointed by the European Council and confirmed by the European Parliament. In any case, it should be pointed out that centralization of power in the FOMC such as occurred with the Banking Act of 1935 did not guarantee good monetary policy, as the Great Inflation from the late 1960s to the early 1980s showed.

To sum up, the analogy with the early Fed is far from conclusive. With the help of the support systems described above, the Governing Council should be able to strike a reasonable balance between decentralization and decisiveness.

7. SUBSIDIARITY AND ECB STAFFING

One problematic issue facing the Eurosystem is the nature of the control that the NCBs will exercise over the staffing budget of the ECB according to the principle of subsidiarity. This is critical because, as the discussion of the Federal Reserve System makes clear, the Eurosystem cannot function effectively without a sufficiently strong ECB. The ECB must perform certain tasks. For instance, the ECB must represent the Eurosystem in its external relationships. Presumably, only the President of the ECB can speak for the Governing Council. Also, the ECB is the natural home for economists following the euro-area economy as a whole. The ECB is a natural repository for euro-area data, and its economists will assume primary responsibility (though by no means an exclusive one) for following and interpreting these data for the Eurosystem.

In addition, the ECB needs a staff with analytical capabilities sufficient to support the President in his role as leader of the Eurosystem. Among other things, the ECB's staff, working with the staff at the NCBs, must devise an analytical framework that can help the President of the ECB guide the members of the Governing Council in their monetary policy deliberations.

The funding of the ECB staff must be authorized by the NCB governors. Yet the NCBs lack the experience to judge the ECB's priorities and needs. The problem is twofold. First, NCBs know relatively little about managing independent monetary policy. Second, NCBs have little experience as regional

[10] See, for example, Begg et al. (1998).

banks in a system of central banks. The division of labor between the NCBs and the ECB will have to be worked out gradually over time.

One hopes that the NCBs will agree to build up staff at the ECB fast enough to provide the leadership that the Eurosystem needs. The analogy with the Fed system makes clear that critical responsibilities should be borne by the ECB. NCBs have responsibilities and comparative advantages of their own that they should exploit for the benefit of the Eurosystem.[11]

8. NATIONAL CENTRAL BANKS AND THE CREDIBILITY OF THE EUROSYSTEM

The Eurosystem will establish full credibility for low inflation over time by satisfying three conditions. First, the Eurosystem must manage monetary policy competently. Second, the NCB governors and Executive Board members on the Governing Council must learn to work together. Third, the Eurosystem must build on its price stability mandate to broaden the public's support for price stability and the preemptive policy actions necessary to sustain it. The NCBs play a central role in seeing that these three conditions are satisfied.

Competence

It seems fair to say that the Eurosystem's expertise in maintaining price stability derives in large part from the Bundesbank, which has had a long and successful track record in managing independent monetary policy.[12] Other NCBs have less experience because for the most part they have chosen to fix their exchange rates to the Deutsche Mark. The Eurosystem adopted many of the Bundesbank's operational procedures to facilitate the transfer of the Bundesbank's monetary policy credibility to the Governing Council.

One significant difference between the Eurosystem and its fixed exchange rate system predecessor led by the Bundesbank is that monetary policy will now take account of euro-area aggregate data. Since those data are only recently being created, little is known about their historical behavior or their relationship to euro-area monetary policy. Until the Eurosystem becomes more familiar with the new area-wide aggregates, the Governing Council needs to rely on anecdotal regional information and the intimate knowledge that NCBs possess of their own country's data.

Finally, the NCBs have relatively large research departments compared to the ECB and extensive operational experience in financial and banking markets. The competence of the Eurosystem will depend on the ability of the ECB to

[11] See, for instance, Liebscher (1998).
[12] See Deutsche Bundesbank (1999).

draw on the talents of staff at the NCBs, as need be, for the good of the system as a whole.

Working Relationships on the Governing Council

Despite the safeguards in the Maastricht Treaty, the independence of the Eurosystem is at risk because the regional members of the Governing Council represent countries. Members could be influenced by their governments. Votes on the Governing Council could be traded for those on other governing bodies of the European Union. As mentioned above, the ambiguity on exchange rate policy opens the door to political interference in monetary policy. Politically motivated disputes could greatly complicate the business of the Governing Council. Such conflicts could cause indecisiveness, inconsistent policy actions, and a loss of credibility.

FOMC experience suggests a number of additional measures to prevent the politicization of the Governing Council. First, a macroeconomic framework should be developed to guide policy deliberations. The framework should be rich enough to encompass a wide variety of views and sufficiently coherent to provide the basis for prioritizing concerns and building a consensus for policy actions. The Governing Council should utilize economic arguments disciplined by the price stability objective to smoke out and defuse political rhetoric. Economic reasoning is, to repeat, a great equalizer.

Second, the ECB President's role in the Governing Council should be strengthened so that he can guide the debate within the agreed upon framework. The ECB President should act against free riding by encouraging members of the Governing Council to prepare thoroughly and to participate actively. The effectiveness of members would be enormously enhanced if each were allowed to bring an economist advisor to the meetings. A verbatim transcript of the meetings should be produced, if only for internal use, to facilitate the give and take that must occur over time.

Third, the macroeconomic framework should be explained to the public in some detail so that Eurosystem watchers can more readily exercise professional discipline on the internal debate.[13] Minutes without individual attribution, published shortly after each Governing Council meeting, would help focus Eurosystem watchers on issues of concern to policymakers. Over the long run, greater transparency can serve as a powerful safeguard against political interference.

Admittedly, the FOMC never had the potential for internal international disputes that exists in the Governing Council. However, FOMC experience suggests that the above-mentioned practices would facilitate the development of productive professional working relationships in the Council.

[13] See Issing (1998).

Broadening Public Support for the Eurosystem

The Bundesbank has an admirable monetary policy record in large part because it always had the full support of the German public for its price stability objective. That support was there because the Bundesbank was associated in the public's mind with the postwar economic miracle that began in the late 1940s at the time that the Deutsche Mark and the Bundesbank were created.

The European public has little natural affinity for the new Eurosystem. As was the case for the Federal Reserve System, the Eurosystem will have to earn the public's confidence. If anything, public relations will be more difficult for the Eurosystem than they have been for the Federal Reserve System because the euro area is made up of 11 different countries whose citizens speak many different languages. The Eurosystem should make extensive use of the regional presence of its NCBs to broaden the understanding of its mission and methods, much as the Fed uses the Reserve Banks.

The Eurosystem has one big advantage over the Fed in explaining itself to the public. In contrast to the Fed, whose mandate only exists in the Federal Reserve Act and is ambiguous at that, the Eurosystem's price stability mandate is unambiguous and part of one of the founding documents of the European Union.

9. SUMMARY

The main message of this paper is that regional (national) banks play an especially important role in central banks whose currency areas span a continent, such as the Eurosystem and the Federal Reserve System. A regional presence facilitates the acquisition of specialized information on the economy and positions the staff to reach out to the public with an explanation of the central bank's policy objectives and practices. Presidents (governors) of regional central banks bring analytical diversity to the monetary policy committee. Above all, a system of central banks promotes a healthy competition that stimulates innovative thinking on operational, regulatory, research, and policy questions.

Federal Reserve experience teaches that a decentralized system needs a strong center. Staff at the center needs to be large enough to support a strong Chairman (President) of the system. The Chairman must be strong enough to encourage diverse views in the policy committee and to build a consensus for decisive and timely policy actions. The Chairman should exploit diversity and promote decisiveness.

The key to success in the Eurosystem, in addition to the above-mentioned points, is to establish good working relationships on the Governing Council. To facilitate this, the staff at the center should take the lead in developing a macroeconomic framework within which diverse policy views can be expressed and debated productively. Personal advisors should accompany members to the policy meetings. Verbatim transcripts should be prepared for internal use to facilitate an exchange of views over time. Minutes without individual attribution should be published to present opposing views clearly, to focus central bank watchers, and to guard against the potential for politically motivated policy mistakes.

The Eurosystem and the Federal Reserve System will succeed in the long run by broadening the public's understanding and support for low inflation and the preemptive policy procedures to maintain price stability. The way to do that is to involve the Reserve Bank presidents (national central bank governors) and their advisors fully in the policymaking process, and to utilize the system's regional presence to take the central bank's monetary policy message to the public.

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The Business Cycle and Industry Comovement

Andreas Hornstein

The U.S. economy, as of the writing of this article, is in its longest postwar expansion. This expansion has prompted various proponents to declare a "new" economy and the death of the business cycle. These pronouncements may well turn out to be premature, as similar announcements have proved in the past. In this case we can already say that the current expansion shares one feature with all previous business cycles, namely that all parts of the economy take part in the expansion, although possibly to different degrees. In particular, although the symbol of the "new" economy appears to be the Internet, a general expansion of all industries in the manufacturing and the service sector accounts for the growth in GDP. Indeed, it is the general up and down movement of all parts of the economy that defines the business cycle in Burns and Mitchell's (1946) early work.

In contrast to this earlier work, modern business cycle research has focused for the most part on the comovement of aggregate variables, like output, employment, consumption, investment, the price level, interest rates, etc. In part, the focus on the aggregate economy has been justified by the observed comovement, which is supposed to indicate the presence of common aggregate disturbances to which all parts of the economy respond in a similar way. The argument for aggregate shocks as the source of business cycles proceeds as follows (Lucas 1977). Suppose the economy is subject to a large number of industry-specific disturbances which are unrelated to each other. Then we would expect that these disturbances change the relative productivities of various inputs such as labor. This change in relative productivities, in turn, should lead to a reallocation of inputs. That is, input use should decline in industries with falling relative productivities and should increase in industries with

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rising relative productivities. What we actually observe, however, is the opposite outcome; therefore we should conclude that the business cycle is not due to unrelated industry disturbances, but rather to aggregate disturbances that affect all sectors of the economy. One natural candidate for an aggregate disturbance is, of course, monetary policy. Given the current economic expansion, which appears to be driven to some extent by the widespread application of computer technology, aggregate productivity shocks are also a possibility.

In this article, I argue that industry comovement is an important defining characteristic of the business cycle, and that current economic theory has difficulties accounting for this characteristic. I first document the pattern of industry comovement for inputs and outputs. I then discuss a simple extension of the standard aggregate business cycle model to make two points. First, I formalize the argument against unrelated industry disturbances as the cause of business cycles. Second, I point out that even if there are only aggregate disturbances, one should not necessarily expect that all sectors of the economy respond in the same way to these disturbances. Finally, I provide some evidence on the extent to which the economy is subject to aggregate productivity disturbances.

1. COMOVEMENT IN THE U.S. ECONOMY

Industry comovement over the business cycle means that the level of activity in different industries increases and decreases together. There are various ways to measure the activity level of an industry. One method is to ask how many inputs are used or how many goods are produced in an industry. For this article, I use data from Jorgenson, Gollop, and Fraumeni (1987), who provide annual series on inputs and outputs at the two-digit industry level. Their data set covers prices and quantities for industry gross output and use of capital services, labor, materials, and energy for the years 1950-1991.[1] I will show that, for almost all measures of activity, industries move together over the business cycle. This result confirms previous work by Christiano and Fitzgerald (1998), who study the comovement of quarterly two-digit industry employment, and Murphy, Shleifer, and Vishny (1989), who study annual one-digit industry value added and employment.

In addition to short-term business cycle fluctuations, most economies are characterized by substantial structural change over time. This change means that some industries are growing, and their production and use of resources is increasing over time relative to other industries such as services or the financial industries. Likewise, other industries' contribution to the economy is declining,

[1] The data used here are taken from Jorgenson's Web page at http://www.economics.harvard.edu/faculty/jorgenson/data.html. All industries of the data set are included, except agriculture (1) and government enterprises (36).

such as textiles. Since I am not interested in the long-run secular changes of industries, I remove this trend component by using a band pass filter.[2]

I study the comovement of industries using two different measures. For the first measure, I consider the comovement of industry variables with their corresponding aggregate counterparts, for example the comovement of industry employment with aggregate employment. For the second measure, I consider cross-industry comovement directly, for example the pairwise industry employment correlations. I find that in almost all industries employment is positively correlated with aggregate employment and that this relationship is quite tight. Furthermore, the same positive comovement of industry variables with aggregate variables occurs for all other output and input measures, such as gross output, value-added, capital services, employment, and intermediate inputs. For pairwise cross-industry correlations, positive correlations are also much more frequently observed than negative correlations. Finally, the positive comovement pattern does not only apply to the manufacturing sector but also to the service sector and the construction industry. Only the mining sector has several industries which do not move in step with the rest of the economy.

In order to study the comovement of industry series with aggregate series, I construct aggregate quantities as Divisia indices using the price and quantity industry series. A Divisia index is a way to weight the contribution of individual series to the aggregate series. Suppose we have a collection of goods with prices and quantities for different time periods $\{q_{it}, p_{it} : i = 1, \ldots, N$ and $t = 1, \ldots, T\}$; then we define the growth rate of the aggregate quantity index between periods t and $t + 1$ as the weighted sum of the growth rates of the individual series

$$\Delta \ln q_t = \sum_{i=1}^{N} \bar{\omega}_{it} \Delta \ln q_{it},$$

where an individual series' weight is its average value share $\bar{\omega}_{it} = 0.5(\omega_{i,t+1} + \omega_{i,t})$ and $\omega_{i,t} = p_{i,t}q_{i,t}/\sum_{j=1,N} p_{j,t}q_{j,t}$. I use this method to construct aggregate input and output series from the industry series and to construct for each industry an intermediate goods index from the materials and energy use series. For each industry, I also construct a value-added quantity index (Sato 1976). Value added of an industry is the total value of payments that goes to primary factors of production: capital and labor. Alternatively, value added represents the industry's value of production after deducting payments for inputs, which have been purchased from other industries in the current accounting period, namely intermediate inputs.

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[2] I identify the components of a time series with periodicity less than or equal to eight years with the business cyle. The band pass filter which extracts the business cycle component is approximated by a symmetric moving average with four leads and lags. For a description of band pass filters, see Hornstein (1998) or Christiano and Fitzgerald (1998).

Comovement of Sectoral Variables with Aggregate Variables

The results for the comovement of industry variables with aggregate variables are displayed in Tables 1a and 1b. Table 1a displays whether an industry series increases or decreases when its corresponding aggregate series increases. Most industry series move contemporaneously with their aggregate counterpart, but I want to allow for the possibility that an industry series is leading or lagging the aggregate series. For this purpose, Table 1a displays the correlation which is maximal in absolute value among the contemporaneous, once-lagged and once-led correlations. In Table 1b, I provide a measure of how tight the relation between the industry and the aggregate economy is. For this purpose I regress the industry series on one lagged value, one leading value, and the contemporaneous value of the aggregate series. Table 1b then displays the R^2 of this regression, that is the variation of the industry series explained by variation of the aggregate series through this regression equation. The higher is the R^2, the tighter is the fit between the industry and the aggregate series.

Industry employment in the manufacturing sector moves with aggregate employment, as Table 1a demonstrates. The correlation between industry and aggregate employment in the manufacturing sector (industries 7 through 27) are all positive, and almost all of them are contemporaneous and quite high, at least 0.4 or higher. Furthermore, as we can see from Table 1b, the relationship between the industry and the aggregate series are quite tight with R^2s of at least 0.4. The main exceptions are tobacco (8), petroleum and coal (16), and food (7), industries where employment is not closely related to the aggregate economy.[3] Notice that these are industries which are subject to shocks exogenous to the aggregate economy, like weather or world oil markets, and whose contribution to the aggregate economy is limited.

The close relation between industry and aggregate variables also holds for other inputs and outputs. With few exceptions, industry gross output, value added, use of intermediate goods, and capital services are all positively correlated with the corresponding aggregate variables. The exceptions concern tobacco (8), leather (18), apparel (10), lumber and wood (11), petroleum and coal (16), primary metals (20), and transportation equipment (25). To the extent that an industry variable declines when the aggregate increases, the relationship tends to be quite weak, with R^2s less than 0.2. Only the use of capital services in primary metals (20) has a strong negative correlation with a high R^2. These results are consistent with Murphy, Shleifer, and Vishny (1989).

The evidence for industry comovement with aggregate variables is not limited to the manufacturing sector. We also find strong evidence for the service sector and the construction industry. Employment in service sector industries

[3] This evidence confirms Christiano and Fitzgerald's (1998) analysis of employment in the manufacturing sector with monthly data.

Table 1a Maximal Correlation of Industry Series with Aggregate Series

Sector	*q*	*y*	*k*	*l*	*x*	*m*	*e*
2 Metal mining	0.53	0.44	-0.13^{+}	0.44	0.41	0.39	0.57
3 Coal mining	-0.31^{+}	0.51	-0.13	0.30	-0.51^{+}	-0.52^{+}	-0.35^{+}
4 Oil and gas extraction	0.47	0.73	0.30	-0.48^{+}	-0.56^{+}	-0.57^{+}	0.19^{+}
5 Non-metallic mining	0.66	0.72	0.25^{-}	-0.31^{+}	0.28	0.29	0.47
6 Construction	0.74	0.61	0.32	0.70	0.74	0.74	0.67
7 Food	0.45	0.44	0.31	0.29^{+}	0.20^{-}	0.21^{-}	0.26^{-}
8 Tobacco	-0.21^{+}	0.38	-0.24^{+}	0.19	-0.32	-0.33	-0.30^{-}
9 Textile mill products	0.78	0.46^{+}	0.58	0.66	0.82	0.83	0.64
10 Apparel	0.72	0.67	-0.43^{-}	0.52	0.55	0.54	0.57
11 Lumber and wood	0.72	-0.30	0.43	0.77	0.75	0.74	0.68
12 Furniture and fixtures	0.93	0.90	0.70	0.84	0.87	0.87	0.76
13 Paper and allied	0.78	0.75	0.62	0.69	0.62	0.62	0.62
14 Printing	0.70	0.69	0.67	0.50	0.62	0.62	0.54
15 Chemicals	0.92	0.77	0.72	0.77	0.73	0.72	0.50
16 Petroleum and coal	0.53	0.62^{+}	0.50	0.37^{+}	0.50	-0.31^{+}	0.70
17 Rubber and misc. plastics	0.88	0.78	0.31	0.85	0.84	0.85	0.60
18 Leather	-0.30^{-}	-0.39	0.60	0.46	0.63	0.63	0.65
19 Stone, clay, and glass	0.92	0.89	0.75	0.84	0.87	0.87	0.75
20 Primary metal	0.90	0.75	-0.67^{+}	0.65	0.89	0.90	0.69
21 Fabricated metal	0.93	0.88	0.76	0.86	0.89	0.89	0.77
22 Machinery, non-electrical	0.79	0.79	0.75	0.86	0.75	0.75	0.69
23 Electrical machinery	0.86	0.84	0.72	0.88	0.86	0.86	0.73
24 Motor vehicles	0.78	0.77	0.66	0.79	0.77	0.77	0.65
25 Transportation equipment	0.40^{-}	0.49^{-}	0.64^{-}	0.62	0.33^{-}	0.32^{-}	-0.22^{+}
26 Instruments	0.70	0.73	0.76	0.67	0.55	0.55	0.54
27 Misc. manufacturing	0.73	0.65	0.46	0.47	0.65	0.64	0.65
28 Transportation	0.88	0.75	0.61	0.84	0.90	0.91	0.78
29 Communications	0.43	-0.45^{+}	0.33	0.55	0.56	0.56	0.35
30 Electric utilities	0.71	0.66	0.17^{+}	0.58^{-}	0.18	0.15	0.45
31 Gas utilities	-0.29^{+}	-0.57^{+}	0.38	0.66	0.41^{+}	-0.24^{-}	0.55
32 Trade	0.79	0.82	0.82	0.81	0.62	0.62	0.57
33 FIRE	0.41^{+}	0.22^{+}	0.75	0.24^{-}	0.49^{+}	0.47^{+}	0.37^{+}
34 Services	0.69	0.71	0.72	0.74	0.47	0.46	0.58

Note: The industry series are gross output q, value-added y, capital k, employment l, intermediate input aggregate x, materials m, and energy e. A correlation is the maximal correlation in absolute value of the contemporaneous, one-period lagged, and one-period leaded correlation between the industry variable z_i and the corresponding aggregate variable $\bar{z}$, $corr[z_{i,t}, \bar{z}_{t+s}]$ with $s = 1, 0, -1$. A plus (minus) superscript denotes that the industry variable is leading (lagging) the aggregate variable, that is $s = 1$ ($s = -1$). No superscript indicates that the contemporaneous correlation is maximal.

(28-34) and construction (6) tends to show a strong positive correlation with aggregate employment above 0.5, and the relationship tends to be quite tight, with R^2 above 0.5. Finance, insurance, and real estate (FIRE) (33) is the only industry where employment is not tightly correlated with aggregate employment.

Table 1b R^2 from Regression of Industry Series on Aggregate Series

Sector	*q*	*y*	*k*	*l*	*x*	*m*	*e*
2 Metal mining	0.50	0.33	0.04	0.23	0.26	0.24	0.38
3 Coal mining	0.20	0.28	0.05	0.18	0.25	0.27	0.15
4 Oil and gas extraction	0.34	0.61	0.15	0.35	0.34	0.37	0.05
5 Non-metallic mining	0.60	0.68	0.12	0.14	0.16	0.14	0.31
6 Construction	0.78	0.60	0.09	0.58	0.81	0.80	0.65
7 Food	0.25	0.41	0.06	0.16	0.08	0.09	0.09
8 Tobacco	0.12	0.22	0.08	0.07	0.20	0.19	0.13
9 Textile mill products	0.85	0.21	0.35	0.57	0.89	0.89	0.48
10 Apparel	0.65	0.50	0.31	0.43	0.48	0.46	0.40
11 Lumber and wood	0.79	0.12	0.19	0.70	0.84	0.83	0.63
12 Furniture and fixtures	0.90	0.83	0.60	0.80	0.84	0.83	0.61
13 Paper and allied	0.69	0.61	0.51	0.57	0.51	0.50	0.39
14 Printing	0.61	0.55	0.41	0.25	0.55	0.56	0.33
15 Chemicals	0.85	0.65	0.49	0.74	0.62	0.62	0.29
16 Petroleum and coal	0.35	0.40	0.20	0.12	0.36	0.21	0.60
17 Rubber and misc. plastics	0.81	0.64	0.33	0.83	0.78	0.78	0.50
18 Leather	0.19	0.21	0.43	0.53	0.57	0.58	0.49
19 Stone, clay, and glass	0.86	0.80	0.61	0.74	0.84	0.84	0.65
20 Primary metal	0.92	0.64	0.50	0.44	0.89	0.90	0.54
21 Fabricated metal	0.93	0.81	0.53	0.76	0.87	0.88	0.61
22 Machinery, non-electrical	0.88	0.82	0.63	0.82	0.83	0.83	0.63
23 Electrical machinery	0.82	0.83	0.52	0.81	0.77	0.76	0.65
24 Motor vehicles	0.74	0.73	0.50	0.80	0.71	0.71	0.54
25 Transportation equipment	0.34	0.37	0.42	0.54	0.31	0.30	0.24
26 Instruments	0.67	0.70	0.57	0.60	0.45	0.45	0.43
27 Misc. manufacturing	0.60	0.47	0.32	0.33	0.51	0.49	0.51
28 Transportation	0.82	0.62	0.37	0.75	0.84	0.85	0.62
29 Communications	0.34	0.25	0.20	0.59	0.35	0.35	0.26
30 Electric utilities	0.56	0.47	0.06	0.54	0.06	0.03	0.20
31 Gas utilities	0.17	0.36	0.18	0.60	0.24	0.13	0.33
32 Trade	0.76	0.79	0.72	0.65	0.51	0.50	0.32
33 FIRE	0.25	0.07	0.56	0.16	0.35	0.35	0.24
34 Services	0.52	0.60	0.53	0.60	0.29	0.29	0.38

Variables other than employment also increase and decrease with their aggregate counterparts. Only for communications (29) and gas utilities (31) do we observe some negative comovement, but the relationship is not very strong, as the low R^2s indicate. Mining is the only sector which does not always increase and decrease with the rest of the economy. In particular, coal mining (3) and oil and gas extraction (4) are not synchronized with the aggregate economy.

Construction, manufacturing, and services contribute about 95 percent to private sector value added and employ almost all labor in that sector. Thus, for the majority of the U.S. economy's industries, gross output, value added, the use of capital services, employment, and intermediate inputs tend to increase and decrease with their aggregate counterparts.

Comovement of Variables Across Sectors

Not only do individual industries move with the aggregate economy, but there is also strong evidence that industries move together individually.[4] Tables 2a through 2d and Figures 1 through 4 display some of the evidence on the pairwise comovement between industries. Even for a small number of industries, there exists a large number of possibilities to pair any two of these industries. I represent this information in two ways. In Tables 2a through 2d, I show the quartile and average values for the pairwise maximal correlations. In Figures 1 through 4, I show the histograms for the maximal and contemporaneous pairwise correlations.

Consider the manufacturing sector. As seen in Figure 1 and Table 2a, the pairwise correlations for industry inputs and outputs are predominantly positive and quite high. Gross output, employment, and energy use display a consistent and strong positive correlation across industries. The average correlation coefficient is about 0.5, and more than three-fourths of all industries are positively correlated with each other. Capital services are less strongly correlated, and there is a relatively high number of negative correlations for value added and material use, especially for maximal correlations. The average correlation coefficient for these variables remains positive, about 0.3.

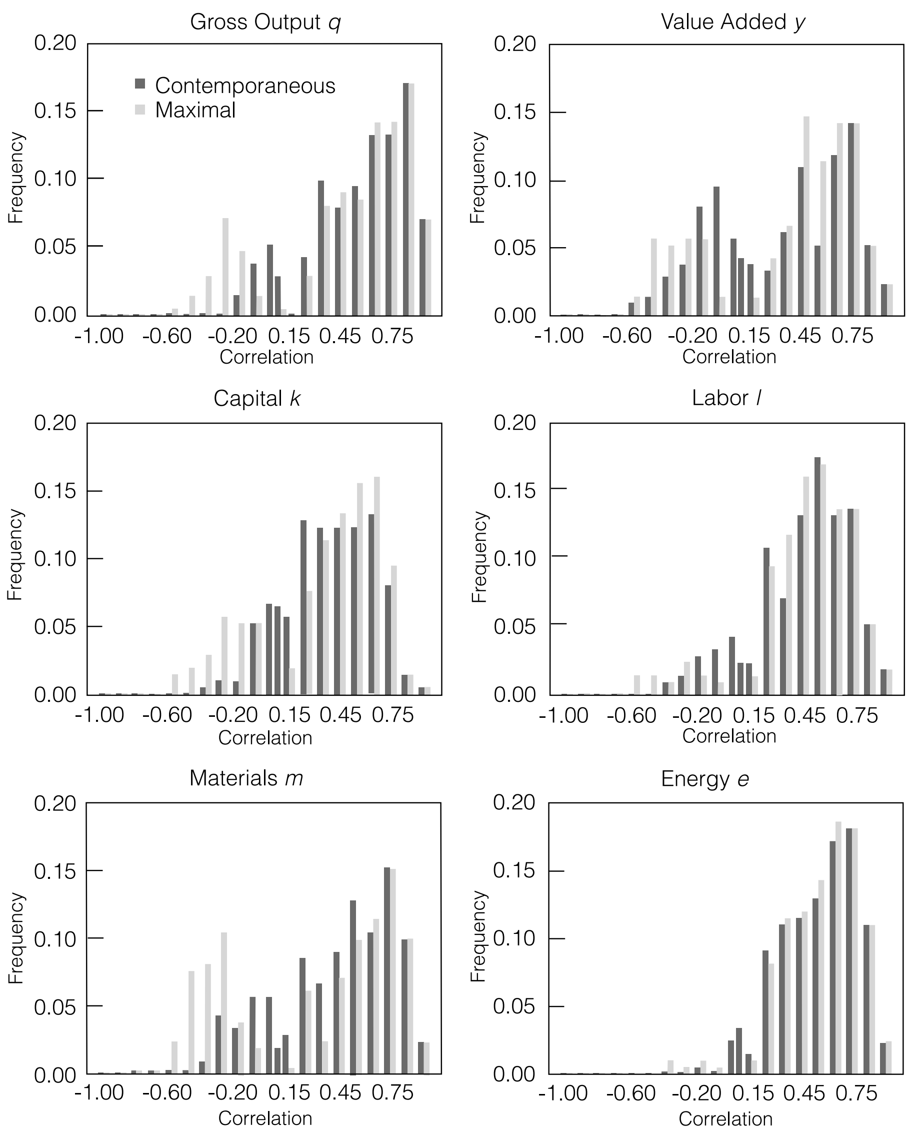
As noted previously, the manufacturing sector industries that produce durable goods tend to be more closely related than those that produce nondurable goods (Christiano and Fitzgerald 1998).[5] Figures 2 and 3 and Tables 2b and 2c confirm this observation. For more than three-fourths of all industries in the durable goods manufacturing sector, we find that all output and input measures are positively correlated across industries, the average correlation coefficient being about 0.5. In the nondurable goods manufacturing sector, employment, energy, and gross output display consistent positive correlations across industries, while value added, capital use, and especially material use show a number of negative correlations. The negative correlations are mainly due to one industry, tobacco (8), which as already noted above is not that tightly related to the aggregate economy.

Finally, consider the cross-industry correlation pattern for the private business sector, excluding mining, summarized in Figure 4 and Table 2d. As we can

[4] It is useful to study the comovement of individual industries for the following reason. An aggregate series is the sum of sectoral series. Therefore, even if the sectoral series are independent of each other, we would observe that each individual series is positively correlated with the aggregate series since it is perfectly correlated with its own contribution to the aggregate series.

[5] Another difference between the nondurable goods and the durable goods sector is that output and input use tends to be more volatile for industries in the latter sector.

Figure 1 Frequency Distribution of Cross-Industry Correlations for All Manufacturing Industries



see, cross-industry correlations for employment, capital services, energy use, and gross output are consistently positive, whereas the pattern is somewhat weaker for value added and materials use. Again, the negative correlations we observe can be attributed to a small number of industries. For gross output,

Table 2a Manufacturing Sector: Maximal Cross-Correlations

	q	*y*	*k*	*l*	*x*	*m*	*e*
Minimum	−0.64	−0.58	−0.59	−0.60	−0.62	−0.63	−0.40
1st Quartile	0.30	−0.15	0.15	0.28	−0.26	−0.30	0.35
Median	0.56	0.44	0.40	0.47	0.48	0.43	0.55
3rd Quartile	0.74	0.61	0.56	0.61	0.66	0.66	0.68
Maximum	0.94	0.90	0.87	0.91	0.91	0.91	0.90
Average	0.44	0.30	0.30	0.41	0.29	0.25	0.51

Note: For notation see Table 1a.

Table 2b Manufacturing Sector: Nondurable Goods, Maximal Cross-Correlations

	q	*y*	*k*	*l*	*x*	*m*	*e*
Minimum	−0.29	−0.58	−0.44	−0.58	−0.60	−0.62	0.09
1st Quartile	0.25	−0.25	−0.15	0.22	−0.35	−0.40	0.32
Median	0.47	0.29	0.25	0.33	−0.11	−0.21	0.42
3rd Quartile	0.66	0.49	0.40	0.49	0.60	0.59	0.60
Maximum	0.89	0.90	0.67	0.91	0.84	0.84	0.88
Average	0.40	0.19	0.16	0.32	0.10	0.05	0.46

Note: For notation see Table 1a.

Table 2c Manufacturing Sector: Durable Goods, Maximal Cross-Correlations

	q	*y*	*k*	*l*	*x*	*m*	*e*
Minimum	−0.53	−0.42	−0.56	−0.45	−0.57	−0.56	−0.40
1st Quartile	0.55	0.40	0.42	0.49	0.42	0.41	0.52
Median	0.67	0.59	0.54	0.61	0.60	0.60	0.62
3rd Quartile	0.78	0.71	0.62	0.70	0.72	0.72	0.74
Maximum	0.91	0.89	0.87	0.88	0.88	0.88	0.90
Average	0.53	0.45	0.48	0.57	0.43	0.43	0.58

Note: For notation see Table 1a.

most of the negative correlations are accounted for by tobacco (8) and gas utilities (31). For value added, most of the negative correlations are accounted for by leather (18), lumber and wood (11), and gas utilities (31).

Figure 2 Frequency Distribution of Cross-Industry Correlations, Nondurable Goods Only

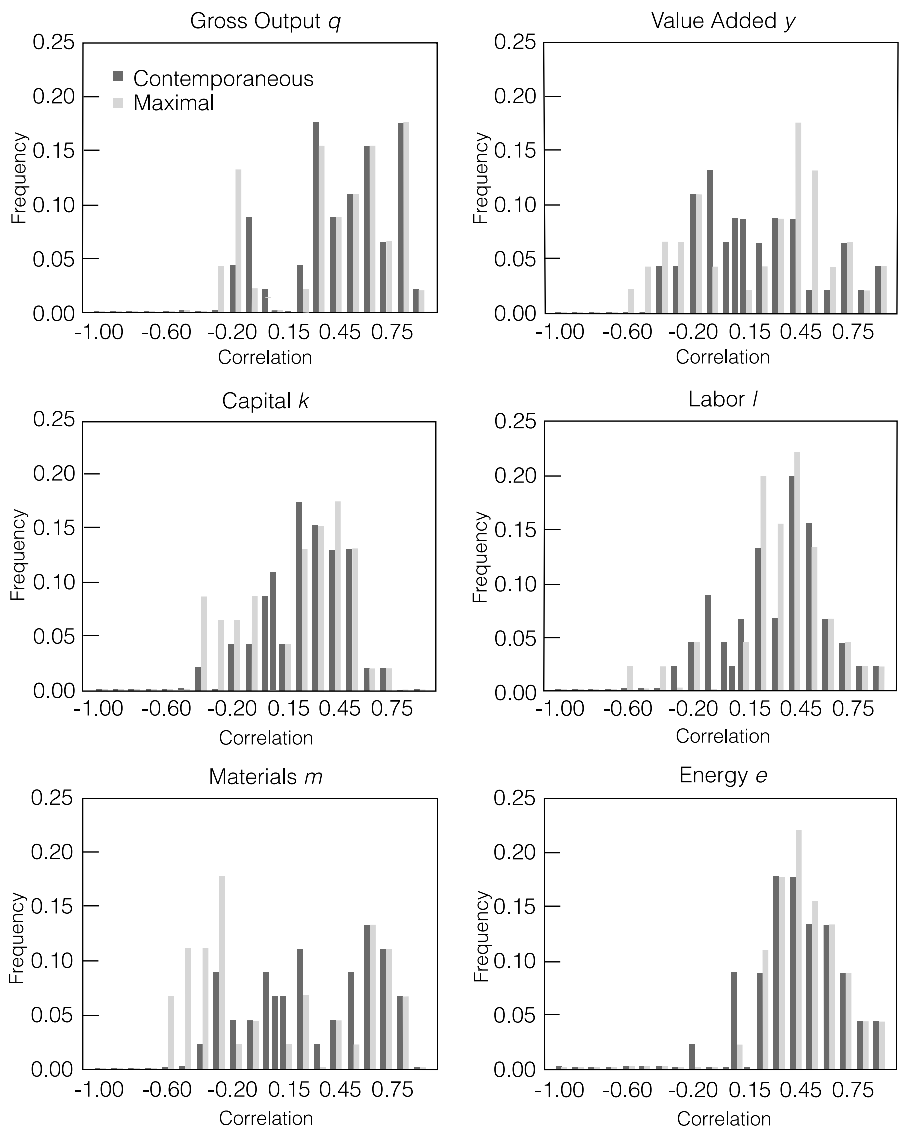


Figure 3 Frequency Distribution of Cross-Industry Correlations, Durable Goods Only

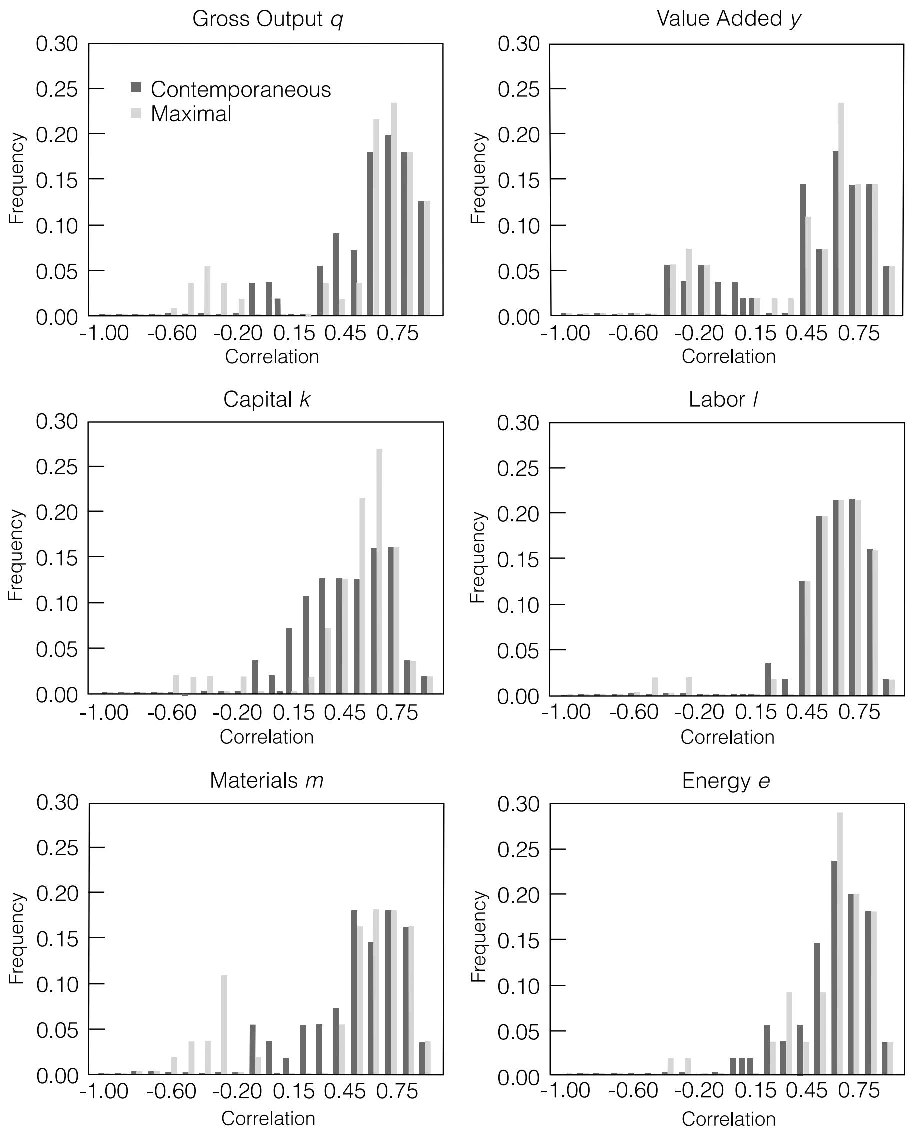


Figure 4 Frequency Distribution of Cross-Industry Correlations for All Industries, Except Mining

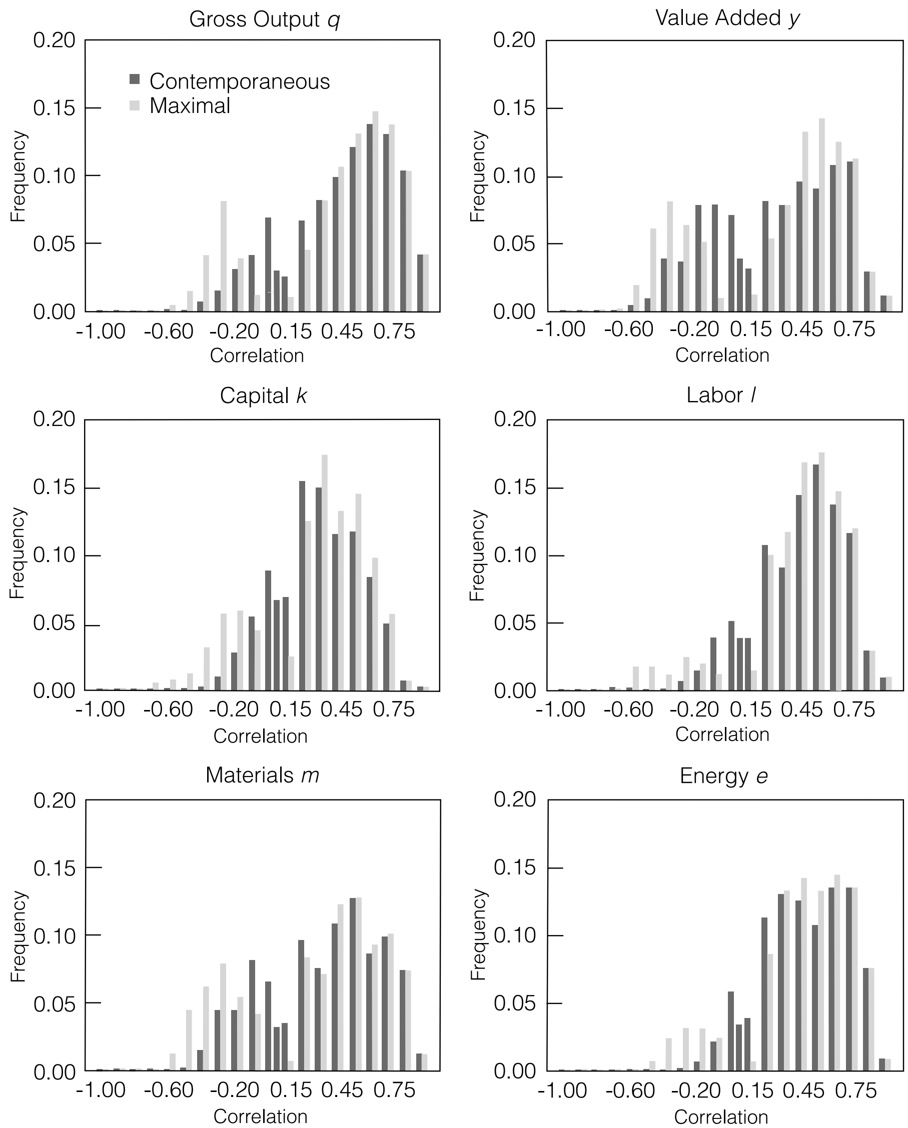


Table 2d All Industries Except Mining: Maximal Cross-Correlations

	q	***y***	***k***	***l***	***x***	***m***	***e***
Minimum	−0.64	−0.72	−0.72	−0.64	-0.62	-0.63	-0.49
1st Quartile	0.25	−0.21	0.14	0.27	0.13	−0.15	0.28
Median	0.51	0.39	0.32	0.44	0.41	0.38	0.45
3rd Quartile	0.67	0.57	0.49	0.59	0.59	0.58	0.62
Maximum	0.94	0.90	0.87	0.91	0.91	0.91	0.90
Average	0.39	0.24	0.25	0.38	0.30	0.26	0.40

Note: For notation see Table 1a.

2. COMOVEMENT IN TWO SIMPLE DYNAMIC GENERAL EQUILIBRIUM MODELS

In this section, I discuss why the observed comovement of inputs and outputs across industries is difficult to reconcile with the basic business cycle model. First, I describe a simple model where labor is the only input to production, and where permanent changes in productivity do not affect employment. For a two-sector version of this economy, I then formalize the argument that changes in relative productivities cause sectoral employment to move in opposite directions. Finally, I discuss a two-sector interpretation of the neoclassical growth model. In this model, employment in the consumption and investment goods sectors move in opposite directions following an aggregate shock that affects production equally in the two sectors.

A Simple Model of Production and Employment

Consider the following simple economy. There are two goods, consumption c and labor n. Labor is used to produce the consumption good

$$c = zn^{\alpha},$$

with $0 < \alpha \leq 1$, and z is labor productivity. Output is produced under conditions of constant returns to scale if $\alpha = 1$. A representative agent has a fixed labor endowment of 1 which can be supplied as labor or used as leisure l, $n + l = 1$. Preferences over consumption and leisure are

$$u(c, l) = \frac{[cl^{\gamma}]^{1-\sigma} - 1}{1 - \sigma}, \tag{1}$$

with $\sigma, \gamma \geq 0$. The competitive equilibrium of this economy is Pareto-optimal. For this setup, Pareto-optimality means that the equilibrium allocation of consumption and labor maximizes the utility of the representative agent subject to being feasible. An allocation is optimal, if at the margin, the utility loss from using one more unit of labor in production is equal to the utility gain derived from the additional consumption produced by that unit of labor:

$$\frac{\partial u}{\partial c} \cdot \frac{\partial c}{\partial n} = \frac{\partial u}{\partial l} \qquad (2)$$

We can use this condition to solve for the optimal labor supply:[6]

$$n = \frac{\alpha}{\alpha + \gamma}.$$

Notice that optimal employment is independent of productivity z. An increase of productivity raises the marginal product of labor and thereby the real wage. Because a higher real wage makes leisure relatively more expensive, the agent consumes less leisure and supplies more labor. This result is called the substitution effect of the real wage increase. A rise in real wages also increases the income of the agent, thereby increasing the demand for leisure and reducing the labor supply. This result is called the income effect of the real wage increase. For the class of preferences defined by (1), the income and substitution effect cancel each other and employment does not depend on the productivity level (King, Plosser, and Rebelo 1987). This property of preferences is desirable if we want to match the long-run behavior of employment in industrialized countries. Relative to the increase in labor productivity over the last hundred years, per capita employment has scarcely moved.

Changes in Relative Productivities

Now consider a two-sector version of the economy described above. To keep things simple, I will treat the two sectors symmetrically. Essentially, the two sectors will only differ with respect to their relative labor productivities. In this economy, aggregate employment also does not depend on labor productivity. Furthermore, employment in the two sectors will always move in opposite directions if relative labor productivity changes. Thus there is negative comovement of employment if productivity changes in the two sectors are not perfectly correlated.

Production of each consumption good is

$$c_i = z_i n_i^{\alpha},$$

with $0 < \alpha \leq 1$. The agent's preferences for the two consumption goods and the labor supply for the two sectors are defined in two stages. First, there is a utility index for aggregate consumption:

$$c = (c_1^{\rho} + c_2^{\rho})^{1/\rho},$$

[6] Using the definition of the production and utility function and substituting for marginal utilities and marginal product of labor yields $\left[c^{-\sigma}(1-n)^{\gamma(1-\sigma)}\right] \cdot \left[\alpha \frac{c}{n}\right] = \gamma c^{1-\sigma}(1-n)^{\gamma(1-\sigma)-1}$, which can be solved for n.

with $\rho \leq 1$. If $\rho = 1$, then the two goods are perfect substitutes. If $\rho = 0$, then the elasticity of substitution is unitary, and the agent spends constant and equal shares of income on the two goods. There is also a disutility index for labor supply in the two sectors:

$$n = (n_1^{\psi} + n_2^{\psi})^{1/\psi},$$

with $\psi \geq 1$. Labor supplied to the two sectors is a perfect substitute when $\psi = 1$. The agent's utility is again a function of the consumption and leisure $l = 1 - n$ as defined in (1). For each consumption good, an optimal allocation equates the marginal utility gain from consuming one more unit of the good with the marginal utility loss from producing this good,

$$\frac{\partial u}{\partial c_i} \cdot \frac{\partial c_i}{\partial n_i} = \frac{\partial u}{\partial l} \cdot \frac{\partial n}{\partial n_i}.$$

This optimality condition, after some algebraic manipulation, simplifies to

$$\alpha \left(\frac{c_i}{c}\right)^{\rho} = \gamma \left(\frac{n}{1-n}\right) \left(\frac{n_i}{n}\right)^{\psi} \text{ for } i \ = \ 1, 2.$$

The ratio of the two optimality conditions yields an expression for the relative employment as a function of relative productivities:

$$\frac{n_1}{n_2} = \left(\frac{z_1}{z_2}\right)^{\rho/(\psi - \alpha\rho)}.$$

If the two goods are substitutable in consumption, $\rho > 0$, then employment in sector one increases relative to employment in sector two if the relative productivity of sector one increases. On the other hand, if the two goods are complementary in consumption, $\rho < 0$, then employment is shifted from the relatively more productive sector to the less productive sector, because the agent tries to maintain the same consumption ratio. With some additional algebraic manipulations, we can show that aggregate employment is again independent of productivity, that is, the percentage increase of employment in one sector is always balanced by the same percentage reduction of employment in the other sector. This result, of course, implies that employment in the two sectors always moves in opposite directions if relative productivities change.

Changes in Aggregate Productivity

I now reinterpret the standard neoclassical growth model as a two sector economy with a consumption goods sector and an investment goods sector. In contrast to the findings of the previous section, this example demonstrates that even without any change in relative sectoral productivities in the two sectors, employment in one sector can move opposite to that in the other simply because the two sectors respond differently to the same shock.[7]

Consider the representative agent described before but now assume that the agent is infinitely lived and has the utility function (1) for every period. The agent discounts future utility at rate $0 < \beta < 1$ and the utility from the consumption-labor sequence $\{c_t, n_t\}$ is given by

$$\sum_{t=0}^{\infty} \beta^t u(c_t, 1 - n_t).$$

There is now one consumption good and an investment good. The investment good x_t is used to augment the capital stock k_t according to

$$k_{t+1} = (1 - \delta)k_t + x_t$$

and $0 < \delta < 1$ is the capital depreciation rate. In the standard neoclassical growth model, capital and labor are used to produce a homogenous output good that can be used for investment or consumption. For the present interpretation of the model, I instead assume that the investment and consumption good are produced in two distinct sectors with the technologies

$$c_t = z_t k_{ct}^{1-\alpha} n_{ct}^{\alpha} \text{ and } x_t = z_t k_{xt}^{1-\alpha} n_{xt}^{\alpha},$$

where $0 < \alpha < 1$. Notice that relative productivity in the two sectors does not change. There are only aggregate productivity changes. The total amount of capital and labor used has to satisfy

$$k_t = k_{ct} + k_{xt} \; and \; n_t = n_{ct} + n_{xt}.$$

Again the competitive equilibrium is Pareto-optimal. Furthermore, the equilibrium allocations of this economy are the same as in the standard growth model.

How does this economy respond to a productivity increase? In general, we cannot derive analytical solutions for the behavior of equilibrium allocations for this economy, rather we have to derive numerical solutions. (See for example King, Plosser, and Rebelo [1987] or Benhabib, Rogerson, and Wright [1991]). It is straightforward, however, to interpret the economy's equilibrium response to the productivity increase. In this economy, output, consumption, investment, and employment all increase. Consumption increases because the representative agent prefers more consumption to less, and higher productivity enables the economy to produce more goods for consumption with the same amount of resources. Investment increases because the household accumulates capital

[7] This observation appears in Benhabib, Rogerson, and Wright (1991). See also Christiano and Fitzgerald (1998).

in order to smooth consumption over time. Employment increases because the higher productivity increases the real wage and labor supply.[8]

What are the implications of the model for sectoral comovement? The model clearly captures the sectoral comovement of output. But I will now show that even though both consumption and investment increase, employment in the two sectors move in opposite directions. Consider the intratemporal optimality condition for the allocation of labor to the production of consumption goods, which is essentially the same as (2) above. At the margin, the utility gain from the production of one additional consumption good has to be balanced by the utility loss from the additional labor supply,

$$\frac{\partial u_t}{\partial c_t} \cdot \frac{\partial c_t}{\partial n_{ct}} = \frac{\partial u_t}{\partial l_t}. \qquad (3)$$

Using the definitions of the utility and production functions, we can simplify this expression[9] to

$$\frac{\alpha}{n_{ct}} = \frac{\gamma}{1 - n_{ct} - n_{xt}}.$$

This equation clearly shows that following the productivity increase, employment in the consumption goods sector falls since total employment increases. Furthermore, employment in the investment goods sector has to increase because total employment increases and employment in the consumption goods sector declines. Thus, employment in the two sectors moves in opposite directions.[10] To understand this behavior of sectoral employment, note that higher employment in the consumption goods sector implies two things. It implies a decline of the marginal product of labor in the production of consumption goods. Likewise, it implies a decline of the marginal utility of consumption since consumption increases. For the optimality condition (3) to be satisfied, the marginal utility of leisure has to decline, that is, the consumption of leisure has to increase. But leisure can only increase if employment in the investment goods sector declines, since employment in the consumption goods sector is assumed to increase.

[8] In this model, as in the previous static models, a change in productivity has both substitution and wealth effects. The higher productivity increases the marginal product of labor, which induces the agent to substitute from leisure to work time. It also increases wealth, which induces the agent to consume more leisure. In the long run, the two effects cancel each other, but during a transitional period, the substitution effect dominates.

[9] The expression is $\left[c_t^{-\sigma}(1-n_t)^{\gamma(1-\sigma)}\right]\left[\alpha \frac{c_t}{n_{ct}}\right] = \gamma c_t^{1-\sigma}(1-n_t)^{\gamma(1-\sigma)-1}$

[10] Christiano and Fitzgerald (1998) discuss the comovement problem for a somewhat more general specification of the growth model.

3. TOTAL FACTOR PRODUCTIVITY COMOVEMENT

As shown in the last section, simple multisector extensions of the neoclassical growth model have difficulties accounting for industry comovement in the presence of aggregate or sector-specific disturbances. The question remains whether the economy is mainly driven by aggregate or sector-specific disturbances.

In the introduction, I alluded to monetary policy shocks as a possible aggregate shock. Here I look at whether we should think of productivity disturbances as aggregate or sector-specific shocks. For this purpose, I study the comovement of measures of total factor productivity (TFP) across industries. I find that TFP in different industries move together over the business cycle, but that comovement appears to be weaker than for outputs or inputs. This finding seems to indicate that industry changes in productivity are not dominated by aggregate productivity changes.

Consider an industry where output is produced using capital, labor, materials, and energy as inputs to a constant returns-to-scale technology

$$q_t = z_t f(k_t, n_t, m_t, e_t), \tag{4}$$

and z represents industry TFP. Changes in output can be attributed to corresponding changes in inputs and TFP, and a first order approximation of the change in output is

$$dq_t = z_t[f_{k,t}dk_t + f_{n,t}dn_t + f_{m,t}dm_t + f_{e,t}de_t] + f_t\, dz_t,$$

where $f_{k,t} = \partial f(k_t, n_t, m_t, e_t)/\partial k_t$ and similarly for the other inputs. Dividing the equation by output yields an expression for output growth as a weighted sum of input growth rates and the TFP growth rate:

$$\frac{dq_t}{q_t} = \frac{f_{k,t}k_t}{f_t}\frac{dk_t}{k_t} + \frac{f_{n,t}n_t}{f_t}\frac{dn_t}{n_t} + \frac{f_{m,t}m_t}{f_t}\frac{dm_t}{m_t} + \frac{f_{e,t}e_t}{f_t}\frac{de_t}{e_t} + \frac{dz_t}{z_t},$$

where each input's weight is equal to the elasticity of output with respect to that input. For given weights, we can use this expression to solve for the TFP growth rate.

Solow's (1957) important insight was that, in a competitive economy, input elasticities can be measured through observations on factor income shares. Suppose that the industry is competitive in input and output markets and that everybody has access to the technology represented by (4). Consider a firm which maximizes profits, sells the output good at a price p_t, and hires, or purchases the services of, inputs capital, labor, materials, and energy at prices w_{kt}, w_{nt}, w_{mt}, and w_{et}. In order to maximize profits, a firm will hire labor until the marginal revenue from the last unit of labor hired equals its price, that is,

$$p_t f_{n,t} = w_{nt}.$$

Multiplying each side of the equation with $n_t/p_t q_t$ shows that the elasticity of output with respect to labor is equal to the share in total revenues that goes to labor:

$$\frac{f_{nt} n_t}{f_t} = \frac{w_{nt} n_t}{p_t q_t} = \omega_{nt}.$$

The same applies to all other inputs. We can therefore measure productivity growth using observations on output growth, input growth, and revenue shares of inputs. This measure of TFP growth is the Solow residual:

$$\frac{dz_t}{z_t} = \frac{dq_t}{q_t} - \left[\omega_{kt} \frac{dk_t}{k_t} + \omega_{nt} \frac{dn_t}{n_t} + \omega_{mt} \frac{dm_t}{m_t} + \omega_{et} \frac{de_t}{e_t} \right]. \qquad (5)$$

The Solow residual provides an accurate measure of disembodied technical change as long as we are willing to assume that all markets are competitive.

Table 3 characterizes the business cycle comovement of industry TFP for the Jorgenson, Gollop, Fraumeni data set used in Section 2.[11] For the TFP calculations, I consider two production/output concepts: TFP of all inputs with respect to gross output and TFP of primary inputs capital and labor with respect to value added. The qualitative features of TFP comovement are similar to those of input and output comovement. First, there is some evidence that TFP in the different industries increases and decreases together. Second, industries in the manufacturing sector appear to move closer together than do industries in the rest of the economy, and within the manufacturing sector we see more comovement in the durable-goods-producing sector than in the nondurable-goods-producing sector. These observations apply to both gross output based and value-added-based measures of TFP. However, there appears to be less comovement of industry TFP than of industry output and labor input, as seen from the lower average and median correlation coefficients for TFP measures. From this I conclude that there is no strong evidence for an aggregate TFP shock.[12]

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[11] I have calculated TFP growth rates for all industries using equation (5). After nomalizing TFP at one in the initial year, TFP levels are calculated as the cumulative sum of the growth rates. The business cycle component is then obtained by detrending industry TFP with the bandpass filter discussed in footnote 2.

[12] In recent work, for example Basu and Fernald (1999), it has been questioned whether Solow residuals accurately measure TFP movements. The issue is whether the assumption of perfect competition and constant returns to scale is appropriate and whether there is substantial unmeasured input variation. It is unlikely that these objections substantially affect the results on comovement of industry TFP. First, in the absence of perfect competition in the product markets or constant returns to scale, one would have to adjust the scale of the measured TFP movements, which would affect the volatility of measured TFP but it is unlikely to affect the industry comovement pattern. Second, most of the empirical work which tries to account for unmeasured input variation, uses some measured input as a proxy. Since we observe positive comovement for measured industry inputs, this correction removes a component from TFP measures that is positively correlated across industries, and corrected TFP measures are likely to display even less comovement.

Table 3 Maximal Industry Cross-Correlations for Total Factor Productivity

	Gross Output Based				Value-Added Based			
	Mft	NDR Mft	DUR Mft	All	Mft	NDR Mft	DUR Mft	All
Minimum	−0.70	−0.61	−0.70	−0.70	−0.68	−0.62	−0.68	−0.68
1st Quartile	−0.25	−0.30	−0.31	−0.27	−0.26	−0.30	−0.31	−0.27
Median	0.32	0.18	0.39	0.26	0.30	0.15	0.38	0.27
3rd Quartile	0.47	0.51	0.49	0.43	0.47	0.52	0.49	0.43
Maximum	0.88	0.88	0.68	0.88	0.89	0.89	0.69	0.89
Average	0.17	0.13	0.20	0.13	0.16	0.12	0.19	0.12

4. CONCLUSION

I have documented that, over the business cycle, activity in almost all industries of the economy simultaneously increases and decreases. This comovement can be observed for a wide variety of activity measures, such as gross output, value added, employment, the use of capital services, or intermediate inputs. Based on this finding one might conjecture that aggregate disturbances to which all sectors of the economy respond in the same way account for the business cycle. Indeed, one might even suggest that this evidence points to a particular disturbance, namely monetary policy, as a major source of the business cycle. Monetary policy shocks arguably affect all sectors of the economy, while evidence of other aggregate shocks, namely aggregate productivity disturbances, is quite weak. However, as shown here, it is by no means clear that all industries of an economy will respond in the same way to an aggregate shock. Explaining the comovement of industries then appears to be an important task for any theory of the business cycle. Initial attempts to study this problem use natural extensions of the growth model such as the inclusion of the input-output structure of the economy (Hornstein and Praschnik 1997 or Horvath 1998) and limited sectoral mobility of labor (Boldrin, Christiano, and Fisher 1999). Other explanations consider the effect of various frictions in standard multisector growth models, for example credit market imperfections as in Murphy, Shleifer, and Vishny (1989). There has been some progress, but the problem clearly has not been addressed successfully.

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Alternative Monetary Policy Rules: A Comparison with Historical Settings for the United States, the United Kingdom, and Japan

Bennett T. McCallum

Recent years have witnessed an upsurge of interest among monetary policy analysts in the topic of simple and explicit rules for monetary policy. In this recent work it is presumed that such rules would not be followed literally and slavishly by central banks, but that they could be consulted for indicative purposes—perhaps by providing a starting point for policy discussions. Tangible evidence of this interest appears in publications based on two 1998 conferences, both entitled "Monetary Policy Rules," sponsored by the National Bureau of Economic Research (NBER) and by the Sveriges Riksbank in collaboration with Stockholm University's Institute for International Economic Studies (IIES).[1] Most of the work in these papers is based on some variant of the now-famous Taylor rule. Introduced in Taylor (1993), this rule specifies settings of a nominal interest rate instrument in response to observed or predicted values of inflation and the output gap (i.e., the percentage difference between output and its reference value[2]).[3] Some of the studies

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[1] Proceedings of the NBER conference have been published in Taylor (1999b); papers from the Riksbank-IIES conference appear in the June 1999 issue of the *Journal of Monetary Economics.*

[2] This reference value is defined variously, in different studies, as the trend or capacity or potential or natural-rate or market-clearing value of output.

[3] In many of the studies, a lagged value of the interest rate is also included as a determinant of the current value, thereby reflecting interest rate smoothing behavior.

consider alternative instrument or target variables,[4] and very recently some criticisms of the Taylor rule have been expressed by Orphanides (1998, 1999), Meltzer (1999), and others. Accordingly, the purpose of the present paper is to conduct counterfactual historical analysis of the type used by Stuart (1996) and Taylor (1999a), and to compare and consider the messages provided by Taylor's rule with others featuring alternative instrument and/or target variables.

The type of analysis developed by Stuart (1996) and Taylor (1999a) consists of contrasting actual settings of instrument variables during some historical time span with the values that would have been specified by particular rules in response to prevailing conditions.[5] Discrepancies or agreements between rule-specified and actual values can then be evaluated, in light of ex-post judgements concerning macroeconomic performance during the span studied, to yield tentative conclusions concerning the merits of the various rules. Of particular interest is whether major policy mistakes, judged ex-post, would have been prevented by adherence to some of the candidate rules. Stuart (1996) conducted such comparisons for Taylor's rule and also one promoted by McCallum (1987, 1993) that features a monetary base instrument and a nominal-income growth target.[6] The sample period utilized by Stuart was 1985.1 through 1996.2 for the United States and the United Kingdom. This article will examine the years spanning the early 1960s through 1998.4 for those two countries and the 1970s through 1998.4 for Japan. The investigation will also extend the range of rules considered by combining interest rate and monetary base instruments with both Taylor-type and nominal-income target variables.

It should be said that no suggestion is intended to the effect that historical analysis of the Stuart-Taylor type represents the only useful approach to policy-rule evaluation. Most of my work, in fact, has involved simulations with quantitative structural macroeconomic models (e.g., McCallum, 1988, 1993; McCallum and Nelson, 1999a, b). The premise is merely that the Stuart-Taylor type of study can also be useful, in addition to simulations with structural models. In this regard, it is important to be clear about the nature of the exercise involved, i.e., to appreciate its limitations and strengths—both of which are considerable. Accordingly, these will be reviewed in Section 2, immediately following the paper's first application of the Stuart-Taylor procedure.

The article proceeds as follows. In Section 1 the alternative rules are specified, notation is established, and some general issues are discussed. Applications to the United States, the United Kingdom, and Japan are then conducted in Sections 2–4. Issues concerning the specification of target variables are taken

[4] See, for example, McCallum and Nelson (1999a, 1999b).

[5] Other examples of such analysis include Judd and Rudebusch (1998) and Kozicki (1999).

[6] In its growth-rate version, considered exclusively here and by Stuart (1996), McCallum's rule is similar (though not identical) to one promoted by Meltzer (1987).

up in Section 5 and others related to instrument variables in Section 6. Section 7 presents a brief conclusion.

1. SPECIFICATION OF RULES

The well-known Taylor rule can be expressed as follows:

$$R_t = \bar{r} + \Delta p_t^a + 0.5(\Delta p_t^a - \pi^*) + 0.5\tilde{y}_t. \tag{1}$$

Here R_t is the short-term nominal interest rate that the central bank in question uses as its instrument or "operating target," i.e., the interest rate over which it exerts control at a daily or weekly frequency. Next, $\bar{r}$ is the long-run average real rate of interest, Δp_t^a is an average of recent inflation rates (or a forecast value), and π^* is the central bank's target inflation rate. Finally, $\tilde{y}_t$ is a measure of the output gap, the percentage difference between actual and capacity output values. In Taylor's original application (1993), the values $\bar{r} = 2$ and $\pi^* = 2$ were specified, expressing the belief that 2 percent per annum is an approximation to the long-run average real rate of interest in the United States, and that 2 percent per annum is a reasonable specification for the Federal Reserve's target inflation rate.[7] Also, in Taylor (1993) the measure used for Δp_t^a is the average of GDP deflator inflation rates over the past four quarters, while capacity output is represented by a linear trend for the log of real GDP fit to quarterly observations for the years 1985–1992. In Taylor (1999a), the Hodrick-Prescott (1997) filter is used instead to generate residuals from "trend" that are taken to represent $\tilde{y}_t$. The rule suggests, of course, that monetary policy should be tightened (by an increase in R_t) when inflation exceeds its target value and/or output exceeds capacity.

Subsequent applications of the Taylor rule have modified or extended formula (1) in several ways. Some have used proxies for expected future inflation in place of Δp_t^a while others have done something similar for $\tilde{y}_t$ or used $\tilde{y}_{t-1}$ instead. A common and major change is to include R_{t-1} on the right-hand side as a determinant of R_t; this adjustment is intended to reflect the practice of interest rate smoothing, which is widely believed to be prevalent in the behavior of many central banks.

An important line of investigation has been pioneered by Orphanides (1998, 1999), who has attempted to base rule calculations on values of Δp_t (inflation) and $\tilde{y}_t$ that were actually available to central bank policymakers at the time that historical instrument settings were chosen. Orphanides (1998) recognizes that current-period values for $\tilde{y}_t$ could not be known until after the end of

[7] It is not necessary that constants be used for these values, but they are in Taylor (1993) and for additional postwar periods in Taylor (1999a).

period t[8] and also emphasizes that macroeconomic data is often substantially revised after its initial reporting. In Orphanides (1999) it is argued that these problems are so severe that adherence to the Taylor rule would not have prevented the inflation of the 1970s, as claimed by Taylor (1999a). Partly for reasons to be mentioned below in Section 5 and partly because of the difficulty of doing otherwise, the present study will be based on data available in June 1999, not on real time data of the type recommended by Orphanides.

The rule proposed by McCallum (1987, 1988, 1993) can be expressed as follows:

$$\Delta b_t = \Delta x^* - \Delta v_t^a + 0.5(\Delta x^* - \Delta x_{t-1}). \qquad (2)$$

Here Δb_t is the change in the log of the adjusted monetary base, i.e., the growth rate of the base between periods $t - 1$ and t. The term Δx^* is a target growth rate for nominal GDP, Δx_t being the change in the log of nominal GDP. This target value Δx^* is specified as $\pi^* + \Delta y^*$, where Δy^* is the long-run average rate of growth of *real* GDP. The second term on the right-hand side of (2), Δv_t^a, is the average growth of base velocity over the previous 16 quarters, $v_t = x_t - b_t$ being the log of base velocity. This term is intended to reflect long-lasting changes in the demand for the monetary base that occur because of technological developments or regulatory changes (presumed to be permanent); it is not intended to reflect cyclical conditions. These conditions are responded to by the final term, which prescribes that base growth is adjusted upward (i.e., policy is loosened) when Δx_{t-1} falls short of Δx^*. In McCallum (1988, 1993), values other than 0.5 are considered for the coefficient attached to $\Delta x^* - \Delta x_{t-1}$, and variants of (2) that respond to discrepancies of the level type, rather than the growth rate type, are investigated. Here, however, we shall limit our attention to the particular formulation given in (2).

A bit of discussion needs to be given to the topic of units of measurement. In previous studies by McCallum, growth rate variables such as Δx_t have been measured as changes in logs. Therefore such variables reflect quarterly changes, instead of annualized changes, and are presented in fractional rather than percentage units. Accordingly, such variables need to be multiplied by 400 to be commensurate with similar variables as measured by Taylor and in most papers on policy rules. Similar comments pertain as well to interest rate measures. To maintain consistency among the different rules considered, we shall here report all results as annualized percentages, rather than in the quarterly fractional units previously used in the work of McCallum.

Another detail of rule specification concerns timing. In (2), both of the variables on the right-hand side are based on variables realized in period $t - 1$ or earlier; i.e., current-period values are not utilized. The reason, as suggested in

[8] This type of operationality issue has been emphasized by McCallum and Nelson (1999b) and McCallum (1999).

footnote 6, is to make the rule specification realistically operational. In Taylor's studies, the inflation variable Δp_t^a is typically measured as referring only to previous-period values, but it is assumed that $\tilde{y}_t$ pertains to period t. Since current-quarter values of real GDP cannot be observed until well into the next quarter, in the present study $\tilde{y}_t$ will be measured as the value of the output gap variable (however measured) pertaining to the previous quarter.

Clearly, the Taylor and McCallum rules differ in regard to both instrument and target variables.[9] It is not obvious, however, why these should be paired in any particular combination. It would be quite natural, that is, to consider a rule with an interest rate instrument and a nominal income growth target. Similarly, it would be reasonable to consider a rule with a base growth instrument and a Taylor-style target specification. Therefore, the investigation that follows will also consider, in addition to (1) and (2), rules of the form

$$R_t = \overline{r} + \Delta p_t^a - 0.5(\Delta x^* - \Delta x_{t-1}) \tag{3}$$

and

$$\Delta b_t = \Delta x^* - \Delta v_t^a - 0.5 h_t, \tag{4}$$

where we define the "hybrid" target variable $h_t = (\Delta p_t^a - \pi^* + \tilde{y}_t)$.[10] Thus rule (4) features responses to the same macroeconomic conditions as in Taylor's rule (1) but with a base instrument. Examination of the results involving (1)–(4) should then enable one to determine whether differences in policy advice offered by (1) and (2) are due primarily to their different instruments or targets.

2. UNITED STATES

We begin with the case of the United States. For x_t, y_t, and p_t we use the logarithms of nominal GDP, real (chain-linked) GDP, and their ratio. The monetary base is the series computed by the St. Louis Fed, which incorporates adjustments for changes in reserve requirements. In addition, an adjustment for sweep accounts has been made for 1994–1998.[11] Finally, R_t is the federal funds rate averaged over the quarter. All variables except R_t are seasonally adjusted. The series are taken from the FRED data base of the Federal Reserve Bank of St. Louis. In what follows, $\Delta p_t^a = 0.25(\Delta p_{t-1} + \Delta p_{t-2} + \Delta p_{t-3} + \Delta p_{t-4})$

[9] Here I am using the term "target variable" to mean a variable that the policy rule responds to in a manner designed to reduce its deviations from some reference path. Svensson (1999) objects to this usage, preferring to reserve the word "target" for variables appearing in loss functions. For a brief discussion see McCallum and Nelson (1999a).

[10] The term "hybrid" was used for this variable by Hall and Mankiw (1994).

[11] Specifically, 0.10 times the cumulative total of sweeps of transaction deposits into MMDAs, reported by FRED, are added to the adjusted base series. Here 0.10 represents the marginal reserve requirement ratio.

while for $\tilde{y}_t$ we report the percentage excess (in period $t-1$) of output over a "trend" reference value provided by the Hodrick-Prescott (HP) filter, as in Taylor (1999a). The effect of the latter choice will be discussed below, in Section 5.

Figure 1 plots values of R_t implied by the Taylor rule (1) with $\pi^* = 2$ and $\bar{r} = 2$ together with actual values over the period 1960–1998.[12] From this figure, it can be seen that the actual interest rate was lower than the rule-implied value throughout the 1970s, indicating that monetary policy was too loose, according to the rule. Beginning in 1981, policy was too tight until 1987, the first year considered in Taylor's original study (1993). Over 1987–1995 policy was about right, according to the figure, but since 1996, it has been somewhat too tight.

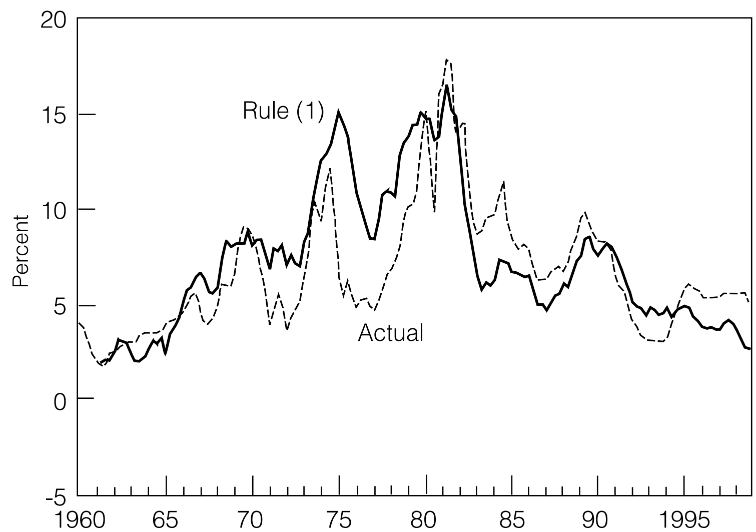
As mentioned above, it is important to recognize the limitations and virtues of the type of comparison provided by Figure 1. If in a particular period the actual value of R_t was lower than the rule-specified value, then the rule's indication is that policy was too loose in that period, given the prevailing conditions. There is no suggestion that the actual setting of R_t in that period was too low *unconditionally.* Indeed, the presumption of Stuart (1996) and Taylor (1999a), which we adopt here, is that prevailing inflation would have been lower during the 1970s if Taylor's rule had been followed in practice. So the R_t settings that would have been appropriate, according to rule (1), would have been lower than those indicated by the solid line in Figure 1.[13] Thus the solid line in this figure does not pretend to represent an optimal or even desirable path for R_t over the period. But that does not prevent the comparison of the two lines from indicating that, conditional upon prevailing conditions, actual R_t values were set lower than the rule would have specified in virtually every period during the '70s. From the standpoint of rule (1), therefore, monetary policy was too loose during the '70s. That is the only type of conclusion provided by Figure 1, and other such plots presented below.

Thus the principal weakness of this type of comparison is that it does not indicate what "optimal" policy settings would have been or even what time path crucial variables would have followed under the rule being examined. But there is an offsetting virtue. Any designation of optimality—indeed, any specification of how R_t or other variables would have evolved historically under any specified policy rule—is necessarily dependent upon the specific model of the economy used to predict how Δp_t and $\tilde{y}_t$ would have responded to R_t settings. The Stuart-Taylor procedure, by contrast, does not require adoption of any specific model. This feature is definitely advantageous, because there is

[12] Since our data base is for 1960.1–1998.4, rule-implied values begin with 1961.2 because lagged values are needed to determine Δp_t^a.

[13] If Δp_t^a had been lower in each period, the R_t values prescribed by (1) would have been lower.

Figure 1 U.S. Interest Rates, Actual and Implied by Rule (1)



no professional agreement concerning the proper specification of the "correct" model of the economy.[14]

We now return to the main line of analysis and move on to rule (2). For its application, we take $\Delta x^* = 5$, combining a 2 percent inflation target with an assumed long-run average output growth rate of 3 percent per year.[15] The comparison of base growth values implied by rule (2) with actual historical values is presented in Figure 2.[16] There it will be seen that policy was too loose—actual base growth was greater than specified by the rule—during the second half of the '60s and much too loose throughout the '70s. This discrepancy was gradually reduced between 1981 and 1987. Then policy became slightly too loose during 1990–1992 and too tight during 1994–1995, according to the rule. Since 1995 it has been about right, on average, although the final observation of 1998 suggests slightly excessive base growth at that date.

[14] For an elaboration on this last point, see McCallum (1999, pp. 1490–1). As mentioned in the introduction, the purpose of the present digression is not to object to counter-factual simulation studies, based on specific models, but only to argue that different procedures have different strengths and weaknesses.

[15] The value of 3 percent for output growth was used in McCallum (1987, 1988)—together with an inflation target of 0 percent—and in subsequent studies. The actual average over 1960–1998 was 2.97 percent.

[16] Rule values begin with 1964.2 because of the lags needed to calculate v_t^a.

Figure 2 U.S. Base Growth, Actual and Rule (2)

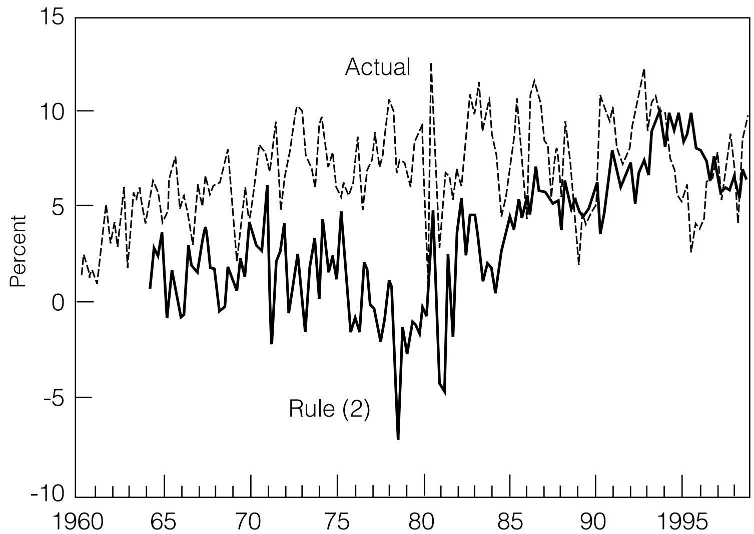


Figure 3 gives results for rule (4), which combines the base instrument (as in (2)) with the hybrid target variable (as in (1)). Somewhat surprisingly, the overall characterization of the results can be described with the same words used for the base rule (2). The main difference is that the rule-indicated path of Δb_t has less quarter-to-quarter variability than in Figure 2. The reason, evidently, is that (4) does not respond to quarter-to-quarter movements in the growth rate of output (real GDP), which are quite volatile. The basic message provided by the hybrid target variable is much the same as that provided by nominal GDP growth because the HP filter yields quite small values for the output gap, as will be illustrated below. Therefore, h_t and Δx_t behave alike except for the volatility introduced into the latter by the y_t component.

Results with rule (3), featuring the interest rate instrument with a nominal GDP growth target variable, are shown in Figure 4. Here the broad overall signals are much like those of Figure 1, which features the Taylor rule, except with a more erratic path because of the output growth component of the target variable. So the comparison among the four figures suggests that the choice of an instrument variable matters more for the trend of monetary policy than the choice of a target variable. It should be emphasized, however, that this preliminary conclusion pertains only to the nominal GDP growth and hybrid variables, with the output gap component of the latter determined by the HP filter method.

Figure 3 U.S. Base Growth, Actual and Rule (4)

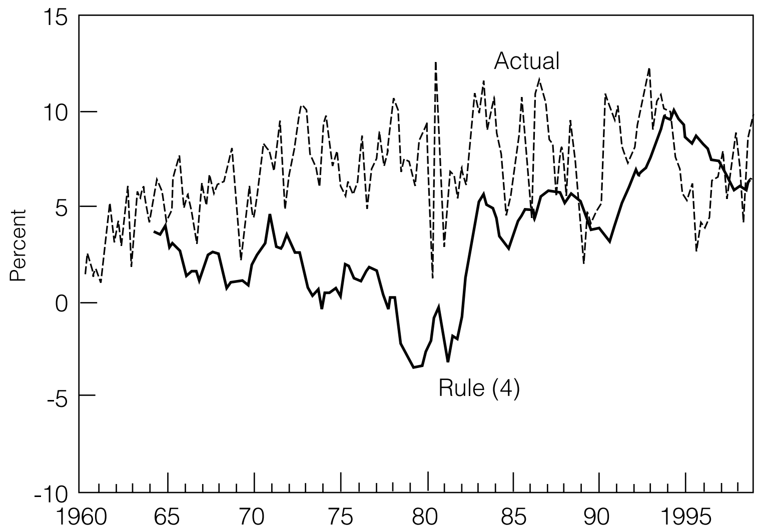
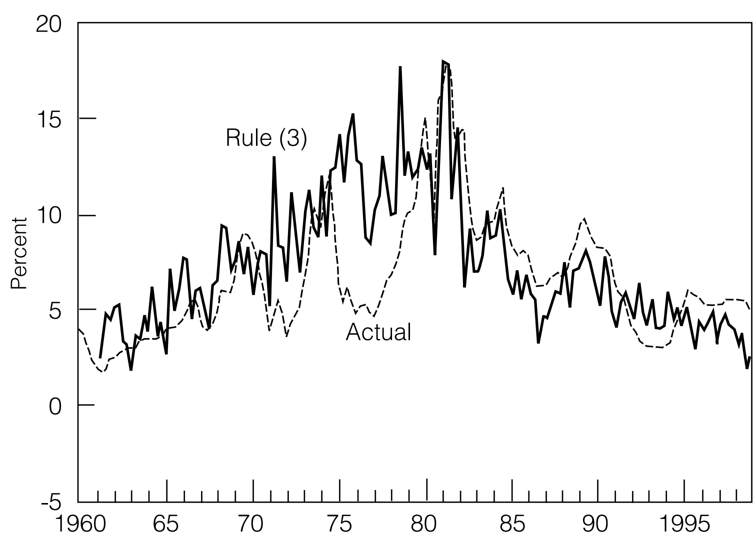


Figure 4 U.S. Interest Rate, Actual and Rule (3)



3. UNITED KINGDOM

Before delving more deeply into the comparisons among the rules, let us look at the basic cases using data for the United Kingdom. Again x_t, y_t, and p_t are logs of nominal GDP, real GDP, and their ratio. For the monetary base b_t we use the Bank of England's M0 measure, seasonally adjusted, which requires no adjustments for reserve requirements because the latter are small enough to be negligible.[17] The interest rate used is a one-month Treasury-bill rate, averaged over the quarter. For the United Kingdom, we use a value of 2.25 for $\overline{r}$, 2 for π^*, and 2.25 for Δy^*. Thus $\Delta x^* = 4.25$. The output gap measure is the percentage departure of real GDP from trend, obtained from the residuals from a regression of the log of real GDP on a linear trend fitted over the years 1960–1998.

Results using the Taylor rule (1) are shown in Figure 5. The indication there is that monetary policy was much too loose during the 1970s, with the rule calling for an interest rate of 38 percent in 1975.3, as compared with an actual value of 10.4.[18] From 1983 through 1987 policy was slightly too tight, according to the rule, and since 1987 it has been just about right, except perhaps in 1994.

The McCallum rule (2) presents a somewhat different story, as can be seen in Figure 6. It agrees that policy was much too loose during the '70s, but suggests that it stayed too loose most of the time until 1990 (when the U.K. entered the European Union's exchange rate mechanism in October, dropping out in September 1992). Since 1992, policy was slightly loose, according to Figure 6, until 1997 when it became just about right. The main difference in the messages of Figures 5 and 6 is that the latter suggests that policy was too loose during the mid–1980s. Ex-post, this suggestion seems correct, as U.K. inflation rose to excessive heights prior to 1990—probably as a consequence of the episode of "shadowing the D-mark" that occurred during 1986–1988.

As in the case of the United States, the messages from rules (3) and (4) tend to agree when the instrument, not the target variable, is the same. Thus in Figure 7 we have base growth figures implied by rule (4), with the hybrid target variable, and the policy messages are much the same as in Figure 6, but with less quarter-to-quarter variability of the indicated Δb_t values. Also, in Figure 8, plotted for an interest instrument and a Δx_t target, we find substantial agreement with the indications of Figure 5, which pertains to the Taylor rule. Agreement is incomplete, however, since this rule does not call for looser policy in the mid–1980s.

[17] Data for M0 are published by the Bank of England for 1969.3–1998.4. Earlier values were obtained from Capie and Webber (1985) and spliced on.

[18] Of course if rule (1) had been followed throughout, actual inflation would probably have been much less severe and the values of R_t indicated by the rule would have been much lower.

Figure 5 U.K. Interest Rate, Actual and Rule (1)

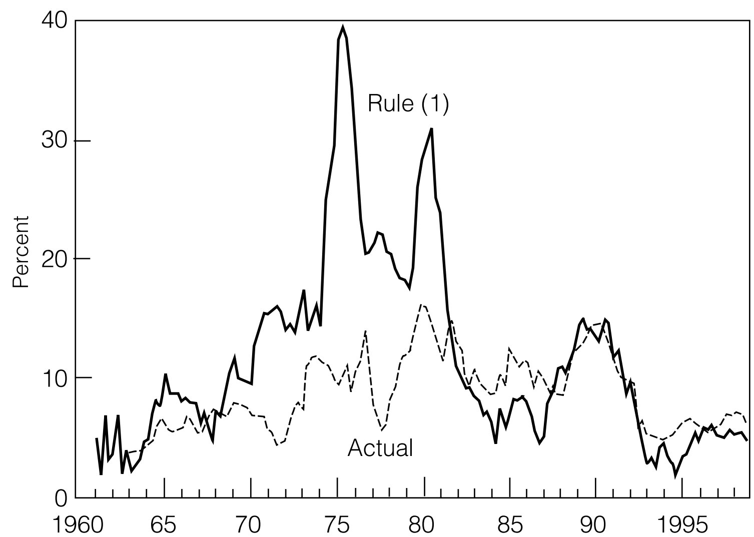


Figure 6 U.K. Base Growth, Actual and Rule (2)

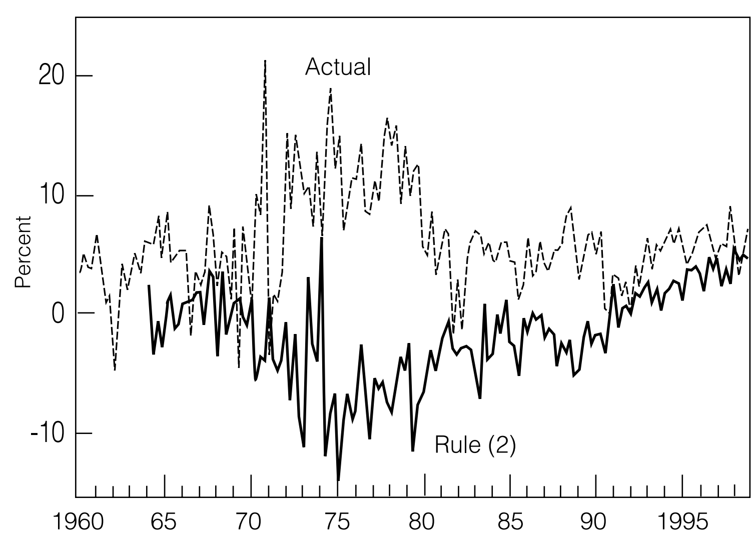


Figure 7 U.K. Base Growth, Actual and Rule (4)

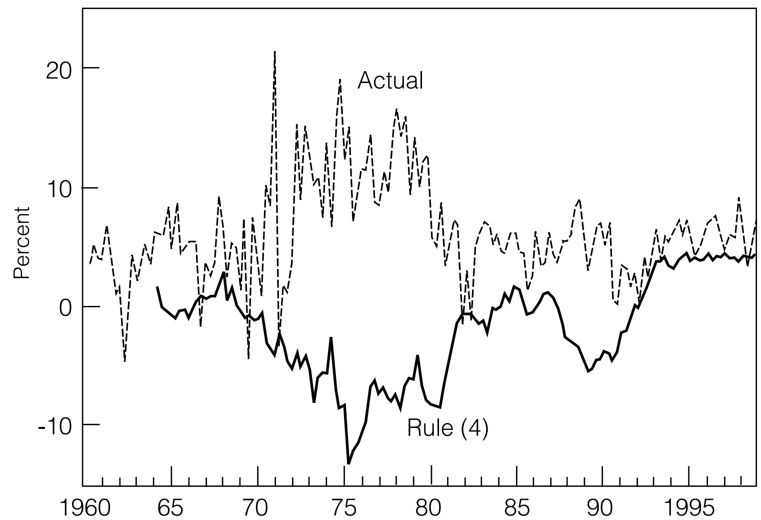
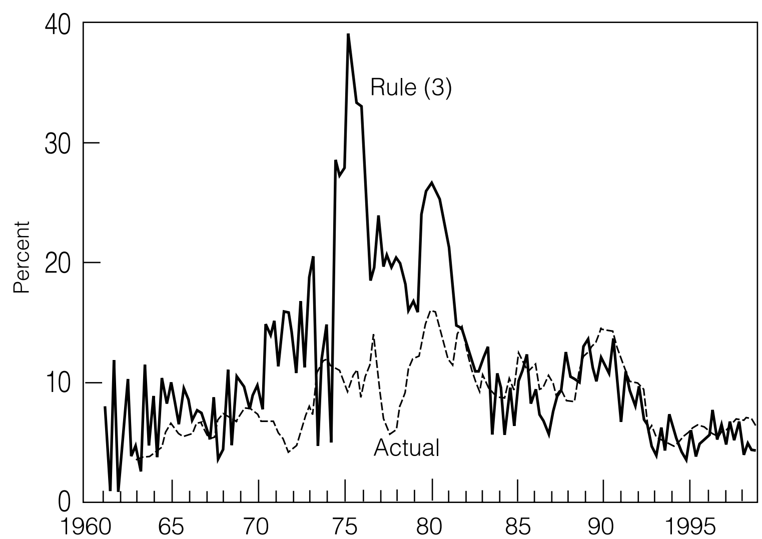


Figure 8 U.K. Interest Rate, Actual and Rule (3)



4. JAPAN

In the case of Japan, our rules will be applied only to the period 1972.1–1998.4, rather than a time span beginning in the early '60s. The reasons are that Japanese data for constructing a monetary base series does not exist prior to 1963; that Japan kept a fixed exchange rate with the U.S. dollar prior to 1971; and that there was a marked break in the growth rate of Japanese real GDP around 1971 or 1972.[19] For the subsequent period we use $\bar{r} = 3$, a higher value than that for the United States or the United Kingdom, because real output growth was higher in Japan. Nevertheless, for Δx^* we adopt a value of 5, corresponding to an average long-run real output growth rate of 3 percent and, again, a target inflation rate of $\pi^* = 2$ percent. In measuring the output gap $\tilde{y}_t$ we cannot use either the HP filter or a linear trend because output in 1998 was quite far below capacity, in the judgement of most observers. Instead, we have measured the fractional gap over 1972.1–1992.2 as the residual from a regression of the log of real GDP on a linear trend (fitted to 1972.1–1992.4 observations), and have assumed that trend or capacity output grew at a rate of 2.5 percent per annum since 1992.2. This procedure yields a gap that grows to a figure of 11.2 percent for 1998.4.

The Bank of Japan now publishes four monthly data series on the monetary base, beginning in 1970, with and without adjustments for seasonality and reserve requirement changes. The monthly series with both adjustments was averaged to generate values for 1970.1–1998 and data from McCallum (1993) was spliced on to cover 1963.1–1969.4. (Values prior to 1967.4 were not used in the study, however.) For R_t the overnight call rate (uncollateralized) was used and official GDP statistics provided the basis for the remaining variables.

Application of Taylor's rule (1) to Japan for 1972.1–1998.4 is depicted in Figure 9. There the indications are that policy should have been much tighter during 1973–1974 and somewhat tighter over 1975–1978. Policy was slightly too tight most of the time over 1982–1987, and then about right until 1994. Since then it has been too tight most of the time, but not in 1997. At the end of 1998, the call rate was almost 4 percentage points too high, the Taylor rule-indicated value being -3.6 percent. Of course, the latter value is not feasible, but it indicates that the rule calls for much more stimulative policy than actually prevailed in late 1998.

This last message is also provided by the base rule (2), as shown in Figure 10, but to an even greater extent. Indeed, this rule suggests that monetary policy has been too tight most of the time since the middle of 1990. Like (1), it points to a too-loose stance over 1972–1978. Interestingly, in light of the "asset-price bubble" of the late 1980s, Figure 10 indicates that monetary policy was slightly too loose during 1986–1988.

[19] For these reasons McCallum (1993) begins its rule study with the quarter 1972.1.

Figure 9 Japan Interest Rate, Actual and Rule (1)

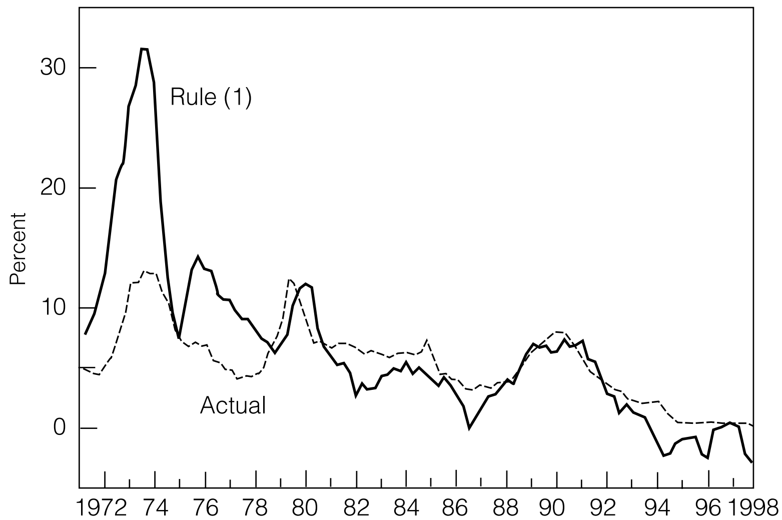


Figure 10 Japan Base Growth, Actual and Rule (2)

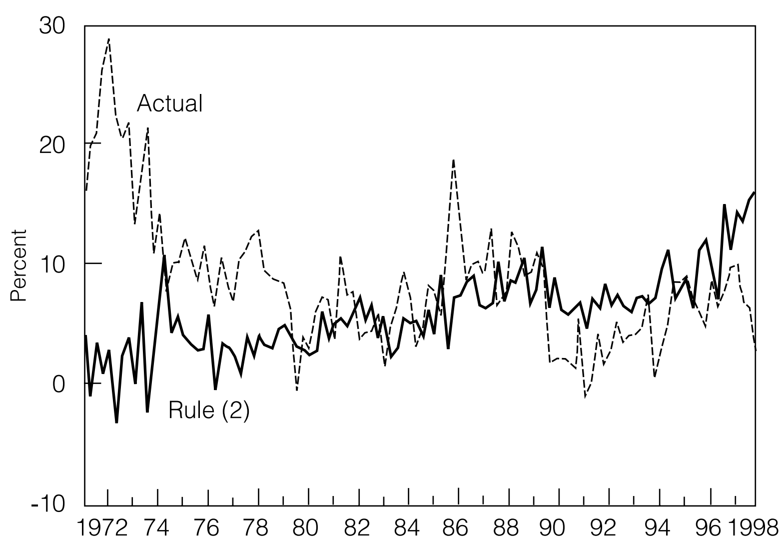


Figure 11 Japan Base Growth, Actual and Rule (4)

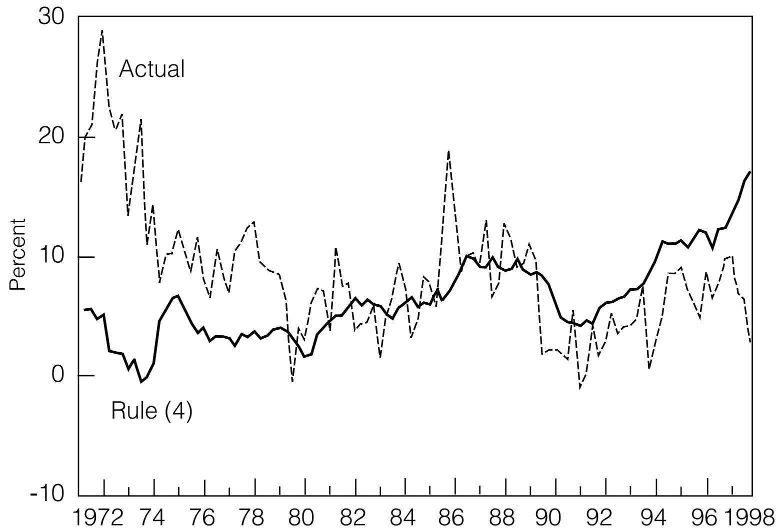
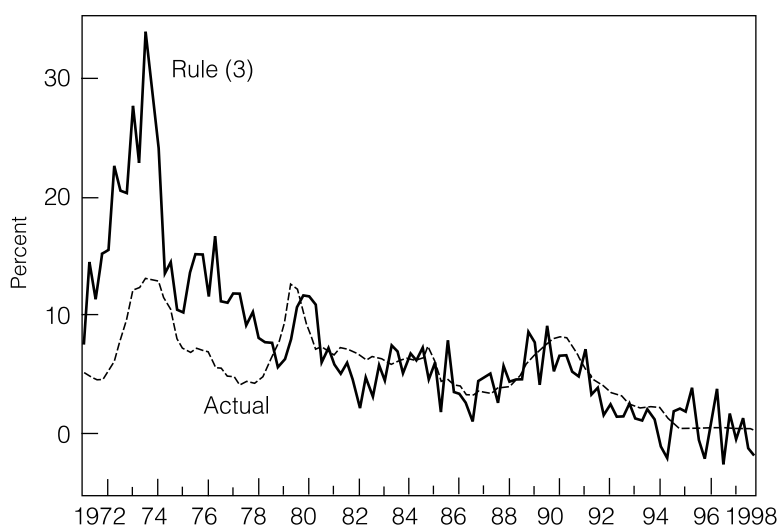


Figure 12 Japan Interest Rate, Actual and Rule (3)



We now turn to rules (3) and (4). Figure 11 shows that in the case of Japan, rule (4) again gives much the same signals as does the other rule with the Δb_t instrument, rule (2). Also, as in previous cases, the hybrid target variable yields a smoother path for base growth than does (2). As for the interest rate rule with a nominal GDP growth target, rule (3), Figure 12's results are more similar to those in Figure 9 than in Figure 10. The extent to which rule (3) calls for added stimulus in recent years is even less than in Figure 9, however. The rule does call for easier policy in the last half of 1998, but finds policy about right during 1995–1997.

5. ISSUES CONCERNING TARGET VARIABLES

One of the main preliminary indications of our previous discussion is that rules with Δx_t and h_t target variables give rather similar policy signals, provided that the instrument variable is the same. This notion needs to be strongly qualified, however, as follows. The main point is that the similarity of Δx_t and h_t signals observed in Sections 2–4 depends upon the use of output gap measures that do not yield large numerical magnitudes over the time span studied. In the case of the United States, the measure used was based on residuals from the HP filter. The standard deviation of these values over 1960–1998 is only 1.63, in percentage points. If instead the output gap measure was based on residuals from a linear trend (for the log of real GDP), the standard deviation would be 4.15 and the impact of the gap measure would be significantly greater. In that case the Taylor rule vs. actual comparison, comparable to Figure 1, would be as shown in Figure 13. Here the monetary policy message is not drastically different from that of Figure 1 for the subperiod 1966–1990, although the need for tighter policy during the '70s would be more clearly indicated. But for the early '60s and the late '90s the message would be quite different, with lower interest rates indicated by the gap based on the log-linear detrending. According to the Figure 13 version of the Taylor rule, the federal funds rate was too high by about 300 basis points throughout 1995–1998!

It is my belief that reliance of a policy rule upon any output gap measure is risky, for different measures give quite different values and there is at present no professional consensus on an appropriate measure—or even a concept. Linear detrending depends rather sensitively on the time period selected for fitting of the trend, as is illustrated in Figure 14, where gap measures based on log-linear trends fitted over 1960–1998 and 1980–1998 are shown, together with values based on the HP filter. One might suggest that quadratic detrending could alleviate this problem, but quadratic trends are themselves rather sensitive to the time period selected for fitting. This claim is supported by Figure 15, which shows gap measures based on quadratic trends for the log of real U.S. GDP fitted over the time periods 1960.1–1998.4 and 1980.1–1998.4. As can be seen there, these measures often differ by as much as 3 percentage points.

Figure 13 U.S. Rule (1) with Output Gaps Based on Log-Linear Detrending, 1960–1998

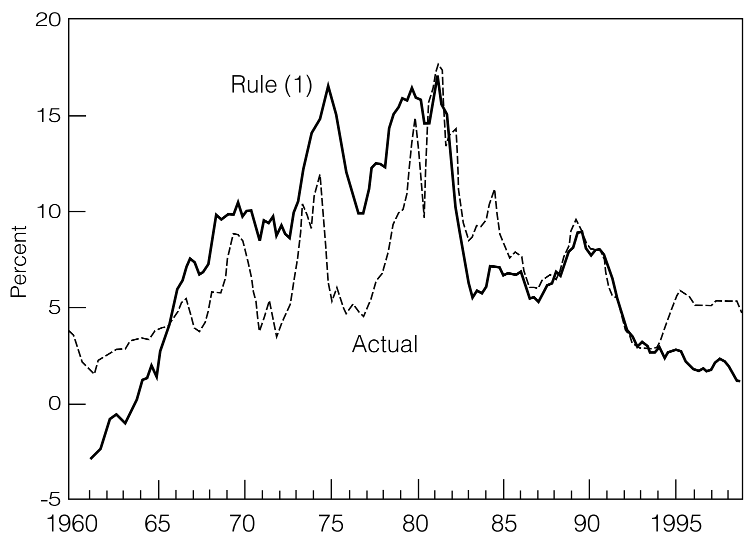
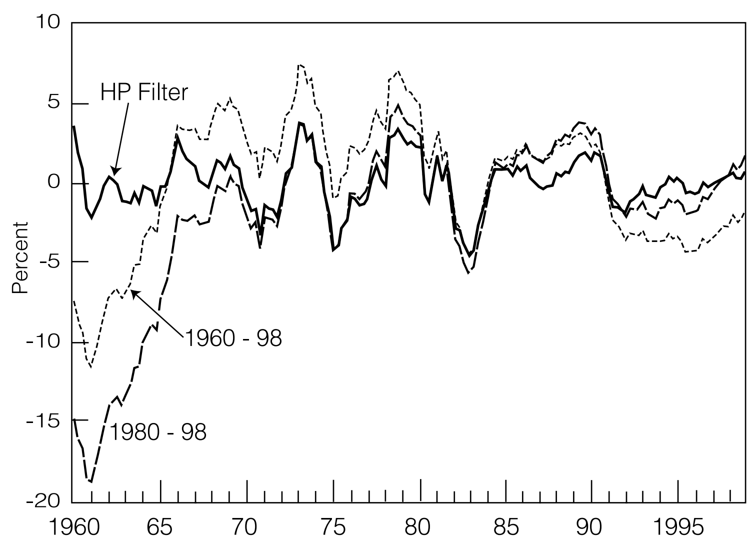


Figure 14 U.S. Output Gaps Based on HP Filter and Log-Linear Detrending, 1960–1998 and 1980–1998



With respect to the HP filter, the problem is that this procedure produces a "trend" that is so flexible that it follows the time path of actual GDP rather closely. Consequently, measures of the output gap are generated that would appear to underestimate (in absolute terms) the economically relevant gap values.[20] To illustrate this point, Figure 16 shows how the HP filter handles U.S. observations on real GDP during the '20s and '30s. According to this figure, U.S. output had fully returned to "trend" by 1934 and the incidence of above-trend output was approximately the same as below-trend output during the '30s, suggesting that the Great Depression actually did not occur.

More fundamentally, McCallum and Nelson (1999b) argue that any gap measure based on an output detrending procedure, which excludes the effects of current shocks from the measured gap, is conceptually inappropriate. The point is that (e.g.) positive technology shocks serve to increase the capacity or natural-rate value of output, not the value of actual output relative to the latter; but many univariate detrending procedures presume just the opposite. To overcome this difficulty, McCallum and Nelson (1999b) propose a measure based on the assumption of a Cobb-Douglas production function and utilizing values of manhours employed per member of the civilian workforce. This measure treats technological change appropriately, at least arguably, but relies upon debatable assumptions about labor supply and does not have a well-defined zero value.

As mentioned above, the recent work of Orphanides (1998, 1999) has attracted considerable attention. In the earlier of the cited papers, Orphanides constructed data series for 1987–1992 reflecting values of macroeconomic variables that were actually available at the time of (FOMC) policy decisions in the past. These series do not, accordingly, reflect data revisions and measurements that have taken place after the FOMC meetings at which instrument settings (usually values of the federal funds rate) were actually decided. In this context, the measurement of "potential" or "natural-rate" output is especially problematic. This study indicated that the magnitude of the informational problems were serious enough that "real-time policy recommendations differ widely from those obtained with the revised published data employed [by researchers] later on" (Orphanides, 1998, p. 3). The broad overall policy messages offered by the Taylor rule for 1987–1992 are not overturned, however, by the results of the 1997 study.

The results in Orphanides (1999) are more drastic. In this later work, the time span studied goes back to 1966.1 and so includes the major inflationary buildup and continuation that Taylor (1999a) refers to as "The Great Inflation." Orphanides' dramatic conclusion is that adherence to Taylor's rule throughout

[20] The present discussion presumes adoption of the standard value of 1600 for the HP filter's smoothing coefficient in work with quarterly data.

Figure 15 U.S. Gap Measures Based on Log-Quadratic Detrending, 1960–1998 and 1980–1998

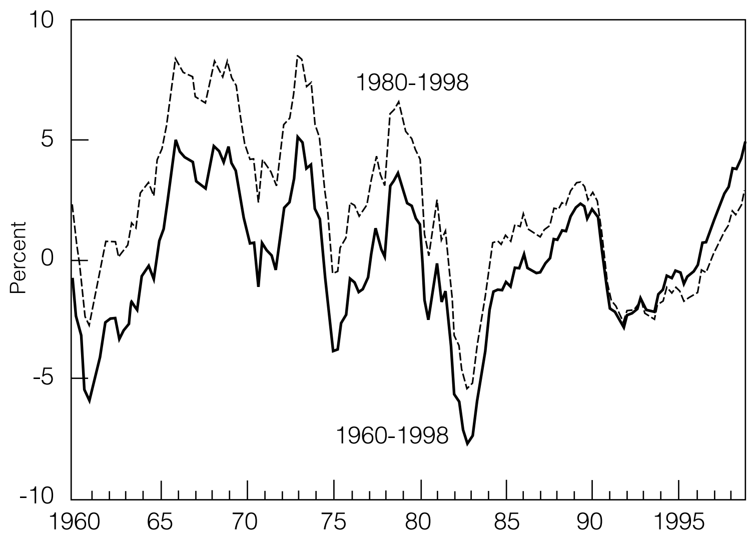
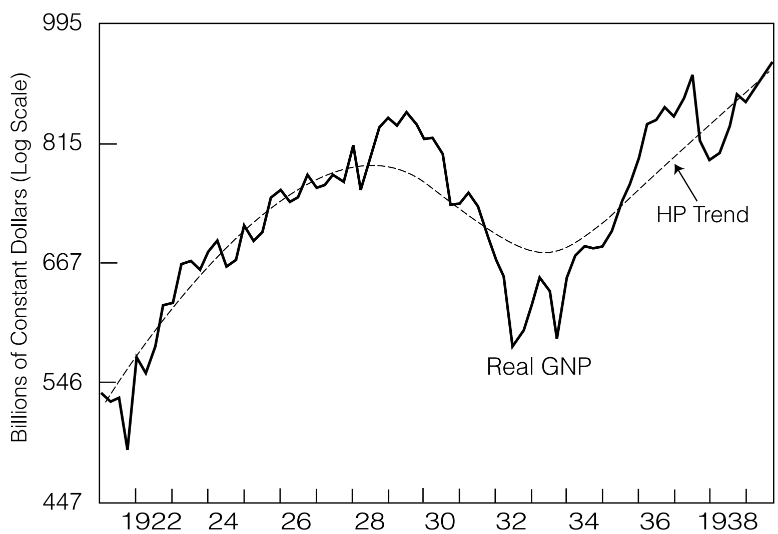


Figure 16 U.S. Real GNP and HP Trend, 1921–1939



the period would not, in constrast to Taylor's (1999a, pp. 338–39) contention, have prevented the Great Inflation.

Developing an appropriate evaluation of Orphanides' (1999) analysis is not a trivial undertaking. Certainly Orphanides' reconstruction of the data represents a major contribution to economic policy analysis; moreover, his arguments are carefully constructed and exposited. In my judgement, they do not imply that simple monetary policy rules cannot be useful when constrained by real-time data availability. Instead, I believe, the (1999) study shows in a striking fashion that reliance on an inappropriate concept of potential (or reference) output can be ruinous, i.e., can result in a monetary policy rule that is counter-productive. But some rules do not rely upon such measures, as the examples of Sections 2 through 4 above illustrate.[21] Also, the truly dramatic results in Orphanides (1999) stem from a potential output *concept* revision, rather than a *data* revision. Thus, although the data-revision problem is not of negligible significance, it is not as profound as a quick reading of Orphanides (1999) might suggest. In my view, it seems satisfactory to abstract from that problem for the purposes of the present study.

Given the foregoing argument and the findings of Sections 2–4, a natural step would be to investigate the performance of rules that use inflation as the target variable, i.e., the cyclical variable responded to by the instrument. Accordingly, we now present figures based on the two policy rules

$$R_t = \overline{r} + \Delta p_t^a + 0.5(\Delta p_t^a - \pi^*) \qquad (5)$$

$$\Delta b_t = \Delta x^* - \Delta v_t^a - 0.5(\Delta p_t^a - \pi^*), \qquad (6)$$

which can be compared with (1) and (4). The results are shown in Figures 17-22. For the United States, the interest rate rule in Figure 17 calls for R_t values quite close to those of Figure 1. Also, the base growth rule in Figure 18 yields settings for Δb_t that are rather close to those shown in Figure 3, in which the rule responds to the hybrid target variable. Likewise, the plots in Figures 19 and 20 for the United Kingdom are fairly similar to those in Figures 5 and 7. For Japan, however, the policy advice for recent years provided by the inflation-target rule in Figure 21 is quite different than that in Figure 9. In particular, in the absence of an output gap signal, rule (5) calls for R_t settings somewhat higher than actual values during 1997 and 1998. The base rule (6) results in Figure 22 remain more stimulative than the actual record for recent years, but to a lesser extent than in Figure 11.

[21] This conclusion is basically consistent with Orphanides' warning against "activist" policy rules, by which he means rules that place emphasis on measures of the level of an output gap concept. Orphanides finds that a rule featuring "natural growth targeting," which is rather similar to nominal income growth targeting as in rules (2) or (3) above, is not strongly subject to the difficulties that he emphasizes.

Figure 17 U.S. Interest Rate, Actual and Rule (5)

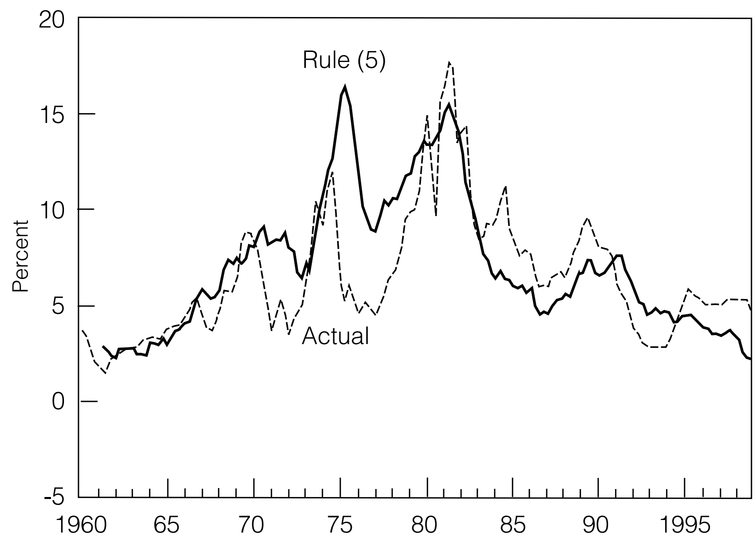


Figure 18 U.S. Base Growth, Actual and Rule (6)

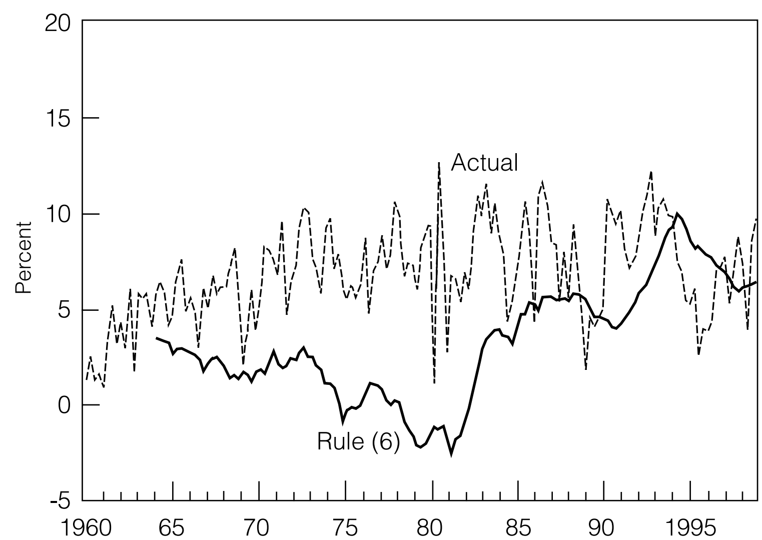


Figure 19 U.K. Interest Rate, Actual and Rule (5)

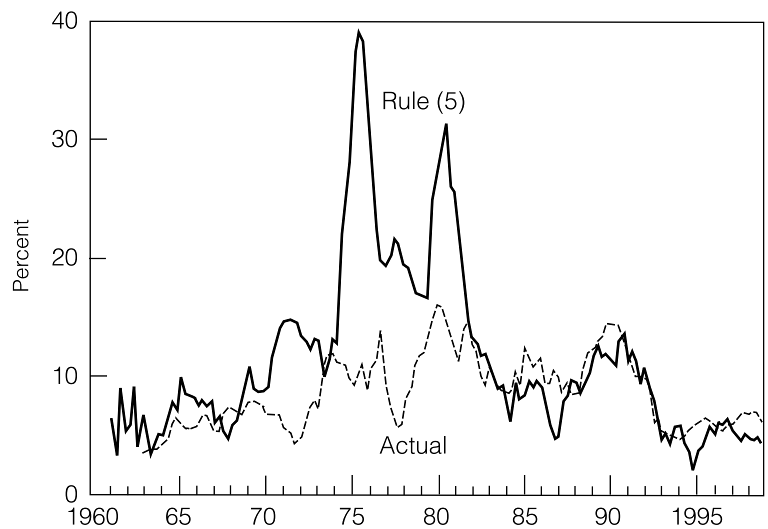


Figure 20 U.K. Base Growth, Actual and Rule (6)

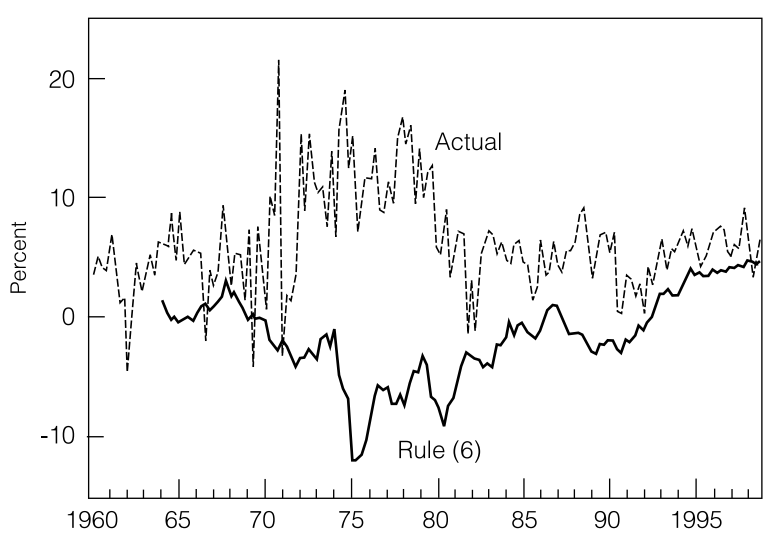


Figure 21 Japan Interest Rate, Actual and Rule (5)

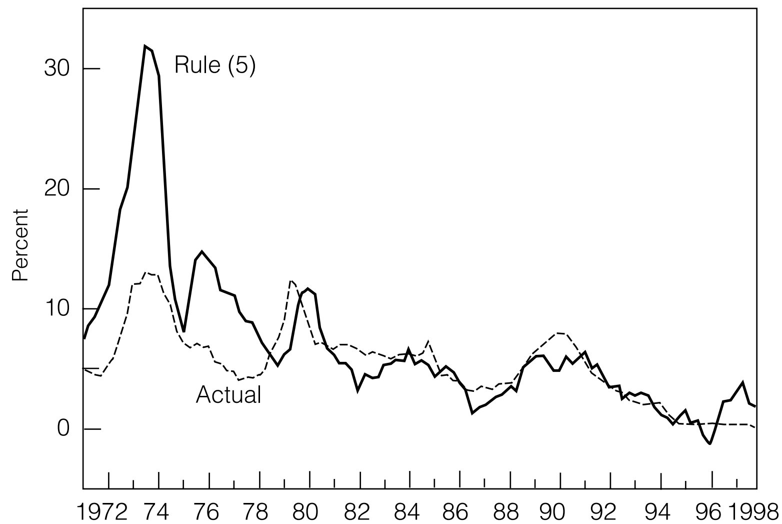
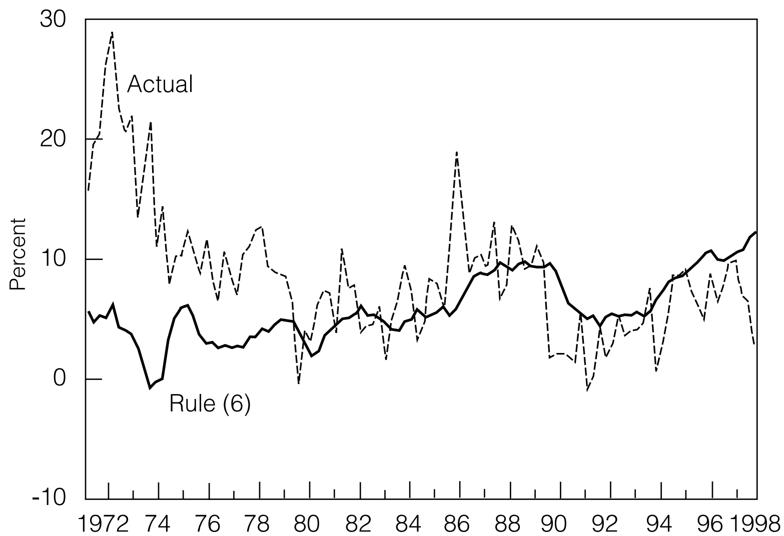


Figure 22 Japan Base Growth, Actual and Rule (6)



One attractive aspect of the inflation target variable Δp_t^a relative to the nominal income variable Δx_{t-1} is that the former features smaller quarter-to-quarter movements and therefore imparts a smoother, less choppy path to the instrument variables in (5) and (6), in comparison to (2) and (3). One reason for this, certainly, is that Δp_t^a reflects four-quarter averaging while Δx_{t-1} does not. Accordingly, it should be of some interest to see how the nominal income variable would perform if averaged over periods $t - 1$ through $t - 4$. Results with that modification are presented in Figures 23-28. In these plots, it can be seen that the choppiness of rules with a nominal GDP growth target is reduced substantially, although the implied instrument settings remain slightly more variable than with the inflation target. Are there any compensating advantages of the averaged Δx values relative to the averaged Δp values? For the United States and the United Kingdom, the policy advice seems to be basically the same in Figures 23–26 as in Figures 17–20. In the case of Japan, however, the nominal income targets in Figures 27–28 give more stimulative signals than with inflation targeting (Figures 21–22), which seems desirable. But the magnitude is not very large.

6. ISSUES CONCERNING INSTRUMENT VARIABLES

One of the more surprising aspects of the results in Sections 2–4 is that the policy diagnoses provided by the various rules seem to be more dependent upon the instrument variable used than upon the choice of target variable. This indication seems inconsistent with most analysts' beliefs about monetary policy design. Reflection upon the role and nature of the rules makes this finding understandable, however, in the following manner. First, the way in which the rules are used in a study such as the present one implies that the rule-specified instrument settings are actually serving as magnitudes of *indicator* variables, not instruments. That is, one could view the resulting values for quarterly settings of R_t or Δb_t as intermediate targets to be obtained by day-to-day or week-to-week manipulation of other variables that serve as the central bank's instrument.[22] Second, the policy stance—i.e., degree of tightness or ease—represented by rule-specified settings of R_t or Δb_t depends upon the magnitude of those variables *relative to* some reference value that can vary from period to period. In the case of the Taylor rule (1) the reference value is $\bar{r} + \Delta p_t^a$, which serves to convert R_t movements into movements in a real interest rate measured relative to $\bar{r}$, since $R_t - (\bar{r} + \Delta p_t^a) = (R_t - \Delta p_t^a) - \bar{r}$. With the McCallum rule (2), the reference value for Δb_t is $\Delta x^* - \Delta v_t^a$. In this case,

[22] A study that proceeds in this fashion is McCallum (1995), which considers how the U.S. federal funds rate could be manipulated on a week-to-week basis to hit quarterly intermediate targets for monetary base growth with the latter set so as to keep nominal income growth close to a specified target value.

Figure 23 U.S. Interest Rate, Actual and Rule with Averaged Nominal Income Growth

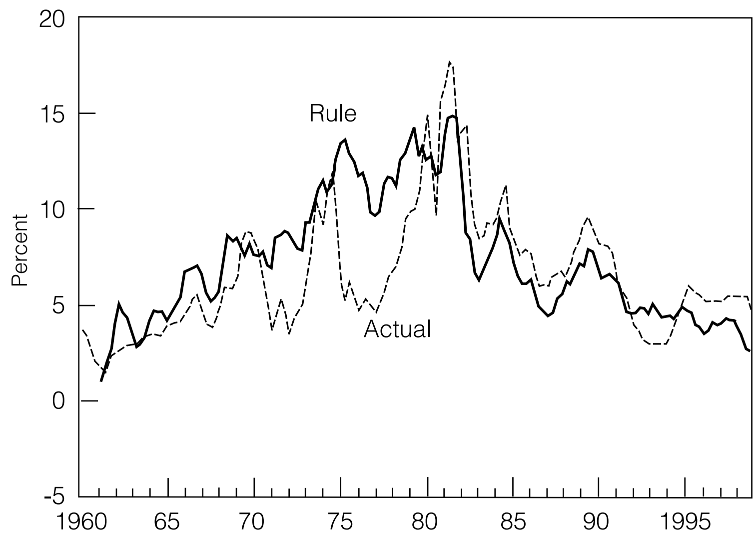


Figure 24 U.S. Base Growth, Actual and Rule with Averaged Nominal Income Growth

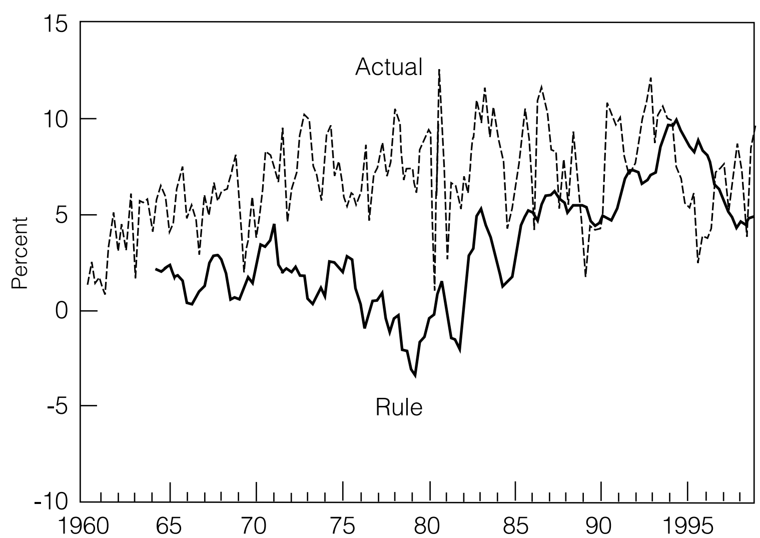


Figure 25 U.K. Interest Rate, Actual and Rule with Averaged Nominal Income Growth

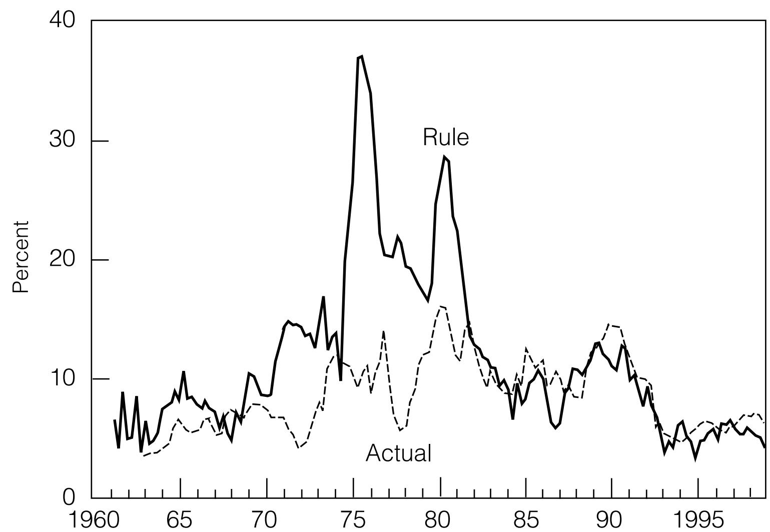


Figure 26 U.K. Base Growth, Actual and Rule with Averaged Nominal Income Growth

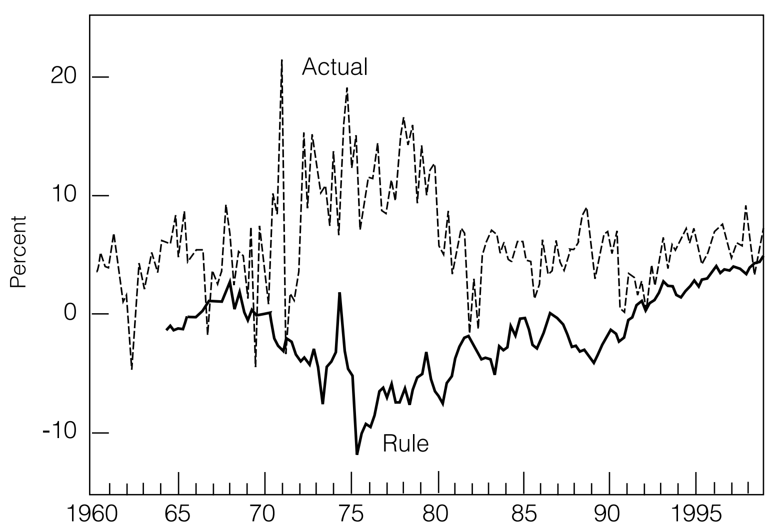


Figure 27 Japan Interest Rate, Actual and Rule with Averaged Nominal Income Growth

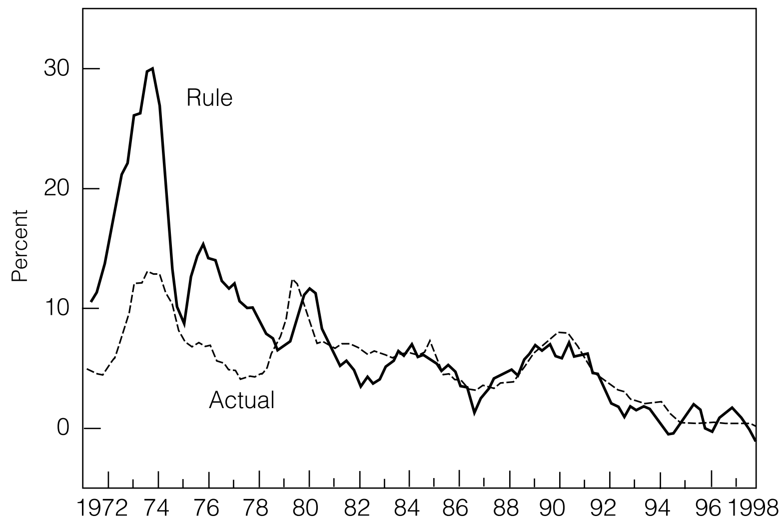
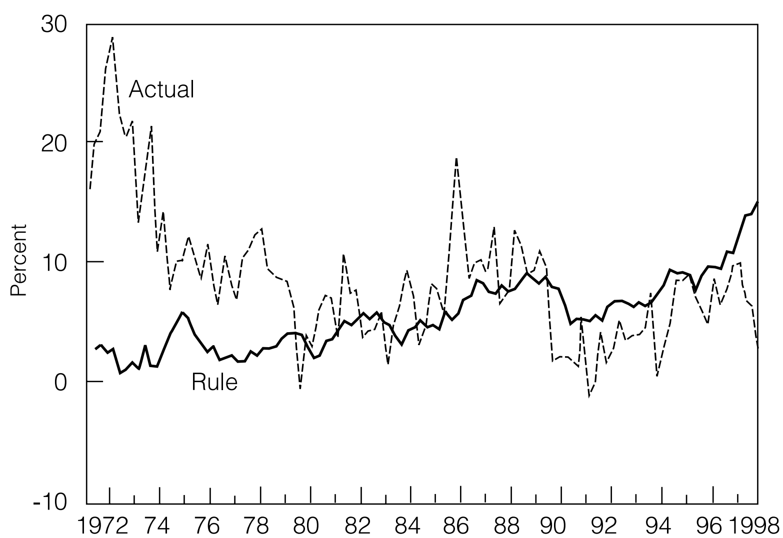


Figure 28 Japan Base Growth, Actual and Rule with Averaged Nominal Income Growth



$\Delta b_t - (\Delta x^* - \Delta v_t^a)$ reflects the difference between Δb_t and the value of base growth that would yield an inflation rate of π^* if output growth were equal to its long-run average value and base velocity growth were equal to its average over the past 16 quarters (a value that is implicitly being used as a forecast of the average over the indefinite future).

In each case, in other words, a necessary reference variable must be specified to convert raw values of R_t or Δb_t into measures of monetary ease or tightness.[23] Therefore the precise specification of these reference variables is of considerable importance to a rule's performance. If rules are to be relatively simple, it is necessary that the specification of these reference values be simple—hence Taylor's specification of a constant "equilibrium" real rate of interest or McCallum's constant "long-run growth rate of output." Evidently, however, the properties of any rule will depend critically upon how these reference values are specified. Consequently, it would appear that future research should perhaps devote more attention to this aspect of policy rule specification. To date, researchers have instead directed most of their attention to the choice among target variables, details of their specification, and the magnitude of coefficients attached to them.

7. CONCLUSION

Let us close with a brief summary of the findings developed above, based on historical policy-rule studies for the United States, the United Kingdom, and Japan. The basic results in this study come from comparisons of actual values with rule specifications involving either interest-rate or monetary-base instrument settings and nominal GDP growth or Taylor-style hybrid (inflation plus output gap) target variables. For the United States, all of the rules considered would have called for tighter monetary policy during the '70s, although the base-instrument rules would have done so more strongly than those with the Fed's actual funds-rate instrument. There is some disagreement among the rules concerning the '80s and '90s, although all of the candidate rules indicate that policy has not been highly inappropriate since 1987. For the United Kingdom, the various rules agree regarding the excessive inflation of the '70s, but the base-instrument rules suggest that policy was too loose during the middle and late '80s whereas the interest-instrument rules do not. In the case of Japan, interest centers on the record since 1990. Most of the rules indicate that policy was too tight in 1998, but the base rules suggest excessive tightness for the entire period 1990–1998, while the interest rate rules do not. All in all, the recommendations provided by the base rules seem somewhat more appropriate from an ex-post perspective.

[23] This statement applies to all of the rules, of course, not just (1) and (2).

Some of the study's suggestions are methodological, rather than substantive. In particular it is argued that reliance on output gap measures is risky, because various measures of potential or natural-rate output levels differ widely and there is no professional consensus on the most appropriate measure or even concept to be used. Most univariate detrending procedures, which are frequently utilized, would seem to be fundamentally inappropriate, because they assign the effects of technology shocks primarily to the gap between output and its reference value, rather than to the latter variable itself. Omitting the output gap term from a rule with the hybrid target converts it into an inflation targeting rule; we show that such rules give good advice in most of the episodes. So, too, do nominal income growth rules that average recent values.

A somewhat surprising finding is that rules' messages are evidently more dependent upon which instrument rather than which target variable is used.[24] This finding can be understood as resulting from the necessity of specifying a reference value, relative to which instrument settings are implicitly compared, in representing policy tightness or ease. For rules to be sufficiently simple, these reference-value specifications must themselves be simple, but different implicit assumptions about macroeconomic behavior are thereby built into the rule. The paper suggests, consequently, that investigation of these implicit assumptions could be an important topic for future research on alternative monetary policy rules.

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[24] Provided that strong dependence upon an output gap measure is avoided.

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